# OpenModelica User's Guide

***Release v1.28.0-dev-1529-gaef66789a3***

**Open Source Modelica Consortium**

**2026**

# CONTENTS


**1 Introduction** **3**
- 1.1 System Overview . . . 4
- 1.2 Interactive Session with Examples . . . 5
- 1.3 Summary of Commands for the Interactive Session Handler . . . 21
- 1.4 Running the compiler from command line . . . 22

**2 Package Management** **25**
- 2.1 Overview of Basic Modelica Package Management Concepts . . . 25
- 2.2 The Package Manager . . . 26
- 2.3 How the package index works . . . 28

**3 OMEdit - OpenModelica Connection Editor** **29**
- 3.1 Starting OMEdit . . . 29
- 3.2 MainWindow & Browsers . . . 29
- 3.3 Perspectives . . . 35
- 3.4 File Menu . . . 37
- 3.5 Edit Menu . . . 39
- 3.6 View Menu . . . 40
- 3.7 SSP Menu . . . 40
- 3.8 Simulation Menu . . . 40
- 3.9 Data Reconciliation . . . 41
- 3.10 Sensitivity Optimization Menu . . . 41
- 3.11 Debug Menu . . . 41
- 3.12 Tools Menu . . . 41
- 3.13 Help Menu . . . 41
- 3.14 Modeling a Model . . . 41
- 3.15 Simulating a Model . . . 43
- 3.16 Calibrating an SSP Model . . . 50
- 3.17 2D Plotting . . . 51
- 3.18 Re-simulating a Model . . . 53
- 3.19 3D Visualization . . . 53
- 3.20 Animation of Realtime FMUs . . . 55
- 3.21 Interactive Simulation . . . 56
- 3.22 How to Create User Defined Shapes - Icons . . . 56
- 3.23 Global head section in documentation . . . 58
- 3.24 Options . . . 59
- 3.25 __OpenModelica_commandLineOptions Annotation . . . 68
- 3.26 __OpenModelica_simulationFlags Annotation . . . 69
- 3.27 Global and Local Flags . . . 69
- 3.28 Debugger . . . 69
- 3.29 Editing Modelica Standard Library . . . 69
- 3.30 Install Library . . . 70
- 3.31 Convert Libraries using Conversion Scripts . . . 70
- 3.32 State Machines . . . 72

3.33 Using OMEdit as Text Editor . . . 73
3.34 Temporary Directory, Log Files and Working Directory . . . 75
3.35 High DPI Settings . . . 76

**4 Modelica Language Server** **83**
4.1 The Language Server Protocol . . . 83
4.2 Features . . . 83
4.3 Clients . . . 84
4.4 Reporting Issues . . . 85

**5 UML Class and Instance Diagrams** **87**
5.1 Formats . . . 87
5.2 Class Diagrams . . . 88
5.3 Instance Diagrams . . . 91

**6 Property Probes and CodeProber** **93**
6.1 The Probe Tree . . . 93
6.2 Properties . . . 94
6.3 Using CodeProber . . . 95

**7 2D Plotting** **99**
7.1 Example . . . 99
7.2 Plot Command Interface . . . 100

**8 OpenModelica Compiler** **103**
8.1 Frontend Modules . . . 103
8.2 Backend Modules . . . 103
8.3 Code generation . . . 105
8.4 Simulation Runtimes . . . 105

**9 Solving Modelica Models** **107**
9.1 Integration Methods . . . 107
9.2 DAE Mode Simulation . . . 109
9.3 Initialization . . . 109
9.4 Tearing . . . 115
9.5 Algebraic Solvers . . . 116

**10 Automatic Parallelization of Simulations** **117**
10.1 Run-time flags . . . 117
10.2 JSON format . . . 117
10.3 External tools . . . 118
10.4 The optimization workflow . . . 119

**11 Debugging** **121**
11.1 The Equation-based Debugger . . . 121
11.2 The Algorithmic Debugger . . . 123

**12 Flattening models to BaseModelica** **129**
12.1 BaseModelica . . . 129
12.2 Converting Modelica models in BaseModelica with OpenModelica . . . 129
12.3 Array-preserving BaseModelica output . . . 129

**13 Porting Modelica libraries to OpenModelica** **131**
13.1 Mapping of the library on the file system . . . 131
13.2 Modifiers for arrays . . . 131
13.3 Access to conditional components . . . 132
13.4 Access to classes defined in partial packages . . . 133
13.5 Equality operator in algorithms . . . 134
13.6 Public non-input non-output variables in functions . . . 134
13.7 Subscripting of expressions . . . 135

13.8 Incomplete specification of initial conditions . . . 135
13.9 Modelica_LinearSystems2 Library . . . 136

**14 Backwards Compatibility of OpenModelica Released Versions 137**

**15 Generating Graph Representations for Models 139**

**16 Functional Mock-up Interface - FMI 141**
16.1 FMI Standards . . . 141
16.2 FMI Export . . . 142
16.3 FMI Import - SSP . . . 149

**17 OMSimulator 151**
17.1 Introduction . . . 151
17.2 OMSimulator . . . 151

**18 Running a Python script 155**

**19 Running an SSP file 157**

**20 Running an FMU 159**
20.1 OMSimulatorLib . . . 159
20.2 OMSimulatorPython3 . . . 171
20.3 OpenModelicaScripting . . . 199
20.4 OMEdit . . . 209
20.5 OMSimulatorGui . . . 218

**21 System Identification 237**
21.1 Examples . . . 237
21.2 Python and C API . . . 239

**22 OpenModelica Encryption 247**
22.1 Encrypting the Library . . . 247
22.2 Loading an Encrypted Library . . . 247
22.3 Notes . . . 247

**23 OMNotebook with DrModelica and DrControl 249**
23.1 Interactive Notebooks with Literate Programming . . . 249
23.2 DrModelica Tutoring System - an Application of OMNotebook . . . 250
23.3 DrControl Tutorial for Teaching Control Theory . . . 256
23.4 OpenModelica Notebook Commands . . . 266
23.5 References . . . 271

**24 Optimization with OpenModelica 273**
24.1 Built-in Dynamic Optimization using Annotations . . . 273
24.2 Built-in Dynamic Optimization using Optimica language extensions . . . 283
24.3 Dynamic Optimization with OpenModelica and CasADi . . . 286
24.4 Parameter Sweep Optimization using OMOptim . . . 291

**25 Parameter Sensitivities with OpenModelica 299**
25.1 Single Parameter sensitivities with IDA/Sundials . . . 299
25.2 Single and Multi-parameter sensitivities with OMSens . . . 300

**26 PDEModelica1 315**
26.1 PDEModelica1 language elements . . . 315
26.2 Limitations . . . 316
26.3 Viewing results . . . 316

**27 MDT - The OpenModelica Development Tooling Eclipse Plugin 317**
27.1 Introduction . . . 317

27.2 Installation . . . 317
27.3 Getting Started . . . 318

**28 MDT Debugger for Algorithmic Modelica** **331**
28.1 The Eclipse-based Debugger for Algorithmic Modelica . . . 331

**29 Modelica Performance Analyzer** **337**
29.1 Profiling information for ProfilingTest . . . 338
29.2 Genenerated JSON for the Example . . . 340
29.3 Using the Profiler from OMEdit . . . 341

**30 Simulation in Web Browser** **343**

**31 Interoperability - C and Python** **345**
31.1 Calling External C functions . . . 345
31.2 Calling external Python Code from a Modelica model . . . 347
31.3 Calling OpenModelica from Python Code . . . 350

**32 OMPython - OpenModelica Python Interface** **353**
32.1 Features of OMPython . . . 353
32.2 Session Classes . . . 354
32.3 Modelica System Classes . . . 359
32.4 Design of Experiments . . . 368
32.5 Execute Compiled Models . . . 370
32.6 Parsers - Parsing OMC Return Data . . . 372
32.7 Compatibility with OMPython v4.0.0 . . . 373

**33 OMMatlab - OpenModelica Matlab Interface** **377**
33.1 Features of OMMatlab . . . 377
33.2 Test Commands . . . 377
33.3 WorkDirectory . . . 379
33.4 BuildModel . . . 379
33.5 Standard get methods . . . 379
33.6 Usage of getMethods . . . 379
33.7 Standard set methods . . . 381
33.8 Usage of setMethods . . . 382
33.9 Advanced Simulation . . . 382
33.10 Linearization . . . 382
33.11 Usage of Linearization methods . . . 383

**34 OMJulia - OpenModelica Julia Scripting** **385**

**35 Jupyter-OpenModelica** **387**

**36 Scripting API** **389**
36.1 OpenModelica Scripting Commands . . . 389
36.2 Simulation Parameter Sweep . . . 477
36.3 Examples . . . 478

**37 OpenModelica Compiler Flags** **483**
37.1 Options . . . 483
37.2 Debug flags . . . 503
37.3 Flags for Optimization Modules . . . 512

**38 Simulation Runtime Flags** **515**
38.1 C Runtime Simulation Flags . . . 515

**39 Technical Details** **533**
39.1 The MATv4 Result File Format . . . 533
39.2 The Arrow Result File Format . . . 534

**40 Data Reconciliation** **535**
40.1 Objective of Data Reconciliation . . . 535
40.2 Defining the Data Reconciliation Problem in OpenModelica . . . 535
40.3 Data Reconciliation Support in OMEdit . . . 539
40.4 Computing the Boundary Conditions from the Reconciled Values . . . 543
40.5 Contacts . . . 546
40.6 References . . . 546

**41 Frequently Asked Questions (FAQ)** **547**
41.1 OpenModelica General . . . 547
41.2 OMNotebook . . . 547

**42 Major OpenModelica Releases** **549**
42.1 Release Notes for nightly . . . 549
42.2 Release Notes for OpenModelica 1.27.1 . . . 549
42.3 Patch release for 1.27.0. . . . 549
42.4 Release Notes for OpenModelica 1.27.0 . . . 549
42.5 2026 summer release of OpenModelica version 1.27.0. . . . 549
42.6 Release Notes for v1.26.9 . . . 551
42.7 Release Notes for v1.28.0-dev . . . 552
42.8 Release Notes for OpenModelica v1.26.8 . . . 552
42.9 Release Notes for OpenModelica v1.26.7 . . . 552
42.10 Release Notes for OpenModelica 1.26.6 . . . 552
42.11 Release Notes for OpenModelica 1.26.5 . . . 552
42.12 Release Notes for OpenModelica 1.26.4 . . . 552
42.13 Patch release for 1.26.3. . . . 552
42.14 Release Notes for OpenModelica 1.26.3 . . . 553
42.15 Patch release for 1.26.2. . . . 553
42.16 Release Notes for OpenModelica 1.26.2 . . . 553
42.17 Patch release for 1.26.1. . . . 553
42.18 Release Notes for OpenModelica 1.26.1 . . . 553
42.19 Patch release for 1.26.0. . . . 553
42.20 Release Notes for OpenModelica 1.26.1 Beta 2 . . . 553
42.21 Patch release for 1.26.0. . . . 553
42.22 Release Notes for OpenModelica 1.26.0 . . . 554
42.23 2025 Winter release of OpenModelica version 1.26.0. . . . 554
42.24 Release Notes for OpenModelica 1.26.0-dev.beta.1 . . . 555
42.25 Release Notes for OpenModelica 1.25.7 . . . 557
42.26 Release Notes for OpenModelica 1.25.6 . . . 557
42.27 Release Notes for OpenModelica 1.25.5 . . . 557
42.28 Release Notes for OpenModelica 1.25.4 . . . 557
42.29 Release Notes for OpenModelica 1.25.3 . . . 557
42.30 Release Notes for OpenModelica 1.25.2 . . . 557
42.31 Release Notes for OpenModelica 1.25.1 . . . 558
42.32 Release Notes for OpenModelica 1.25.0 . . . 558
42.33 Release Notes for OpenModelica 1.24.5 . . . 559
42.34 Release Notes for OpenModelica 1.24.4 . . . 559
42.35 Release Notes for OpenModelica 1.24.3 . . . 559
42.36 Release Notes for OpenModelica 1.24.2 . . . 560
42.37 Release Notes for OpenModelica 1.24.0 . . . 560
42.38 Release Notes for OpenModelica 1.23.1 . . . 561
42.39 Release Notes for OpenModelica 1.23.0 . . . 561
42.40 Release Notes for OpenModelica 1.22.3 . . . 562
42.41 Release Notes for OpenModelica 1.22.2 . . . 562
42.42 Release Notes for OpenModelica 1.22.1 . . . 563
42.43 Release Notes for OpenModelica 1.22.0 . . . 563
42.44 Release Notes for OpenModelica 1.21.0 . . . 564
42.45 Release Notes for OpenModelica 1.20.0 . . . 565

42.46 Release Notes for OpenModelica 1.19.2 . . . 567
42.47 Release Notes for OpenModelica 1.19.0 . . . 567
42.48 Release Notes for OpenModelica 1.18.0 . . . 568
42.49 Release Notes for OpenModelica 1.17.0 . . . 570
42.50 Release Notes for OpenModelica 1.16.5 . . . 572
42.51 Release Notes for OpenModelica 1.16.4 . . . 572
42.52 Release Notes for OpenModelica 1.16.2 . . . 572
42.53 Release Notes for OpenModelica 1.16.1 . . . 572
42.54 Release Notes for OpenModelica 1.16.0 . . . 573
42.55 Release Notes for OpenModelica 1.14.2 . . . 574
42.56 Release Notes for OpenModelica 1.14.0 . . . 574

**43 Contributors to OpenModelica** **597**
43.1 OpenModelica Contributors 2015 . . . 597
43.2 OpenModelica Contributors 2014 . . . 599
43.3 OpenModelica Contributors 2013 . . . 600
43.4 OpenModelica Contributors 2012 . . . 602
43.5 OpenModelica Contributors 2011 . . . 604
43.6 OpenModelica Contributors 2010 . . . 606
43.7 OpenModelica Contributors 2009 . . . 607
43.8 OpenModelica Contributors 2008 . . . 609
43.9 OpenModelica Contributors 2007 . . . 609
43.10 OpenModelica Contributors 2006 . . . 610
43.11 OpenModelica Contributors 2005 . . . 611
43.12 OpenModelica Contributors 2004 . . . 611
43.13 OpenModelica Contributors 2003 . . . 611
43.14 OpenModelica Contributors 2002 . . . 612
43.15 OpenModelica Contributors 2001 . . . 612
43.16 OpenModelica Contributors 2000 . . . 612
43.17 OpenModelica Contributors 1999 . . . 612
43.18 OpenModelica Contributors 1998 . . . 613

**Bibliography** **615**

**Index** **617**

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This users guide provides documentation and examples on how to use the OpenModelica system, both for the Modelica beginners and advanced users.

CHAPTER

ONE

# INTRODUCTION

The OpenModelica system described in this document has both short-term and long-term goals:

- The short-term goal is to develop an efficient interactive computational environment for the Modelica language, as well as a rather complete implementation of the language. It turns out that with support of appropriate tools and libraries, Modelica is very well suited as a computational language for development and execution of both low level and high level numerical algorithms, e.g. for control system design, solving nonlinear equation systems, or to develop optimization algorithms that are applied to complex applications.
- The long-term goal is to have a complete reference implementation of the Modelica language, including simulation of equation based models and additional facilities in the programming environment, as well as convenient facilities for research and experimentation in language design or other research activities. However, our goal is not to reach the level of performance and quality provided by current commercial Modelica environments that can handle large models requiring advanced analysis and optimization by the Modelica compiler.

The long-term *research* related goals and issues of the OpenModelica open source implementation of a Modelica environment include but are not limited to the following:

- Development of a *complete formal specification* of Modelica, including both static and dynamic semantics. Such a specification can be used to assist current and future Modelica implementers by providing a semantic reference, as a kind of reference implementation.
- *Language design*, e.g. to further *extend the scope* of the language, e.g. for use in diagnosis, structural analysis, system identification, etc., as well as modeling problems that require extensions such as partial differential equations, enlarged scope for discrete modeling and simulation, etc.
- *Language design* to *improve abstract properties* such as expressiveness, orthogonality, declarativity, reuse, configurability, architectural properties, etc.
- *Improved implementation techniques*, e.g. to enhance the performance of compiled Modelica code by generating code for parallel hardware.
- *Improved debugging* support for equation based languages such as Modelica, to make them even easier to use.
- *Easy-to-use* specialized high-level (graphical) *user interfaces* for certain application domains.
- *Visualization* and animation techniques for interpretation and presentation of results.
- *Application usage* and model library development by researchers in various application areas.

The OpenModelica environment provides a test bench for language design ideas that, if successful, can be submitted to the Modelica Association for consideration regarding possible inclusion in the official Modelica standard.

The current version of the OpenModelica environment allows most of the expression, algorithm, and function parts of Modelica to be executed interactively, as well as equation models and Modelica functions to be compiled into efficient C code. The generated C code is combined with a library of utility functions, a run-time library, and a numerical DAE solver.

## 1.1 System Overview

The OpenModelica environment consists of several interconnected subsystems, as depicted in Figure 1.1.

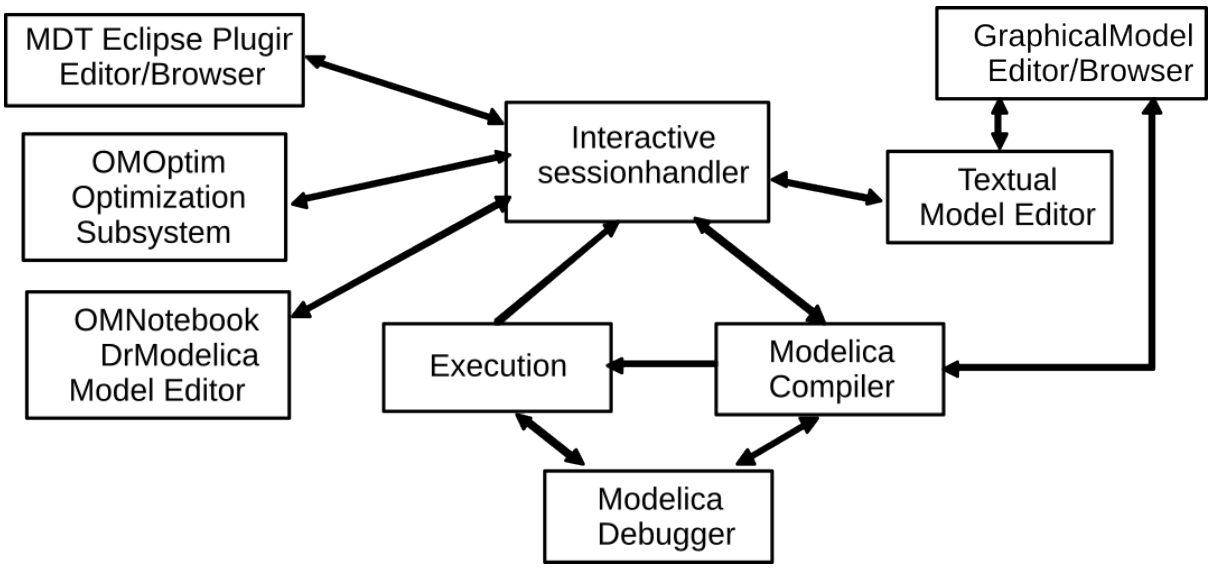



Figure 1.1: The architecture of the OpenModelica environment. Arrows denote data and control flow. The interactive session handler receives commands and shows results from evaluating commands and expressions that are translated and executed. Several subsystems provide different forms of browsing and textual editing of Modelica code. The debugger currently provides debugging of an extended algorithmic subset of Modelica.

The following subsystems are currently integrated in the OpenModelica environment:

- *An interactive session handler*, that parses and interprets commands and Modelica expressions for evaluation, simulation, plotting, etc. The session handler also contains simple history facilities, and completion of file names and certain identifiers in commands.
- *A Modelica compiler subsystem*, translating Modelica to C code, with a symbol table containing definitions of classes, functions, and variables. Such definitions can be predefined, user-defined, or obtained from libraries. The compiler also includes a Modelica interpreter for interactive usage and constant expression evaluation. The subsystem also includes facilities for building simulation executables linked with selected numerical ODE or DAE solvers.
- *An execution and run-time module*. This module currently executes compiled binary code from translated expressions and functions, as well as simulation code from equation based models, linked with numerical solvers. In the near future event handling facilities will be included for the discrete and hybrid parts of the Modelica language.
- *Eclipse plugin editor/browser*. The Eclipse plugin called MDT (Modelica Development Tooling) provides file and class hierarchy browsing and text editing capabilities, rather analogous to previously described Emacs editor/browser. Some syntax highlighting facilities are also included. The Eclipse framework has the advantage of making it easier to add future extensions such as refactoring and cross referencing support.
- *OMNotebook DrModelica model editor*. This subsystem provides a lightweight notebook editor, compared to the more advanced Mathematica notebooks available in MathModelica. This basic functionality still allows essentially the whole DrModelica tutorial to be handled. Hierarchical text documents with chapters and sections can be represented and edited, including basic formatting. Cells can contain ordinary text or Modelica models and expressions, which can be evaluated and simulated. However, no mathematical typesetting facilities are yet available in the cells of this notebook editor.
- *Graphical model editor/browser OMEdit*. This is a graphical connection editor, for component based model design by connecting instances of Modelica classes, and browsing Modelica model libraries for reading and picking component models. The graphical model editor also includes a textual editor for editing model class definitions, and a window for interactive Modelica command evaluation.

- *Optimization subsystem OMOptim*. This is an optimization subsystem for OpenModelica, currently for design optimization choosing an optimal set of design parameters for a model. The current version has a graphical user interface, provides genetic optimization algorithms and Pareto front optimization, works integrated with the simulators and automatically accesses variables and design parameters from the Modelica model.
- *Dynamic Optimization subsystem*. This is dynamic optimization using collocation methods, for Modelica models extended with optimization specifications with goal functions and additional constraints. This subsystem is integrated with in the OpenModelica compiler.
- *Modelica equation model debugger*. The equation model debugger shows the location of an error in the model equation source code. It keeps track of the symbolic transformations done by the compiler on the way from equations to low-level generated C code, and also explains which transformations have been done.
- *Modelica algorithmic code debugger*. The algorithmic code Modelica debugger provides debugging for an extended algorithmic subset of Modelica, excluding equation-based models and some other features, but including some meta-programming and model transformation extensions to Modelica. This is a conventional full-feature debugger, using Eclipse for displaying the source code during stepping, setting breakpoints, etc. Various back-trace and inspection commands are available. The debugger also includes a data-view browser for browsing hierarchical data such as tree- or list structures in extended Modelica.

## 1.2 Interactive Session with Examples

The following is an interactive session using the interactive session handler in the OpenModelica environment, called OMShell - the OpenModelica Shell. Most of these examples are also available in the *OMNotebook with DrModelica and DrControl* UsersGuideExamples.onb as well as the testmodels in:

```
>>> getInstallationDirectoryPath() + "/share/doc/omc/testmodels/"
"«OPENMODELICAHOME»/share/doc/omc/testmodels/"
```

The following commands were run using OpenModelica version:

```
>>> getVersion()
"v1.28.0-dev.1529+gaef66789a3.cmake"
```

### 1.2.1 Starting the Interactive Session

Under Windows, go to the Start Menu and run OpenModelica->OpenModelica Shell which responds with an interaction window.

Under Linux, run `OMShell-terminal` to start the interactive session at the prompt.

We enter an assignment of a vector expression, created by the range construction expression 1:12, to be stored in the variable x. The value of the expression is returned.

```
>>> x := 1:12
{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12}
```

### 1.2.2 Using the Interactive Mode

When running OMC in interactive mode (for instance using OMShell) one can make load classes and execute commands. Here we give a few example sessions.

#### Example Session 1

```
>>> model A Integer t = 1.5; end A; //The type is Integer but 1.5 is of Real Type
{A}
>>> instantiateModel(A)
""
```

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```
"[<interactive>:1:9-1:23:writable] Error: Type mismatch in binding t = 1.5, expected␣
↪subtype of Integer, got type Real."
```

#### Example Session 2

If you do not see the error-message when running the example, use the command `getErrorString()`.

```
model C
  Integer a;
  Real b;
equation
  der(a) = b; // der(a) is illegal since a is not a Real number
  der(b) = 12.0;
end C;
```

```
>>> instantiateModel(C)
""
```

**Error**

[<interactive>:5:3-5:13:writable] Error: Argument 'a' of der is not differentiable.

### 1.2.3 Trying the Bubblesort Function

Load the function bubblesort, either by using the pull-down menu File->Load Model, or by explicitly giving the command:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/bubblesort.mo
↪")
true
```

The function bubblesort is called below to sort the vector x in descending order. The sorted result is returned together with its type. Note that the result vector is of type Real[:], instantiated as Real[12], since this is the declared type of the function result. The input Integer vector was automatically converted to a Real vector according to the Modelica type coercion rules. The function is automatically compiled when called if this has not been done before.

```
>>> bubblesort(x)
{12.0, 11.0, 10.0, 9.0, 8.0, 7.0, 6.0, 5.0, 4.0, 3.0, 2.0, 1.0}
```

Another call:

```
>>> bubblesort({4,6,2,5,8})
{8.0, 6.0, 5.0, 4.0, 2.0}
```

### 1.2.4 Trying the system and cd Commands

It is also possible to give operating system commands via the system utility function. A command is provided as a string argument. The example below shows the system utility applied to the UNIX command cat, which here outputs the contents of the file bubblesort.mo to the output stream when running omc from the command-line.

```
>>> system("cat '"+getInstallationDirectoryPath()+"/share/doc/omc/testmodels/
↪bubblesort.mo' > bubblesort.mo")
0
```

```
function bubblesort
  input Real[:] x;
  output Real[size(x,1)] y;
protected
  Real t;
algorithm
  y := x;
  for i in 1:size(x,1) loop
    for j in 1:size(x,1) loop
      if y[i] > y[j] then
        t := y[i];
        y[i] := y[j];
        y[j] := t;
      end if;
    end for;
  end for;
end bubblesort;
```

Note: The output emitted into stdout by system commands is put into log-files when running the graphical clients, not into the visible GUI windows. Thus the text emitted by the above cat command would not be returned, which is why it is redirected to another file.

A better way to read the content of files would be the readFile command:

```
>>> readFile("bubblesort.mo")
function bubblesort
  input Real[:] x;
  output Real[size(x,1)] y;
protected
  Real t;
algorithm
  y := x;
  for i in 1:size(x,1) loop
    for j in 1:size(x,1) loop
      if y[i] > y[j] then
        t := y[i];
        y[i] := y[j];
        y[j] := t;
      end if;
    end for;
  end for;
end bubblesort;
```

The system command only returns a success code (0 = success).

```
>>> system("dir")
0
>>> system("Non-existing command")
127
```

Another built-in command is cd, the *change current directory* command. The resulting current directory is returned as a string.

```
>>> dir:=cd()
"«DOCHOME»"
>>> cd("source")
"«DOCHOME»/source"
>>> cd(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/")
```

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```
"/var/lib/jenkins/ws/OpenModelica/build/share/doc/omc/testmodels"
>>> cd(dir)
"«DOCHOME»"
```

### 1.2.5 Modelica Library and DCMotor Model

We load a model, here the whole Modelica standard library, which also can be done through the File->Load Modelica Library menu item:

```
>>> loadModel(Modelica, {"3.2.3"})
true
```

We also load a file containing the dcmotor model:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/dcmotor.mo")
true
```

**Warning**

Warning: dcmotor requested package Modelica of version 3.2.2. Modelica 4.1.0 is used instead which states that it is only compatible with a conversion script. Use convertPackageToLibrary(dcmotor, Modelica, "4.1.0") to run the conversion script or proceed with potential issues as a result.

It is simulated:

```
>>> simulate(dcmotor, startTime=0.0, stopTime=10.0)
record SimulationResult
    resultFile = "",
    simulationOptions = "startTime = 0.0, stopTime = 10.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'dcmotor', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "Failed to build model: dcmotor",
    timeFrontend = 0.0,
    timeBackend = 0.0,
    timeSimCode = 0.0,
    timeTemplates = 0.0,
    timeCompile = 0.0,
    timeSimulation = 0.0,
    timeTotal = 0.0
end SimulationResult;
```

**Error**

[/var/lib/jenkins/ws/OpenModelica/build/share/doc/omc/testmodels/dcmotor.mo:7:3-7:24:writable] Error: Class Basic.EMF not found in scope dcmotor.

We list the source code of the model:

```
>>> list(dcmotor)
model dcmotor
  import Modelica.Electrical.Analog.Basic;
```

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```
  Basic.Resistor resistor1(R = 10);
  Basic.Inductor inductor1(L = 0.2, i.fixed = true);
  Basic.Ground ground1;
  Modelica.Mechanics.Rotational.Components.Inertia load(J = 1, phi.fixed = true, w.
↪fixed = true);
  Basic.EMF emf1(k = 1.0);
  Modelica.Blocks.Sources.Step step1;
  Modelica.Electrical.Analog.Sources.SignalVoltage signalVoltage1;
equation
  connect(step1.y, signalVoltage1.v);
  connect(signalVoltage1.p, resistor1.p);
  connect(resistor1.n, inductor1.p);
  connect(inductor1.n, emf1.p);
  connect(emf1.flange, load.flange_a);
  connect(signalVoltage1.n, ground1.p);
  connect(ground1.p, emf1.n);
  annotation(
    uses(Modelica(version = "3.2.2")));
end dcmotor;
```

We test code instantiation of the model to flat code:

```
>>> instantiateModel(dcmotor)
```

**Error**

[/var/lib/jenkins/ws/OpenModelica/build/share/doc/omc/testmodels/dcmotor.mo:7:3-7:24:writable] Error: Class Basic.EMF not found in scope dcmotor.

We plot part of the simulated result:

**Error**

Unable to execute gnuplot directive

expected str, bytes or os.PathLike object, not NoneType Traceback (most recent call last): File "/var/lib/jenkins/ws/OpenModelica/build_usersguide/source/sphinxcontribopenmodelica.py", line 290, in run filename = os.path.abspath(self.options.get('filename') or sendExpression("currentSimulationResult")) ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

File "<frozen posixpath>", line 415, in abspath TypeError: expected str, bytes or os.PathLike object, not NoneType

### 1.2.6 The val() function

The val(*variableName*,*time*) scription function can be used to retrieve the interpolated value of a simulation result variable at a certain point in the simulation time, see usage in the BouncingBall simulation below.

### 1.2.7 BouncingBall and Switch Models

We load and simulate the BouncingBall example containing when-equations and if-expressions (the Modelica keywords have been bold-faced by hand for better readability):

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
true
```

**Error**

[<interactive>:1:1-1:0:writable] Error: Variable currentSimulationResult not found in scope <global scope>.

```
>>> list(BouncingBall)
model BouncingBall
  parameter Real e = 0.7 "coefficient of restitution";
  parameter Real g = 9.81 "gravity acceleration";
  Real h(fixed = true, start = 1) "height of ball";
  Real v(fixed = true) "velocity of ball";
  Boolean flying(fixed = true, start = true) "true, if ball is flying";
  Boolean impact;
  Real v_new(fixed = true);
  Integer foo;
equation
  impact = h <= 0.0;
  foo = if impact then 1 else 2;
  der(v) = if flying then -g else 0;
  der(h) = v;
  when {h <= 0.0 and v <= 0.0, impact} then
    v_new = if edge(impact) then -e*pre(v) else 0;
    flying = v_new > 0;
    reinit(v, v_new);
  end when;
  annotation(
    Documentation(figures = {Figure(title = "Bouncing ball", preferred = true, plots␣
↪= {Plot(curves = {Curve(y = h, legend = "Height of ball")})})}, info = "<html><head>
↪</head><body>Adeel Asghar</body></html>"));
end BouncingBall;
```

Instead of just giving a simulate and plot command, we perform a runScript command on a .mos (Modelica script) file sim_BouncingBall.mos that contains these commands:

```
>>> writeFile("sim_BouncingBall.mos", "
  loadFile(getInstallationDirectoryPath() + \"/share/doc/omc/testmodels/BouncingBall.
↪mo\");
  simulate(BouncingBall, stopTime=3.0);
  /* plot({h,flying}); */
")
true
>>> runScript("sim_BouncingBall.mos")
"true
record SimulationResult
    resultFile = \"«DOCHOME»/BouncingBall_res.mat\",
    simulationOptions = \"startTime = 0.0, stopTime = 3.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'BouncingBall', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''\",
    messages = \"LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
```

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```
\",
    timeFrontend = 0.002856575,
    timeBackend = 0.008251762000000001,
    timeSimCode = 0.002352929,
    timeTtemplates = 0.0046011210000000006,
    timeCompile = 0.46652073600000005,
    timeSimulation = 0.017575919000000002,
    timeTotal = 0.502244719
end SimulationResult;
"
```

```
model Switch
  Real v;
  Real i;
  Real i1;
  Real itot;
  Boolean open;
equation
  itot = i + i1;
  if open then
    v = 0;
  else
    i = 0;
  end if;
  1 - i1 = 0;
  1 - v - i = 0;
  open = time >= 0.5;
end Switch;
```

```
>>> simulate(Switch, startTime=0, stopTime=1)
record SimulationResult
    resultFile = "«DOCHOME»/Switch_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 1.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'Switch', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.003844679,
    timeBackend = 0.021287569999999922,
    timeSimCode = 0.0028731670000000003,
    timeTemplates = 0.004047862,
    timeCompile = 0.43149130500000005,
    timeSimulation = 0.010514418000000001,
    timeTotal = 0.474157975
end SimulationResult;
```

Retrieve the value of itot at time=0 using the val(variableName, time) function:

```
>>> val(itot,0)
1.0
```

Plot itot and open:

We note that the variable open switches from false (0) to true (1), causing itot to increase from 1.0 to 2.0.

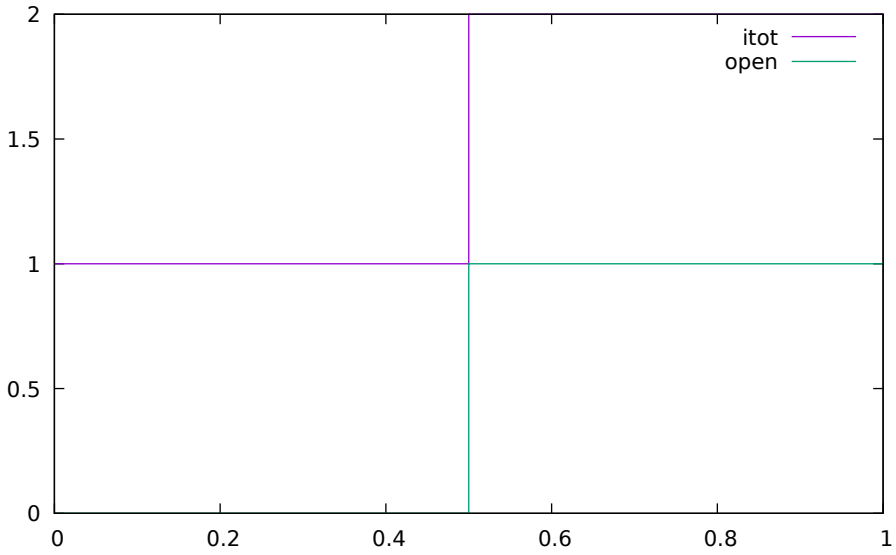



Figure 1.2: Plot when the switch opens

### 1.2.8 Clear All Models

Now, first clear all loaded libraries and models:

```
>>> clear()
true
```

List the loaded models - nothing left:

```
>>> list()
""
```

### 1.2.9 VanDerPol Model and Parametric Plot

We load another model, the VanDerPol model (or via the menu File->Load Model):

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/VanDerPol.mo
↪")
true
```

It is simulated:

```
>>> simulate(VanDerPol, stopTime=80)
record SimulationResult
    resultFile = "«DOCHOME»/VanDerPol_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 80.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'VanDerPol', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.0030831390000000004,
    timeBackend = 0.020641635000000002,
    timeSimCode = 8.96871e-4,
    timeTemplates = 0.00321206,
    timeCompile = 0.437290588,
```

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```
    timeSimulation = 0.011619634,
    timeTotal = 0.476889531
end SimulationResult;
```

It is plotted:

```
>>> plotParametric("x","y")
```

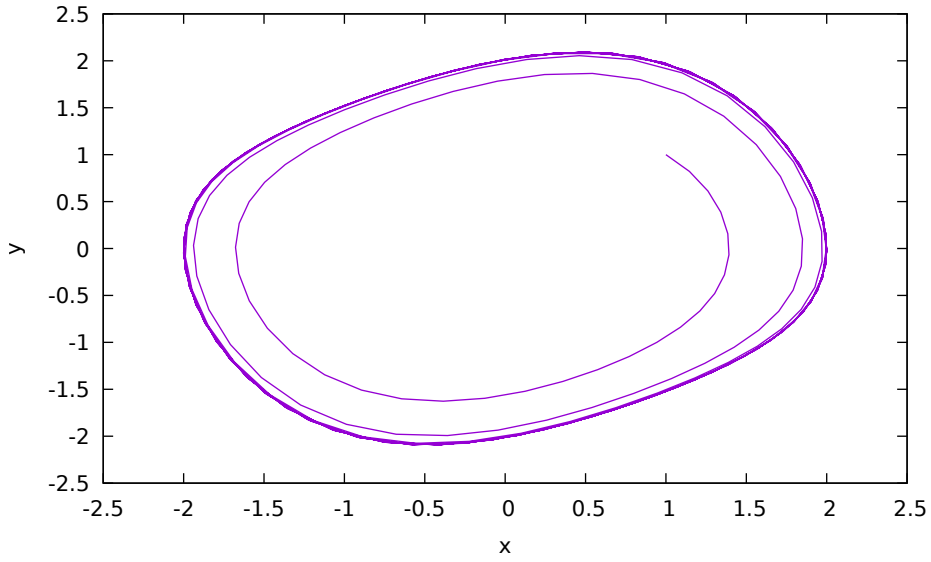


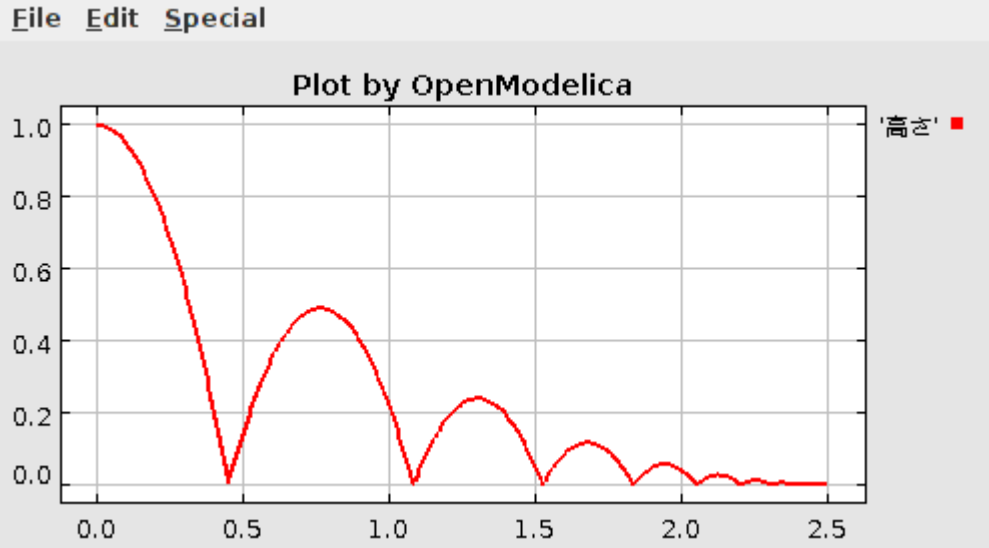

Figure 1.3: VanDerPol plotParametric(x,y)

Perform code instantiation to flat form of the VanDerPol model:

```
>>> instantiateModel(VanDerPol)
class VanDerPol "Van der Pol oscillator model"
  Real x(start = 1.0, fixed = true);
  Real y(start = 1.0, fixed = true);
  parameter Real lambda = 0.3;
equation
  der(x) = y;
  der(y) = lambda * (1.0 - x * x) * y - x;
end VanDerPol;
```

### 1.2.10 Using Japanese or Chinese Characters

Japenese, Chinese, and other kinds of UniCode characters can be used within quoted (single quote) identifiers, see for example the variable name to the right in the plot below:




### 1.2.11 Scripting with For-Loops, While-Loops, and If-Statements

A simple summing integer loop (using multi-line input without evaluation at each line into OMShell requires copy-paste as one operation from another document):

```
>>> k := 0;
>>> for i in 1:1000 loop
  k := k + i;
end for;
>>> k
500500
```

A nested loop summing reals and integers:

```
>>> g := 0.0;
>>> h := 5;
>>> for i in {23.0,77.12,88.23} loop
  for j in i:0.5:(i+1) loop
    g := g + j;
    g := g + h / 2;
  end for;
  h := h + g;
end for;
```

By putting two (or more) variables or assignment statements separated by semicolon(s), ending with a variable, one can observe more than one variable value:

```
>>> h; g
1997.4500000000003
1479.0900000000001
```

A for-loop with vector traversal and concatenation of string elements:

```
>>> i:="";
>>> lst := {"Here ", "are ","some ","strings."};
>>> s := "";
>>> for i in lst loop
  s := s + i;
end for;
```

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```
>>> s
"Here are some strings."
```

Normal while-loop with concatenation of 10 "abc " strings:

```
>>> s:="";
>>> i:=1;
>>> while i<=10 loop
  s:="abc "+s;
  i:=i+1;
end while;
>>> s
"abc abc abc abc abc abc abc abc abc abc "
```

A simple if-statement. By putting the variable last, after the semicolon, its value is returned after evaluation:

```
>>> if 5>2 then a := 77; end if; a
77
```

An if-then-else statement with elseif:

```
>>> if false then
  a := 5;
elseif a > 50 then
  b:= "test"; a:= 100;
else
  a:=34;
end if;
```

Take a look at the variables a and b:

```
>>> a;b
100
"test"
```

### 1.2.12 Variables, Functions, and Types of Variables

Assign a vector to a variable:

```
>>> a:=1:5
{1, 2, 3, 4, 5}
```

Type in a function:

```
function mySqr
  input Real x;
  output Real y;
algorithm
  y:=x*x;
end mySqr;
```

Call the function:

```
>>> b:=mySqr(2)
4.0
```

Look at the value of variable a:

```
>>> a
{1, 2, 3, 4, 5}
```

Look at the type of a:

```
>>> typeOf(a)
"Integer[5]"
```

Retrieve the type of b:

```
>>> typeOf(b)
"Real"
```

What is the type of mySqr? Cannot currently be handled.

```
>>> typeOf(mySqr)
```

List the available variables:

```
>>> listVariables()
{b, a, s, lst, i, h, g, k, currentSimulationResult}
```

Clear again:

```
>>> clear()
true
```

### 1.2.13 Getting Information about Error Cause

Call the function getErrorString() in order to get more information about the error cause after a simulation failure:

```
>>> getErrorString()
""
```

### 1.2.14 Alternative Simulation Output Formats

There are several output format possibilities, with mat being the default. plt and mat are the only formats that allow you to use the val() or plot() functions after a simulation. Compared to the speed of plt, mat is roughly 5 times for small files, and scales better for larger files due to being a binary format. The csv format is roughly twice as fast as plt on data-heavy simulations. The plt format allocates all output data in RAM during simulation, which means that simulations may fail due applications only being able to address 4GB of memory on 32-bit platforms. Empty does no output at all and should be by far the fastest. The csv and plt formats are suitable when using an external scripts or tools like gnuplot to generate plots or process data. The mat format can be post-processed in MATLAB or Octave.

```
>>> simulate(... , outputFormat="mat")
>>> simulate(... , outputFormat="csv")
>>> simulate(... , outputFormat="plt")
>>> simulate(... , outputFormat="empty")
```

It is also possible to specify which variables should be present in the result-file. This is done by using POSIX Extended Regular Expressions. The given expression must match the full variable name (^ and $ symbols are automatically added to the given regular expression).

// Default, match everything

```
>>> simulate(... , variableFilter=".*")
```

// match indices of variable myVar that only contain the numbers using combinations

// of the letters 1 through 3

```
>>> simulate(... , variableFilter="myVar\\\[[1-3]*\\\]")
```

// match x or y or z

```
>>> simulate(... , variableFilter="x|y|z")
```

### 1.2.15 Using External Functions

See Chapter *Interoperability - C and Python* for more information about calling functions in other programming languages.

### 1.2.16 Using Parallel Simulation via OpenMP Multi-Core Support

Faster simulations on multi-core computers can be obtained by using a new OpenModelica feature that automatically partitions the system of equations and schedules the parts for execution on different cores using shared-memory OpenMP based execution. The speedup obtained is dependent on the model structure, whether the system of equations can be partitioned well. This version in the current OpenModelica release is an experimental version without load balancing. The following command, not yet available from the OpenModelica GUI, will run a parallel simulation on a model:

```
>>> omc -d=openmp model.mo
```

### 1.2.17 Loading Specific Library Version

There exist many different versiosn of Modelica libraries which are not compatible. It is possible to keep multiple versions of the same library stored in the directory given by calling getModelicaPath(). By calling loadModel(Modelica,{"3.2"}), OpenModelica will search for a directory called "Modelica 3.2" or a file called "Modelica 3.2.mo". It is possible to give several library versions to search for, giving preference for a pre-release version of a library if it is installed. If the searched version is "default", the priority is: no version name (Modelica), main release version (Modelica 3.1), pre-release version (Modelica 3.1Beta 1) and unordered versions (Modelica Special Release).

The loadModel command will also look at the uses annotation of the top-level class after it has been loaded. Given the following package, Complex 1.0 and ModelicaServices 1.1 will also be loaded into the AST automatically.

```
package Modelica
  annotation(uses(Complex(version="1.0"),
  ModelicaServices(version="1.1")));
end Modelica;
```

**Note**

Notification: Automatically loaded package Complex 4.1.0 due to uses annotation from Modelica.

Notification: Automatically loaded package ModelicaServices 4.1.0 due to uses annotation from Modelica.

```
>>> clear()
true
```

Packages will also be loaded if a model has a uses-annotation:

```
model M
  annotation(uses(Modelica(version="3.2.1")));
end M;
```

**Note**

Notification: Automatically loaded package Modelica 4.1.0 due to uses annotation from M.

Notification: Automatically loaded package Complex 4.1.0 due to uses annotation from Modelica.

Notification: Automatically loaded package ModelicaServices 4.1.0 due to uses annotation from Modelica.

```
>>> instantiateModel(M)
class M
end M;
```

Packages will also be loaded by looking at the first identifier in the path:

```
>>> instantiateModel(Modelica.Electrical.Analog.Basic.Ground)
class Modelica.Electrical.Analog.Basic.Ground "Ground node"
  Real p.v(quantity = "ElectricPotential", unit = "V") "Potential at the pin";
  Real p.i(quantity = "ElectricCurrent", unit = "A") "Current flowing into the pin";
equation
  p.i = 0.0;
  p.v = 0.0;
end Modelica.Electrical.Analog.Basic.Ground;
```

**Note**

Notification: Automatically loaded package Complex 4.1.0 due to uses annotation from Modelica.

Notification: Automatically loaded package ModelicaServices 4.1.0 due to uses annotation from Modelica.

Notification: Automatically loaded package Modelica default due to usage.

### 1.2.18 Calling the Model Query and Manipulation API

In the OpenModelica System Documentation, an external API (application programming interface) is described which returns information about models and/or allows manipulation of models. Calls to these functions can be done interactively as below, but more typically by program clients to the OpenModelica Compiler (OMC) server. Current examples of such clients are the OpenModelica MDT Eclipse plugin, OMNotebook, the OMEdit graphic model editor, etc. This API is untyped for performance reasons, i.e., no type checking and minimal error checking is done on the calls. The results of a call is returned as a text string in Modelica syntax form, which the client has to parse. An example parser in C++ is available in the OMNotebook source code, whereas another example parser in Java is available in the MDT Eclipse plugin.

Below we show a few calls on the previously simulated BouncingBall model. The full documentation on this API is available in the system documentation. First we load and list the model again to show its structure:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo");
>>> list(BouncingBall)
model BouncingBall
  parameter Real e = 0.7 "coefficient of restitution";
```

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```
  parameter Real g = 9.81 "gravity acceleration";
  Real h(fixed = true, start = 1) "height of ball";
  Real v(fixed = true) "velocity of ball";
  Boolean flying(fixed = true, start = true) "true, if ball is flying";
  Boolean impact;
  Real v_new(fixed = true);
  Integer foo;
equation
  impact = h <= 0.0;
  foo = if impact then 1 else 2;
  der(v) = if flying then -g else 0;
  der(h) = v;
  when {h <= 0.0 and v <= 0.0, impact} then
    v_new = if edge(impact) then -e*pre(v) else 0;
    flying = v_new > 0;
    reinit(v, v_new);
  end when;
  annotation(
    Documentation(figures = {Figure(title = "Bouncing ball", preferred = true, plots␣
↪= {Plot(curves = {Curve(y = h, legend = "Height of ball")})})}, info = "<html><head>
↪</head><body>Adeel Asghar</body></html>"));
end BouncingBall;
```

Different kinds of calls with returned results:

```
>>> getClassRestriction(BouncingBall)
"model"
>>> getClassInformation(BouncingBall)
("model", "", false, false, false, "/var/lib/jenkins/ws/OpenModelica/build/share/doc/
↪omc/testmodels/BouncingBall.mo", false, 1, 1, 24, 17, {}, false, false, "", "",␣
↪false, "", "", "", "", "")
>>> isFunction(BouncingBall)
false
>>> existClass(BouncingBall)
true
>>> getComponents(BouncingBall)
{{Real, e, "coefficient of restitution", "public", false, false, false, false,
↪"parameter", "none", "unspecified", {}}, {Real, g, "gravity acceleration", "public",
↪ false, false, false, false, "parameter", "none", "unspecified", {}}, {Real, h,
↪"height of ball", "public", false, false, false, false, "unspecified", "none",
↪"unspecified", {}}, {Real, v, "velocity of ball", "public", false, false, false,␣
↪false, "unspecified", "none", "unspecified", {}}, {Boolean, flying, "true, if ball␣
↪is flying", "public", false, false, false, false, "unspecified", "none",
↪"unspecified", {}}, {Boolean, impact, "", "public", false, false, false, false,
↪"unspecified", "none", "unspecified", {}}, {Real, v_new, "", "public", false, false,
↪ false, false, "unspecified", "none", "unspecified", {}}, {Integer, foo, "", "public
↪", false, false, false, false, "unspecified", "none", "unspecified", {}}}
>>> getConnectionCount(BouncingBall)
0
>>> getInheritanceCount(BouncingBall)
0
>>> getComponentModifierValue(BouncingBall,e)
"0.7"
>>> getComponentModifierNames(BouncingBall,"e")
{}
>>> getClassRestriction(BouncingBall)
```

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```
"model"
>>> getVersion() // Version of the currently running OMC
"v1.28.0-dev.1529+gaef66789a3.cmake"
```

### 1.2.19 Quit OpenModelica

Leave and quit OpenModelica:

```
>>> quit()
```

### 1.2.20 Dump XML Representation

The command dumpXMLDAE dumps an XML representation of a model, according to several optional parameters.

dumpXMLDAE(*modelname*[,asInSimulationCode=<Boolean>] [,filePrefix=<String>] [,storeInTemp=<Boolean>] [,addMathMLCode =<Boolean>])

This command dumps the mathematical representation of a model using an XML representation, with optional parameters. In particular, asInSimulationCode defines where to stop in the translation process (before dumping the model), the other options are relative to the file storage: filePrefix for specifying a different name and storeInTemp to use the temporary directory. The optional parameter addMathMLCode gives the possibility to don't print the MathML code within the xml file, to make it more readable. Usage is trivial, just: addMathMLCode=*true/false* (default value is false).

### 1.2.21 Dump Matlab Representation

The command export dumps an XML representation of a model, according to several optional parameters.

exportDAEtoMatlab(*modelname*);

This command dumps the mathematical representation of a model using a Matlab representation. Example:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
true
>>> exportDAEtoMatlab(BouncingBall)
"The equation system was dumped to Matlab file:BouncingBall_imatrix.m"
```

```
% Adjacency Matrix
% ===================================
% number of rows: 6
IM={{3,6},{1,{'if', 'true','==' {3},{},}},{{'if', 'true','==' {4},{},}},{5},{2,{'if',
↪'edge(impact)' {3},{5},}},{4,2}};
VL = {'foo','v_new','impact','flying','v','h'};


EqStr = {'impact = h <= 0.0;','foo = if impact then 1 else 2;','der(v) = if flying␣
↪then -g else 0.0;','der(h) = v;','when {h <= 0.0 and v <= 0.0, impact} then v_new =␣
↪if edge(impact) then (-e) * pre(v) else 0.0; end when;','when {h <= 0.0 and v <= 0.
↪0, impact} then flying = v_new > 0.0; end when;'};


OldEqStr={'class BouncingBall','  parameter Real e = 0.7 "coefficient of restitution";
↪','  parameter Real g = 9.81 "gravity acceleration";','  Real h(start = 1.0, fixed␣
↪= true) "height of ball";','  Real v(fixed = true) "velocity of ball";','  Boolean␣
↪flying(start = true, fixed = true) "true, if ball is flying";','  Boolean impact;',
↪'  Real v_new(fixed = true);','  Integer foo;','equation','  impact = h <= 0.0;',' ␣
↪foo = if impact then 1 else 2;','  der(v) = if flying then -g else 0.0;','  der(h)␣
```

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```
↪= v;','  when {h <= 0.0 and v <= 0.0, impact} then','    v_new = if edge(impact)␣
↪then -e * pre(v) else 0.0;','    flying = v_new > 0.0;','    reinit(v, v_new);',' ␣
↪end when;','end BouncingBall;',''};
```

## 1.3 Summary of Commands for the Interactive Session Handler

The following is the complete list of commands currently available in the interactive session hander.

simulate(*modelname*) Translate a model named *modelname* and simulate it.

simulate(*modelname*[,startTime=<*Real*>][,stopTime=<*Real*>][,numberOfIntervals =<*Integer*>][,outputInterval=<*Real*>][,method=<*String*>] [,tolerance=<*Real*>][,fixedStepSize=<*Real*>] [,outputFormat=<*String*>]) Translate and simulate a model, with optional start time, stop time, and optional number of simulation intervals or steps for which the simulation results will be computed. More intervals will give higher time resolution, but occupy more space and take longer to compute. The default number of intervals is 500. It is possible to choose solving method, default is "dassl", "cvode", gbode and "euler" are also available. Output format "mat" is default. "plt" and "mat" (MATLAB) are the only ones that work with the val() command, "csv" (comma separated values) and "empty" (no output) are also available (see section *Alternative Simulation Output Formats*).

plot(*vars*) Plot the variables given as a vector or a scalar, e.g. plot({x1,x2}) or plot(x1).

plotParametric(*var1*, *var2*) Plot var2 relative to var1 from the most recently simulated model, e.g. plotParametric(x,y).

cd() Return the current directory.

cd(*dir*) Change directory to the directory given as string.

clear() Clear all loaded definitions.

clearVariables() Clear all defined variables.

dumpXMLDAE(*modelname*, ...) Dumps an XML representation of a model, according to several optional parameters.

exportDAEtoMatlab(*name*) Dumps a Matlab representation of a model.

instantiateModel(*modelname*)Performs code instantiation of a model/class and return a string containing the flat class definition.

list() Return a string containing all loaded class definitions.

list(*modelname*) Return a string containing the class definition of the named class.

listVariables() Return a vector of the names of the currently defined variables.

loadModel(*classname*) Load model or package of name *classname* from the path indicated by the environment variable OPENMODELICALIBRARY.

loadFile(*str*) Load Modelica file (.mo) with name given as string argument *str*.

readFile(*str*) Load file given as string *str* and return a string containing the file content.

runScript(*str*) Execute script file with file name given as string argument *str*.

system(*str*) Execute *str* as a system(shell) command in the operating system; return integer success value. Output into stdout from a shell command is put into the console window.

timing(*expr*) Evaluate expression *expr* and return the number of seconds (elapsed time) the evaluation took.

typeOf(*variable*) Return the type of the *variable* as a string.

saveModel(*str*,*modelname*) Save the model/class with name *modelname* in the file given by the string argument *str*.

val(*variable*,*timePoint*) Return the (interpolated) value of the *variable* at time *timePoint*.

help() Print this helptext (returned as a string).

quit() Leave and quit the OpenModelica environment

## 1.4 Running the compiler from command line

The OpenModelica compiler can also be used from command line, in Windows cmd.exe or a Unix shell. The following examples assume omc is on the PATH; if it is not, you can run `C:\OpenModelica 1.16.0\build\bin\omc.exe` or similar (depending on where you installed OpenModelica).

### 1.4.1 Example Session 1 - obtaining information about command line parameters

```
$ omc --help
OpenModelica Compiler v1.28.0-dev.1529+gaef66789a3.cmake
Copyright © 2019 Open Source Modelica Consortium (OSMC)
Distributed under OSMC-PL and AGPL3, see www.openmodelica.org

Usage: omc [Options] (Model.mo | Script.mos) [Libraries | .mo-files]
* Libraries: Fully qualified names of libraries to load before processing Model or␣
↪Script.
...
Documentation is available in the built-in package OpenModelica.Scripting or
online <https://build.openmodelica.org/Documentation/OpenModelica.Scripting.html>.
```

### 1.4.2 Example Session 2 - create an TestModel.mo file and run omc on it

```
model TestModel
  parameter Real x = 1;
end TestModel;
```

```
$ omc TestModel.mo
class TestModel
  parameter Real x = 1.0;
end TestModel;
```

### 1.4.3 Example Session 3 - create a mos-script and run omc on it

```
loadModel(Modelica);
getErrorString();
simulate(Modelica.Mechanics.MultiBody.Examples.Elementary.Pendulum);
getErrorString();
```

```
$ omc TestScript.mos
true
""
record SimulationResult
    resultFile = "/var/lib/jenkins/ws/OpenModelica/build_usersguide/source/Modelica.
↪Mechanics.MultiBody.Examples.Elementary.Pendulum_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 5.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'Modelica.Mechanics.MultiBody.
```

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```
↪Examples.Elementary.Pendulum', options = '', outputFormat = 'mat', variableFilter =
↪'.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.086856976,
    timeBackend = 0.378280842,
    timeSimCode = 0.042834799,
    timeTemplates = 0.051615633,
    timeCompile = 0.642372856,
    timeSimulation = 0.043772317000000005,
    timeTotal = 1.245852689
end SimulationResult;
""
```

In order to obtain more information from the compiler one can use the command line options **--showErrorMessages -d=failtrace** when running the compiler:

```
$ omc --showErrorMessages -d=failtrace TestScript.mos
InstFunction.getRecordConstructorFunction failed for OpenModelica.Scripting.loadModel
- Static.elabCrefSubs failed on: [top:<Prefix.NOPRE()>].<Prefix.NOPRE()>.Modelica␣
↪env: <global scope>
- Static.elabCref failed: Modelica in env: <global scope>
- Static.elabCrefSubs failed on: [top:<Prefix.NOPRE()>].<Prefix.NOPRE()>.Modelica␣
↪env: <global scope>
...
    timeTotal = 1.2642043520000001
end SimulationResult;
"[/var/lib/jenkins/ws/OpenModelica/OMCompiler/Compiler/BackEnd/ExpressionSolve.
↪mo:314:9-314:216:writable] Error: Internal error Failed to solve \"world.z_label.
↪cylinders[2].lengthDirection[1] = world.z_label.cylinders[1].lengthDirection[1]\" w.
↪r.t. \"world.z_label.R_lines[1,1]\"
"
```

CHAPTER

TWO

# PACKAGE MANAGEMENT

## 2.1 Overview of Basic Modelica Package Management Concepts

The Modelica language promotes the orderly reuse of component models by means of packages that contain structured libraries of reusable models. The most prominent example is the Modelica Standard Library (MSL), that contains basic models covering many fields of engineering. Other libraries, both open-source and commercial, are available to cover specific applications domains.

When you start a simulation project using Modelica, it is common practice to collect all related system models in a project-specific package that you develop. The models in this package are often instantiated (e.g. by drag-and-drop in OMEdit) from released libraries, which are read-only for your project. This establishes a dependency between your project package and a certain version of a read-only package (or library), which is the one you have loaded in OMEdit and that you drag-and-drop components from.

This dependency is automatically marked in your package by adding a uses annotation at the top level. For example, if you drag and drop components from MSL 4.0.0 into models of your package, the `annotation(uses(Modelica(version="4.0.0")));` will be added automatically to it. This information allows OpenModelica to automatically load all the libraries that are required to compile the models in your own package next time you (or someone else, possibly on a different computer) loads your package, provided they are installed in places on the computer's file system where OpenModelica can find them.

The default place where OpenModelica looks for packages is set by environment variable `OPENMODELICALIBRARY`. The variable MODELICAPATH from the language specification is ignored by OpenModelica, see *FAQ OpenModelica General*. You can check where it is by typing `getModelicaPath()` in the Interactive Environment (Tools | OpenModelica Compiler CLI in OMEdit), or by browsing the General group under Tools|Options|Libraries. Installed read-only libraries are all placed by default in the `OPENMODELICALIBRARY`.

However, when you open a package directly from the file system, OpenModelica will also look for packages it depends upon in the same directory that contains the package you just opened. For example, if you open `/home/John/ModelicaPackages/MoonShot/package.mo`, and your MoonShot package contains `annotation(uses(Rockets));`, OpenModelica will also check `/home/John/ModelicaPackages/Rockets/package.mo` and `/home/John/ModelicaPackages/Rockets.mo`. So, if you are developing several packages with dependencies among them, you can place them in the same common root directory to make sure that all the dependencies are loaded automatically, without the need of putting them in the `OPENMODELICALIBRARY`, or to change it to include that directory.

Please note that if the `uses` annotation refers to a specific version of a package, that package will only be loaded if the name of the directory or of the single file that contains it also indicates the version number, as allowed by the Modelica Specification, Section 18.8.3. For example, if MoonShot contains `annotation(uses(Rockets(version = "2.0.0"));`, OpenModelica will try to load `/home/John/ModelicaPackages/Rockets 2.0.0/package.mo` or `/home/John/ModelicaPackages/Rockets 2.0.0.mo`; in this case, packages without the version number in their root directory, such as `/home/John/ModelicaPackages/Rockets/package.mo`, will be ignored. All installed packages in the `OPENMODELICALIBRARY` include version numbers in their directory name, which also allows to install multiple versions of the same library.

When a new version of certain package comes out, conversion annotations in it declare whether your models using a certain older version of it can be used as they are with the new one, which is then 100% backwards-compatible, or whether they need to be upgraded by running a conversion script, provided with the new version

of the package. The former case is declared explicitly by a `conversion(noneFromVersion)` annotation. For example, a `conversion(noneFromVersion="3.0.0")` annotation in version `3.1.0` of a certain package means that all packages using version `3.0.0` can use `3.1.0` without any change. Of course it is preferable to use a newer, backwards-compatible version, as it contains bugfixes and possibly new features.

Hence, if you install a new version of a library which is 100% backwards-compatible with the previous ones, all your models that used the old one will automatically load and use the new one, without the need of any further action.

If the new version is not backwards-compatible, instead, you will need to create a new version of your library that uses it, by running the provided conversion scripts.

OpenModelica has a package manager that can be used to install and update libraries on your computer, and is able to run conversion scripts. Keep in mind there are three stages in package usage: *available* packages are indexed on the OSMC servers and can be downloaded from public repositories; *installed* packages are stored in the `OPENMODELICALIBRARY` of your computer; *loaded* packages are loaded in memory in an active OMC session, either via the Interactive Environment, or via the OMEdit GUI, where they are shown in the Libraries Browser. When you load a package, OpenModelica tries to load the best possible installed versions of all the dependencies declared in the uses annotation.

## 2.2 The Package Manager

The Open Source Modelica Consortium (OSMC) maintains a collection of publicly available, open-source Modelica libraries on its servers, see https://github.com/OpenModelica/OMPackageManager. These libraries are routinely tested with past released versions of OpenModelica, as well as with the current development version on the master branch, see the overview report. Based on the testing results and on information gathered from the library developers, these packages are classified in terms of level of support in OpenModelica. Backwards-compatibility information is also collected from the conversion annotations.

The OpenModelica Package Manager relies on this information to install the best versions of the library dependencies of your own, locally developed Modelica packages and models. It can be run both from the OMEdit GUI and from the command-line interactive environment. The libraries and their `index.json` index file with all the library metadata are installed in the `~/.openmodelica/libraries` directory under Linux and in the `%AppData%\.openmodelica\libraries` directory on Windows. Note that these directories are user-specific, so if there are multiple users on the same computer, each of them will install and manage his/her own set of libraries independently from the others.

The Package Manager may install multiple builds of the same library version in your own package manager directory, if they are indexed on the OSMC servers. When this happens, they are distinguished among each other by means of semver-style pre- or post-release metadata in the top directory name on the file system. Post-release builds are denoted by a plus sign (e.g. `2.0.0+build.02`) and have higher priority over the corresponding plain release (e.g. `2.0.0`), while pre-release builds are denoted by a minus sign (e.g. `2.0.0-dev.30`) and have a lower priority.

When loading a certain version of a library, unless a specific build is explicitly referenced, the one with higher precedence will always be loaded. For example, if the versions `2.0.0-beta.01`, `2.0.0`, and `2.0.0+build.01` are installed, the latter is loaded by libraries with uses annotation requiring version `2.0.0`. Unless, of course, there are later backwards-compatible versions installed, e.g., `2.0.1`, in which case the one with the highest release number and priority is installed.

In any case, semver version semantics is only used to order the releases, while backwards-compatibility is determined exclusively on the basis of `noneFromVersion` annotations.

When installing OpenModelica, a cached version of the latest versions of the Modelica Standard Library is included in the installation files. As soon as a user starts any OpenModelica tool (e.g., OMEdit, OMNotebook, OMShell, or direct command-line invocation of omc), if the user's `.openmodelica` directory is empty the Modelica Standard Library will be installed automatically using this cached version. This happens when using OpenModelica for the first time, or if the contents of the `.openmodelica` directory have been deleted to get rid of all installed libraries. This automatic installation needs no Internet connection, so it also works behind firewalls or in set-ups with limited available bandwidth. Therefore, the Modelica Standard Library is immediately available without the need of using

the package manager explicitly. It is then possible to install and manage other libraries using the package manager, as explained previously.

As a final remark, please note that the version numbers of the various Modelica packages have no relation with the version numbers of the OpenModelica tool itself. Since version 1.19.0, OpenModelica is no longer shipped with built-in installed libraries, that are instead managed independently by the user with the online Package Manager. You can install and use old and new versions of a certain open source Modelica library using the latest released version of OpenModelica, by using the Package Manager. We strive to make sure that new released versions of OpenModelica are backwards-compatible, meaning that you should always be able to run the same models/libraries with a new version of OpenModelica if you could with an older version of the tool. Hence, we strongly advise you to always use the latest released version of OpenModelica, even if you are running old models; by doing so, you benefit from faster performance, more robust numerical performance, new tool features, and a lot of bug fixes.

You should never find yourself in a situation where you are forced to stick to an old version of OpenModelica to run your models. If that happens to you, please open a ticket on the issue tracker, so we can hopefully fix the problem and allow you to keep using the latest OpenModelica release.

### 2.2.1 Package Management in OMEdit

*Installing a new library in OMEdit*.

### 2.2.2 Running Conversion Scripts in OMEdit

*Converting a library in OMEdit*.

### 2.2.3 Automatically Loaded Packages in OMEdit

When you start OMEdit, some packages can be automatically loaded into the environment, and shown in the Libraries Browser. You can configure which ones are loaded from the Tools|Options|Libraries menu.

Please note that automatically loaded libraries may be in conflict with the dependencies of packages that you may later load from the File menu. For example, if you automatically load Modelica `4.0.0`, and then load a library XYZ that still uses MSL `3.2.3`, you get a conflict, because Modelica `4.0.0` is not backwards-compatible with Modelica `3.2.3`, so XYZ cannot be used.

In this case you have two options:

- Cancel Operation: this means XYZ is not actually loaded, and all previously loaded libraries remain in place.
- Unload all and Reload XYZ: in this case, all previously loaded libraries, that may generate conflicts, are unloaded first; then XYZ is loaded, and finally the right versions of the libraries XYZ uses, as declared in its `uses` annotation, will be loaded automatically.

If you are normally working with only one version of the Modelica standard library, you can set it to be automatically loaded from the Tools|Options|Libraries menu; in case you need to work with a library that uses a previous, non-backwards compatible version, the Unload all and Reload option comes handy. Otherwise, you can avoid loading the Modelica library automatically upon starting OMEdit, and let the right version of the Modelica library be loaded automatically when you open the library you want to work with. In this case, if you want to get the Modelica library into the Package Browser to start developing a new library, you can do so easily from the Welcome tab, by clicking on the System Libraries button and selecting the version that you want to load.

### 2.2.4 Manually Loading Packages

If you want to maintain full control over which library dependencies are loaded, you can use the File | Open Model/Library Files(s) menu command in OMEdit to open the libraries one by one from specific locations in your file system. Note, however, that whenever a library is loaded, its dependencies, that are declared in its `uses` annotation, will automatically be loaded. If you want to avoid that, you need to load the library dependencies in reverse order, so that the intended library dependencies are already loaded when you open the library that needs them.

If you are using the Interactive Environment, you can use the `loadFile()` command to load libraries from specific locations on the file system, also in reverse dependency order, unless you also set the optional `uses = false` input argument to disable the automatic loading of dependencies.

### 2.2.5 Using the Package Manager from the Interactive Environment

The Package Manager can also be used from the Interactive Environment command line shell. Here is a list of examples of relevant commands; please type them followed by *getErrorString()*, e.g., *updatePackageIndex()*; *getErrorString()*, in order to get additional information, notifications and error messages.

- *updatePackageIndex()* - this command puts the Package Manager in contact with the OSMC servers and updates the internally stored list of available packages;
- *getAvailablePackageVersions(Building, "")* - lists all available versions of the Buildings library on the OSMC server, starting from the most recent one, in descending order of priority. Note that pre-release versions have lower priority than all other versions;
- *getAvailablePackageVersions(Building, "7.0.0")* - lists all available versions of the Buildings library on the OSMC server that are backwards-compatible with version `7.0.0`, in descending order of priority;
- *installPackage(Buildings, "")* - install the most recent version of the Building libraries, *and all its dependencies*;
- *installPackage(Buildings, "7.0.0")* - install the most recent version of the Building libraries which is backwards-compatible with version `7.0.0`, *and all its dependencies*;
- *installPackage(Buildings, "7.0.0", exactMatch = true)* - install version `7.0.0` even if there are more recent backwards-compatible versions available, *and all its dependencies*;
- *upgradeInstalledPackages(installNewestVersions = true)* - installs the latest available version of all installed packages.

## 2.3 How the package index works

The package index is generated by OMPackageManager on an OSMC server, based on these settings. See its documentation to see how to add new packages to the index, change support level, and so on.

The index is generated by scanning git repositories on github. All tags and optionally some specific branches are scanned. The tag name is parsed as if it was a semantic version, with prerelease and metadata of the tag added to the version of Modelica packages in the repository. If the tag name is not a semantic version, it is sorted differently.

Packages are sorted as follows:

- Support level: each package is given a level of support in the index
- Semantic version: according to the semver specification, but build metadata is also considered (sorted the same way as pre-releases)
- Non-semantic versions: alphabetically

CHAPTER

THREE

# OMEDIT - OPENMODELICA CONNECTION EDITOR

OMEdit - OpenModelica Connection Editor is the new Graphical User Interface for graphical model editing in OpenModelica. It is implemented in C++ using the Qt graphical user interface library and supports the Modelica Standard Library that is included in the latest OpenModelica installation. This chapter gives a brief introduction to OMEdit and also demonstrates how to create a DCMotor model using the editor.

OMEdit provides several user friendly features for creating, browsing, editing, and simulating models:

- *Modeling* - Easy model creation for Modelica models.
- *Pre-defined models* - Browsing the Modelica Standard library to access the provided models.
- *User defined models* - Users can create their own models for immediate usage and later reuse.
- *Component interfaces* - Smart connection editing for drawing and editing connections between model interfaces.
- *Simulation* - Subsystem for running simulations and specifying simulation parameters start and stop time, etc.
- *Plotting* - Interface to plot variables from simulated models.

## 3.1 Starting OMEdit

A splash screen similar to the one shown in Figure 3.1 will appear indicating that it is starting OMEdit. The executable is found in different places depending on the platform (see below).

### 3.1.1 Microsoft Windows

OMEdit can be launched using the executable placed in OpenModelicaInstallationDirectory/bin/OMEdit/OMEdit.exe. Alternately, choose OpenModelica > OpenModelica Connection Editor from the start menu in Windows.

### 3.1.2 Linux

Start OMEdit by either selecting the corresponding menu application item or typing "**OMEdit**" at the shell or command prompt.

### 3.1.3 Mac OS X

The default installation is /Application/MacPorts/OMEdit.app.

## 3.2 MainWindow & Browsers

The MainWindow contains several dockable browsers,

- Libraries Browser
- Documentation Browser

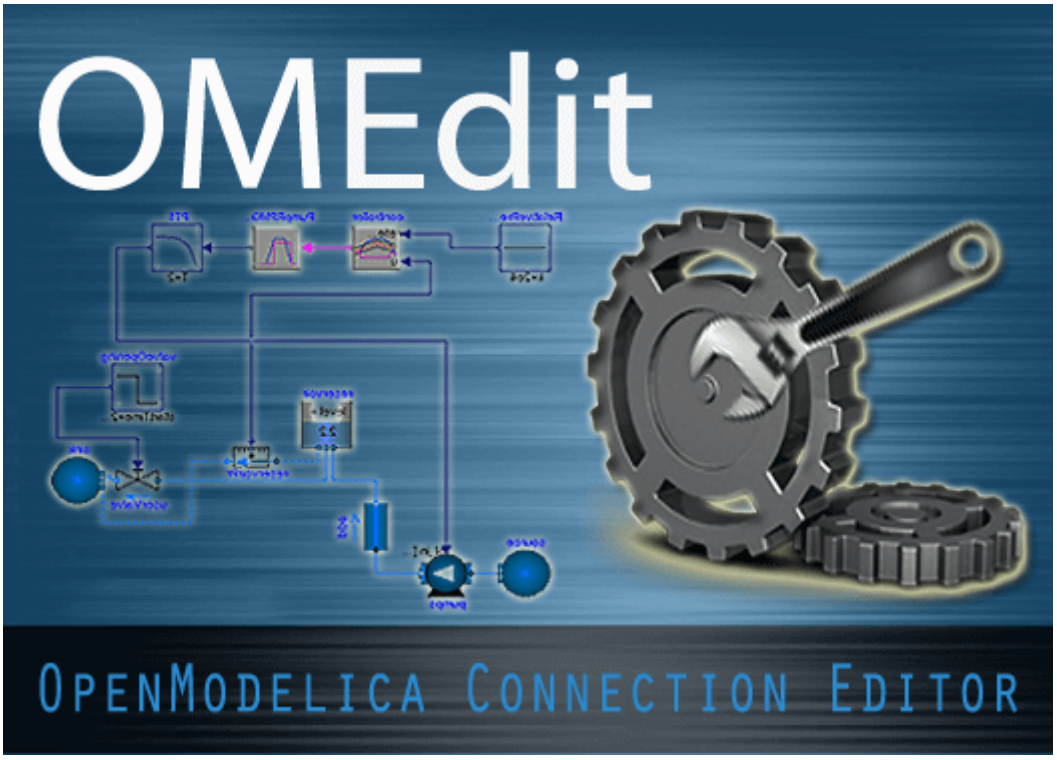



Figure 3.1: OMEdit Splash Screen.

- Variables Browser
- Messages Browser

Figure 3.2 shows the MainWindow and browsers.

The default location of the browsers are shown in Figure 3.2. All browsers except for Message Browser can be docked into left or right column. The Messages Browser can be docked into top or bottom areas. If you want OMEdit to remember the new docked position of the browsers then you must enable Preserve User's GUI Customizations option, see section *General Options*.

### 3.2.1 Filter Classes

To filter a class click Edit > Filter Classes or press keyboard shortcut Ctrl+Shift+F. The loaded Modelica classes can be filtered by typing any part of the class name.

### 3.2.2 Libraries Browser

To view the Libraries Browser click View > Windows > Libraries Browser. Shows the list of loaded Modelica classes. Each item of the Libraries Browser has right click menu for easy manipulation and usage of the class. The classes are shown in a tree structure with name and icon. The protected classes are not shown by default. If you want to see the protected classes then you must enable the Show Protected Classes option, see section *General Options*.

### 3.2.3 Documentation Browser

Displays the HTML documentation of Modelica classes. It contains the navigation buttons for moving forward and backward. It also contains a WYSIWYG editor which allows writing class documentation in HTML format. To view the Documentation Browser click View > Windows > Documentation Browser.

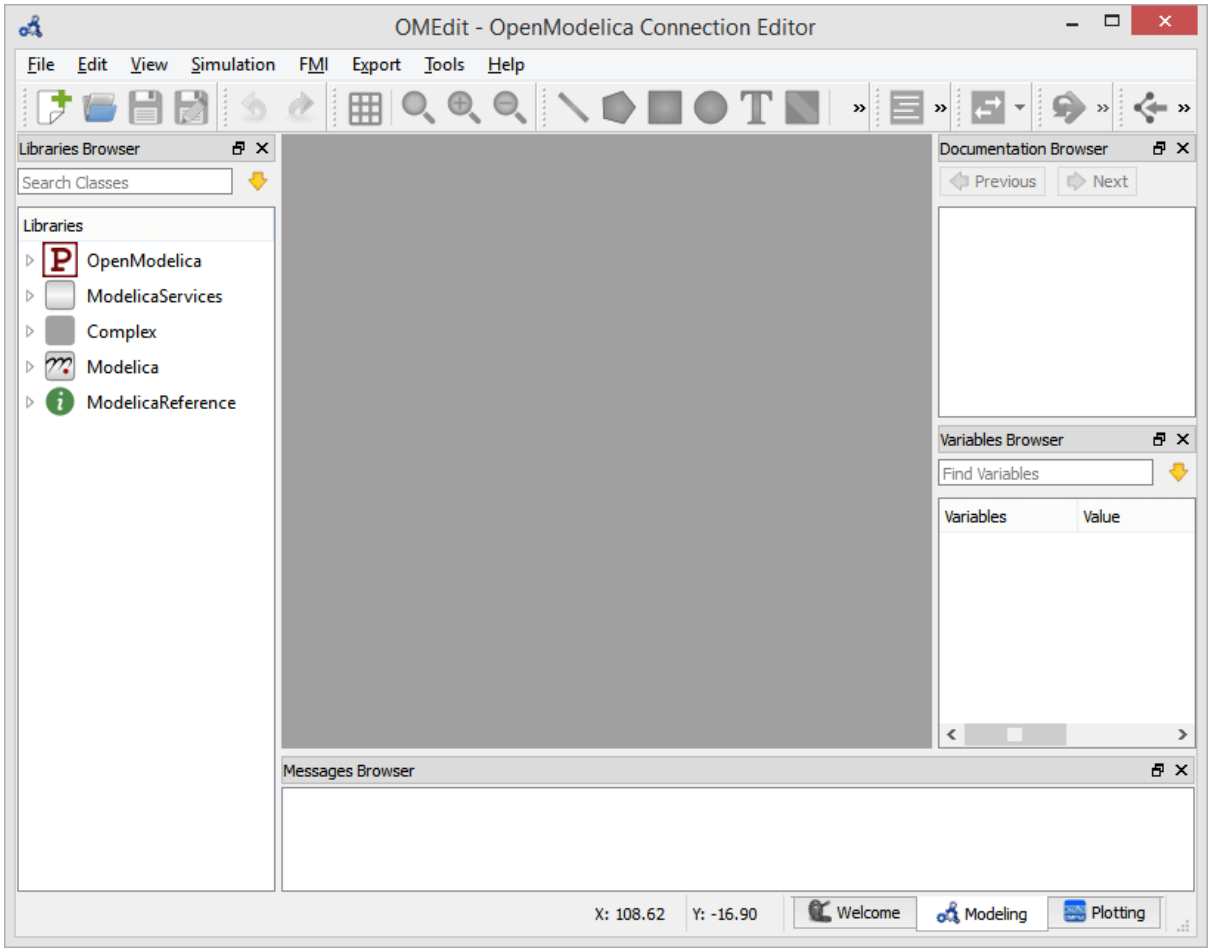



Figure 3.2: OMEdit MainWindow and Browsers.

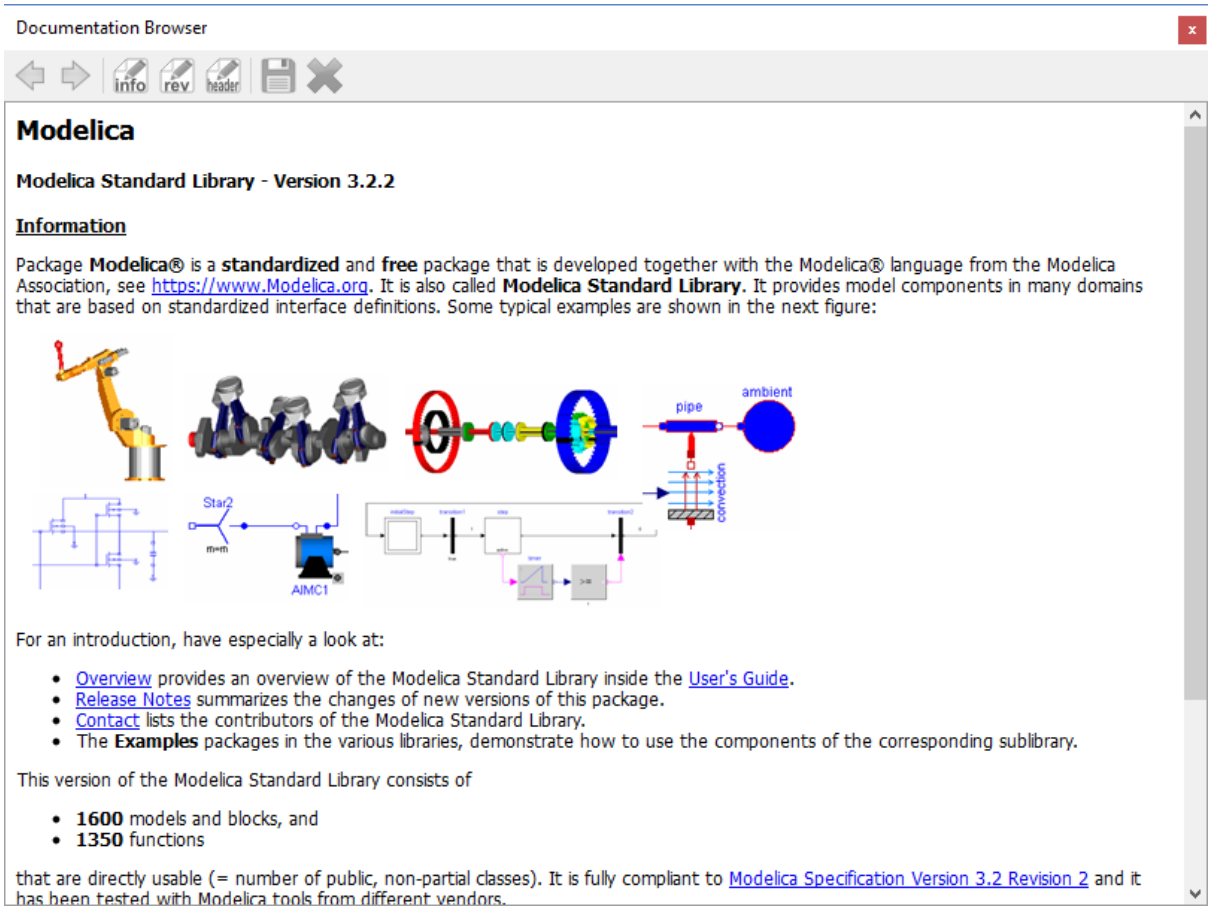



Figure 3.3: Documentation Browser.

### 3.2.4 Variables Browser

The class variables are structured in the form of the tree and are displayed in the Variables Browser. Each variable has a checkbox. Ticking the checkbox will plot the variable values. The complete Variables Browser can be collapsed and expanded using the Collapse All and Expand All buttons.

There is a find box for filtering the variable in the tree. By clicking the yellow down arrow you can set all the filtering options. The filtering can be done using Regular Expression, Wildcard and Fixed String; in all three cases, all variables whose full name *contains* a string corresponding to the filter string will be displayed.

Fixed String: shows all variables whose name contains the string verbatim

- `abc` shows `abc`, `abc.def`, `xyz.abc`, `der(abc)` etc.
- `a.b` shows `a.b`, `a.bcd`, `a.b.c`, `x.a.b`, `x.a.b.c`, etc.

Wildcard: same as Fixed String; additionally, asterisks match any number of characters

- `der(*)` shows all derivatives, e.g. `der(x)`, `der(abc)`, `abc.der(xyz)`, etc.
- `a*c` shows `ac`, `abc`, `abdc`, `xyz.adefc`, etc.

Regular expression: shows all variables whose name contain a string that matches the regexp; if the regexp ends with `$`, then the name must end with a string matching the regexp

- `abc` shows `abc`, `abc.def`, `xyz.abc`, `der(abc)` etc.
- `abc$` shows `abc`, `xyz.abc` only
- `a.c` shows `abc`, `abc.def`, `azc`, `xyz.adc` etc. (`.` matches any character)
- `a.*c` shows `abc`, `abc.def`, `axyc`, `xyz.axxxxdc` etc. (`.*` matches any number of character)
- `body\.a_0\[1\]` shows variables containing `body.a_0[1]`. Note that `.`, `[`, and `]` are special regexp characters, so they must be escaped
- `der\(.*\)` shows all derivatives in the model. Note that `(` and `)` must be escaped
- `x\[[2-4]\]` shows elements 2, 3, and 4 of arrays `x[:]`, `abc.x[:]`, `x[:].abc`
- `x\[.*\]` shows all elements of arrays `x[:]`, `abc.x[:]`, `x[:].abc`
- `abc|def` shows all variables with names containing either `abc` or `def`

The browser allows manipulation of changeable parameters for *Plot Window*. It also displays the unit and description of the variable.

The browser also contains the slider and animation buttons. These controls are used for variable graphics and schematic animation of models i.e., DynamicSelect annotation. They are also used for debugging of state machines. Open the *Diagram Window* for animation. It is only possible to animate one model at a time.

### 3.2.5 Messages Browser

Shows the list of errors. Following kinds of error can occur,

- Syntax
- Grammar
- Translation
- Symbolic
- Simulation
- Scripting

See section *Messages Options* for Messages Browser options.

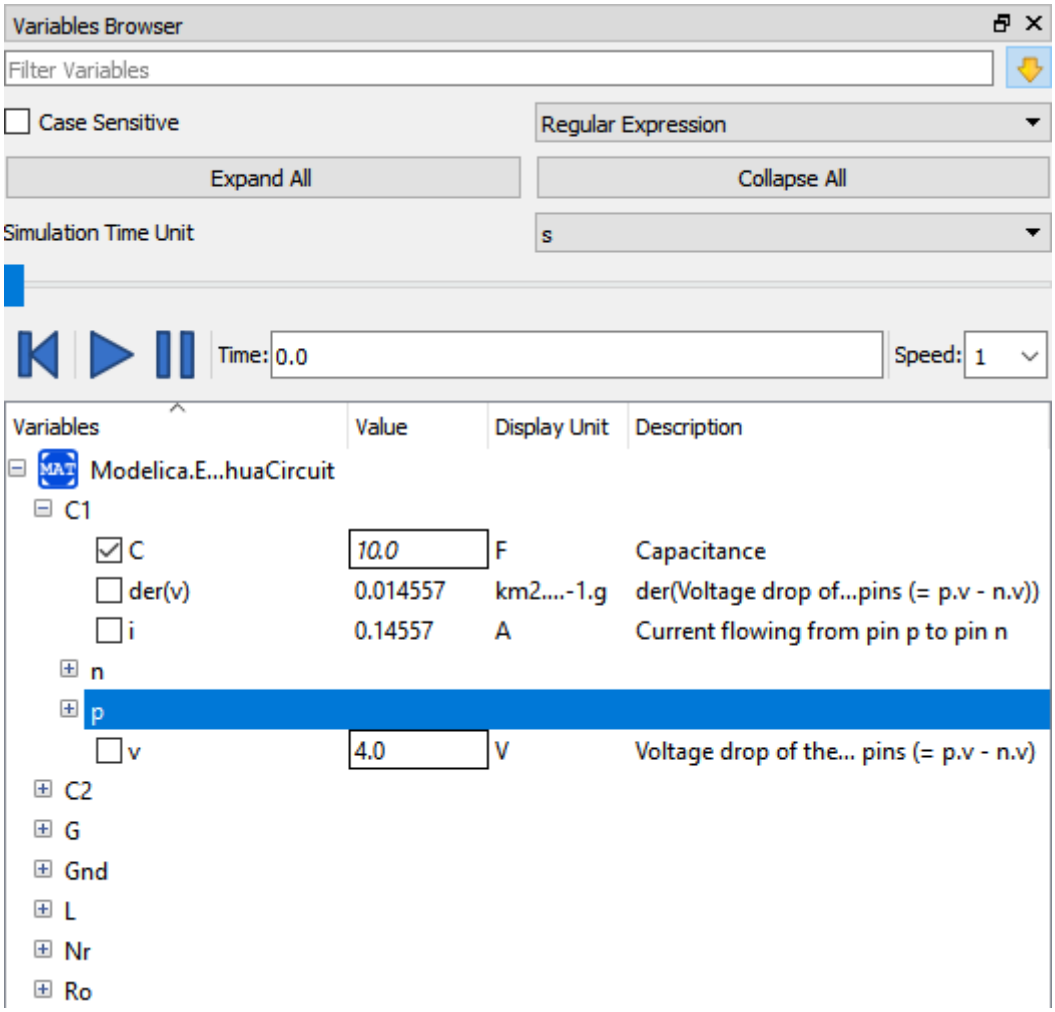



Figure 3.4: Variables Browser.

## 3.3 Perspectives

The perspective tabs are located at the bottom right of the Main Window:

- Welcome Perspective
- Modeling Perspective
- Plotting Perspective
- Debugging Perspective

### 3.3.1 Welcome Perspective

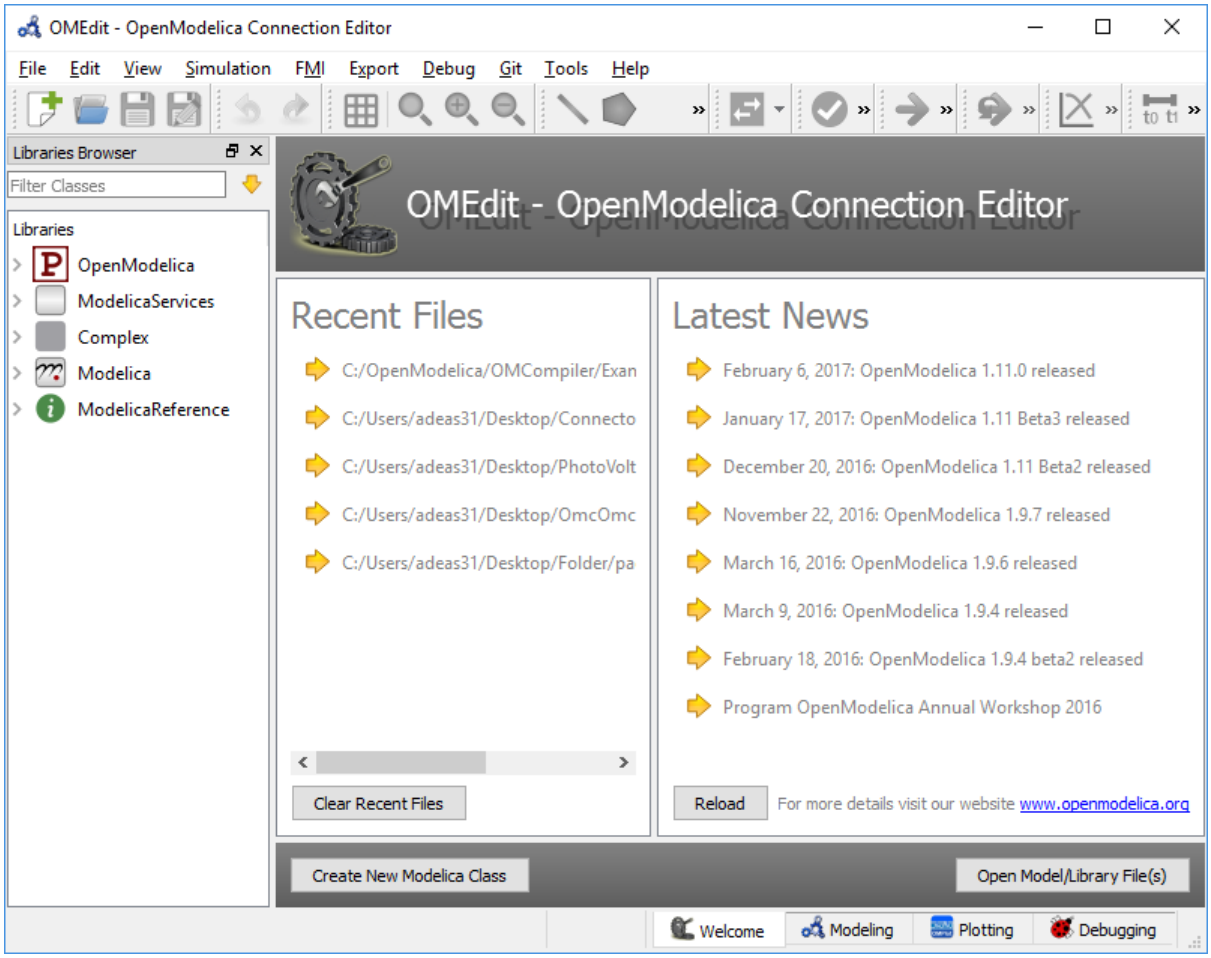



Figure 3.5: OMEdit Welcome Perspective.

The Welcome Perspective shows the list of recent files and the list of latest news from https://www.openmodelica.org. See Figure 3.5. The orientation of recent files and latest news can be horizontal or vertical. User is allowed to show/hide the latest news. See section *General Options*.

### 3.3.2 Modeling Perspective

The Modeling Perspective provides the interface where user can create and design their models. See Figure 3.6.

The Modeling Perspective interface can be viewed in two different modes, the tabbed view and sub-window view, see section *General Options*.

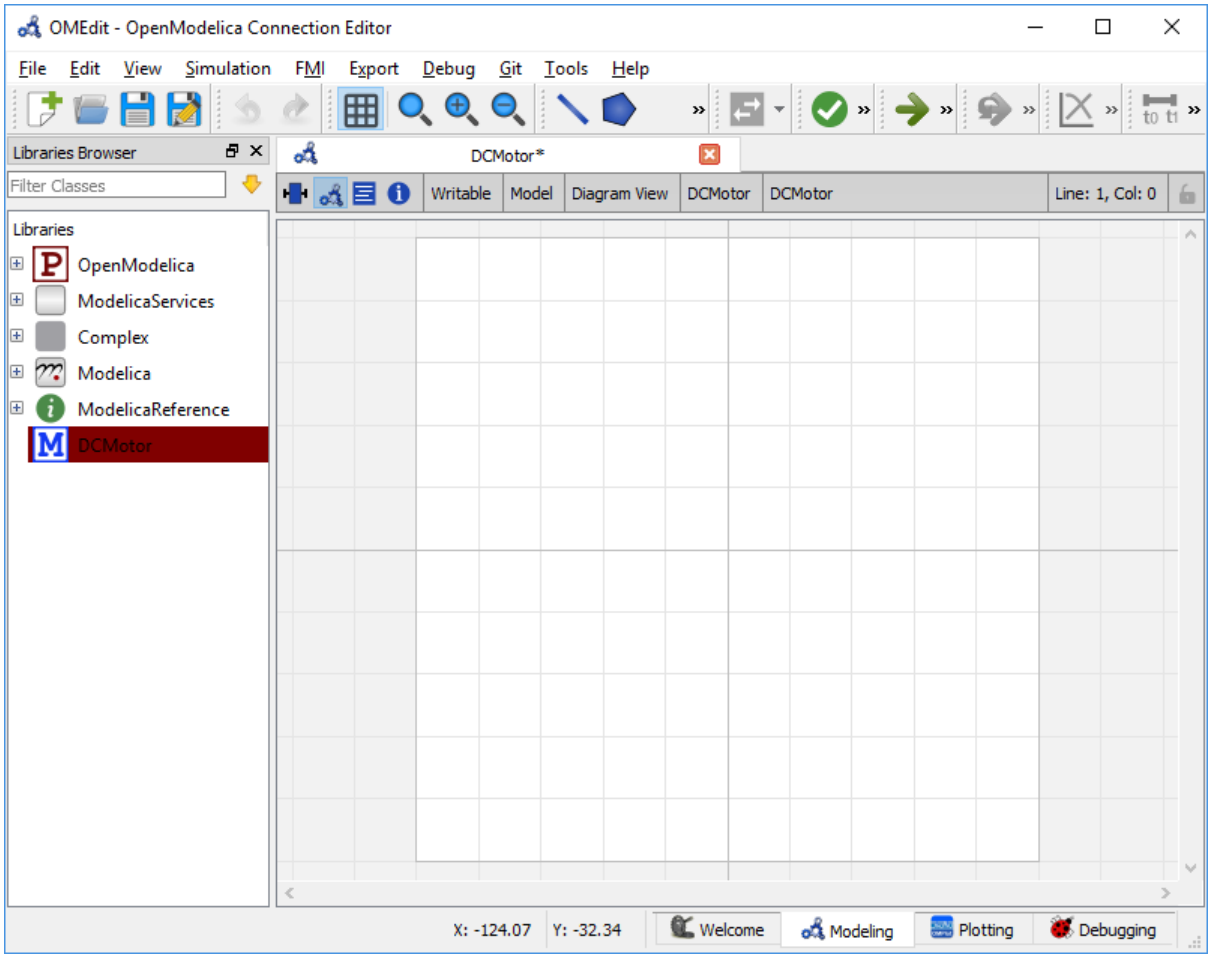



Figure 3.6: OMEdit Modeling Perspective.

### 3.3.3 Plotting Perspective

The Plotting Perspective shows the simulation results of the models. Plotting Perspective will automatically become active when the simulation of the model is finished successfully. It will also become active when user opens any of the OpenModelica's supported result file. Similar to Modeling Perspective this perspective can also be viewed in two different modes, the tabbed view and sub-window view, see section *General Options*.

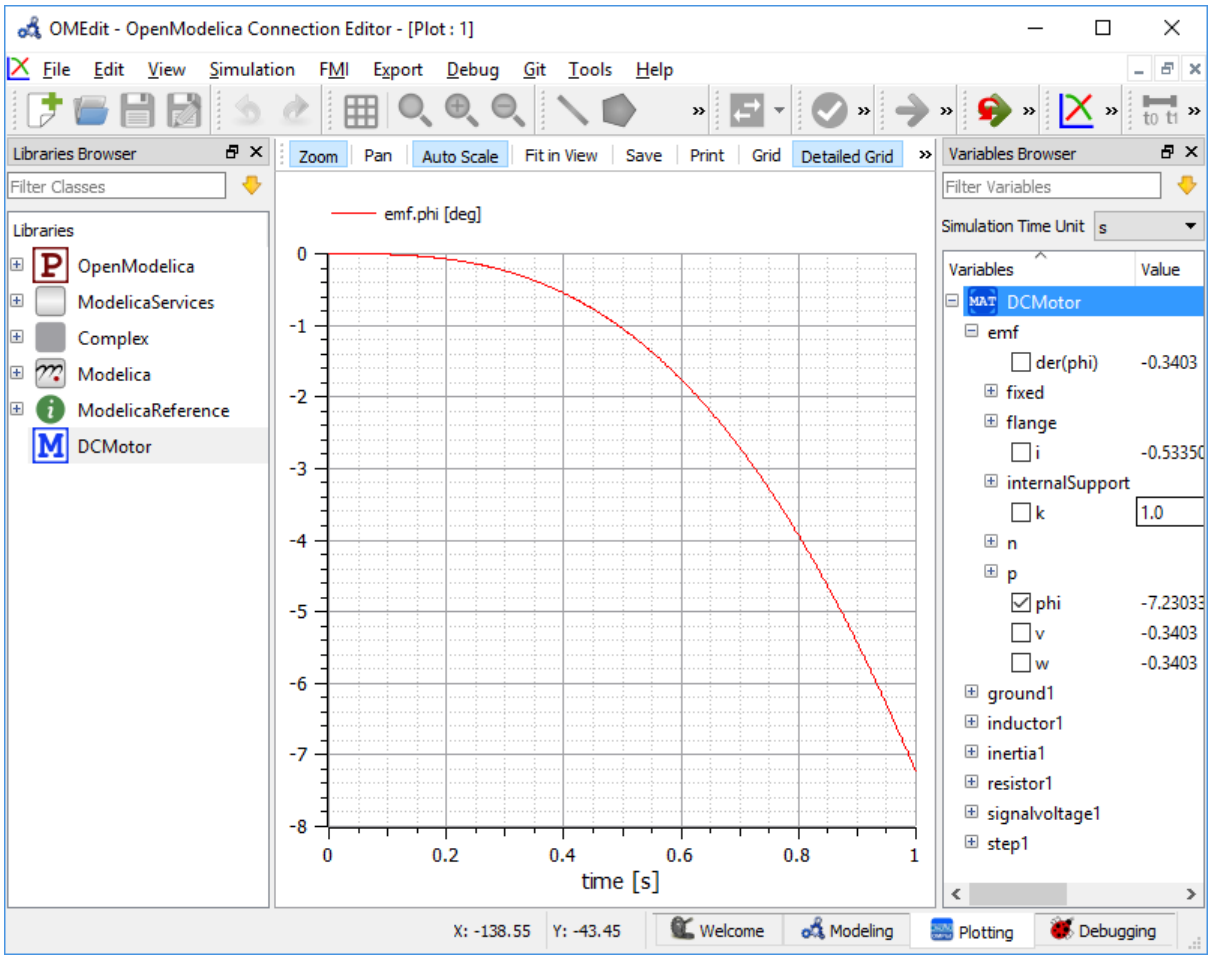



Figure 3.7: OMEdit Plotting Perspective.

### 3.3.4 Debugging Perspective

The application automatically switches to Debugging Perspective when user simulates the class with algorithmic debugger. The perspective shows the list of stack frames, breakpoints and variables.

## 3.4 File Menu

- *New*
- *New Modelica Class* - Creates a new Modelica class.
- *New SSP Model* - Creates a new SSP model.
- *Open Model/Library File(s)* - Opens the Modelica file or a library.
- *Open/Convert Modelica File(s) With Encoding* - Opens the Modelica file or a library with a specific encoding. It is also possible to convert to UTF-8.
- *Load Library* - Loads a Modelica library. Allows the user to select the library path assuming that the path contains a package.mo file.

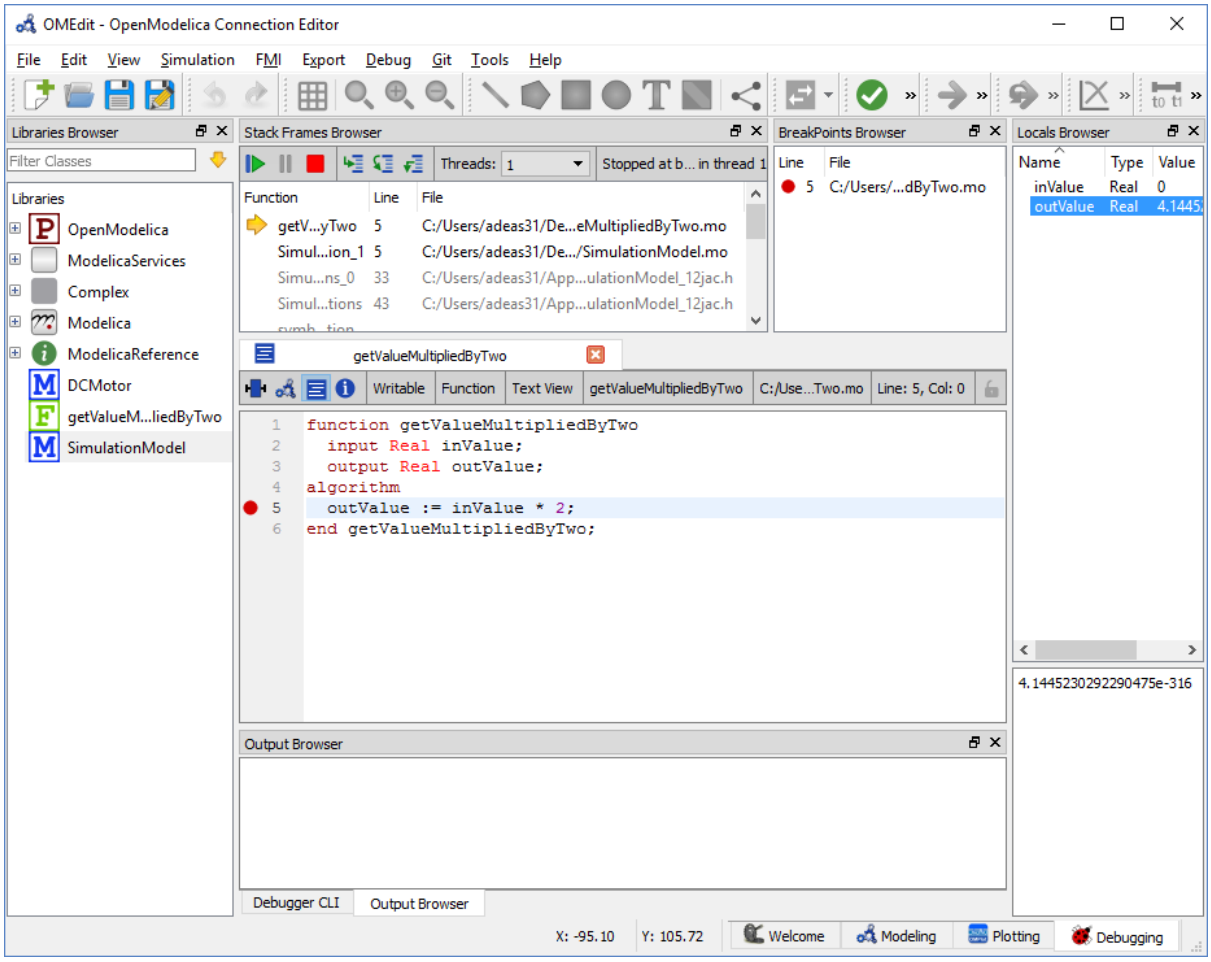



Figure 3.8: OMEdit Debugging Perspective.

- *Load Encrypted Library* - Loads an encrypted library. see *OpenModelica Encryption*
- *Open Result File(s)* - Opens a result file.
- *Open Transformations File* - Opens a transformational debugger file.
- *Unload All* - Unloads all loaded classes.
- *Open Directory* - Loads the files of a directory recursively. The files are loaded as text files.
- *Save* - Saves the class.
- *Save As* - Save as the class.
- *Save Total* - Saves the class and all the classes it uses in a single file. The class and its dependencies can only be loaded later by using the *loadFile()* API function in a script. Allows third parties to reproduce an issue with a class without worrying about library dependencies.
- *Import*
- *FMU* - Imports the FMU.
- *FMU Model Description* - Imports the FMU model description.
- *From OMNotbook* - Imports the Modelica models from OMNotebook.
- *Ngspice netlist* - Imports the ngspice netlist to Modelica code.
- *Export*
- *To Clipboard* - Exports the current model to clipboard.
- *Image* - Exports the current model to image.
- *FMU* - Exports the current model to FMU.
- *Read-only Package* - Exports a zipped Modelica library with file extension .mol
- *Encrypted Package* - Exports an encrypted package. see *OpenModelica Encryption*
- *XML* - Exports the current model to a xml file.
- *Figaro* - Exports the current model to Figaro.
- *To OMNotebook* - Exports the current model to a OMNotebook file.
- *System Libraries* - Contains a list of system libraries.
- *Manage Libraries*
- *Install Library* - Opens a dialog to select and install a new library, see *Install Library*
- *Upgrade Installed Libraries* - Opens a dialog to upgrade the installed libraries.
- *Update Library Index* - Updates the library index.
- *Recent Files* - Contains a list of recent files.
- *Clear Recent Files* - Clears the list of recent files.
- *Print* - Prints the current model.
- *Quit* - Quit the OpenModelica Connection Editor.

## 3.5 Edit Menu

- *Undo* - Undoes the last change.
- *Redo* - Redoes the last undone change.
- *Filter Classes* - Filters the classes in Libraries Browser, see *Filter Classes*

## 3.6 View Menu

- *Toolbars* - Toggle visibility of toolbars.
- *Windows* - Toggle visibility of windows.
- *Close Window* - Closes the current model window.
- *Close All Windows* - Closes all the model windows.
- *Close All Windows But This* - Closes all the model windows except the current.
- *Cascade Windows* - Arranges all the child windows in a cascade pattern.
- *Tile Windows Horizontally* - Arranges all child windows in a horizontally tiled pattern.
- *Tile Windows Vertically* - Arranges all child windows in a vertically tiled pattern.
- *Toggle Tab/SubWindow View* - Switches between tab and sub-window view.
- *Grid Lines* - Toggle grid lines of the current model.
- *Reset Zoom* - Resets the zoom of the current model.
- *Zoom In* - Zoom in the current model.
- *Zoom Out* - Zoom out the current model.
- *Fit to Diagram* - Fit the current model diagram in the view.

## 3.7 SSP Menu

- *Add System* - Adds the system to a model.
- *Add/Edit Icon* - Add/Edit the system/submodel icon.
- *Delete Icon* - Deletes the system/submodel icon.
- *Add Connector* - Adds a connector to a system/submodel.
- *Add Bus* - Adds a bus to a system/submodel.
- *Add TLM Bus* - Adds a TLM bus to a system/submodel.
- *Add SubModel* - Adds a submodel to a system.

## 3.8 Simulation Menu

- *Check Model* - Checks the current model.
- *Check All Models* - Checks all the models of a library.
- *Instantiate Model* - Instantiates the current model.
- *Simulation Setup* - Opens the simulation setup window.
- *Simulate* - Simulates the current model.
- *Simulate with Transformational Debugger* - Simulates the current model and opens the transformational debugger.
- *Simulate with Algorithmic Debugger* - Simulates the current model and opens the algorithmic debugger.
- *Simulate with Animation* - Simulates the current model and open the animation.
- *Archived Simulations* - Shows the list of simulations already finished or running. Double clicking on any of them opens the simulation output window.

## 3.9 Data Reconciliation

- *Calculate Data Reconciliation* - Opens the dialog to run the data reconciliation algorithm.

## 3.10 Sensitivity Optimization Menu

- *Run Sensitivity Analysis and Optimization* - Runs the sensitivity analysis and optimization.

## 3.11 Debug Menu

- *Debug Configurations* - Opens the debug configurations window.
- *Attach to Running Process* - Attaches the algorithmic debugger to a running process.

## 3.12 Tools Menu

- *OpenModelica Compiler CLI* - Opens the OpenModelica Compiler command line interface window.
- *OpenModelica Command Prompt* - Opens the OpenModelica Command Prompt (Only available on Windows).
- *Open Temporary Directory* - Opens the current temporary directory.
- *Open Working Directory* - Opens the current working directory.
- *Open Terminal* - Runs the terminal command set in *General Options*.
- *Options* - Opens the options window.

## 3.13 Help Menu

- *OpenModelica User's Guide* - Opens the OpenModelica User's Guide.
- *OpenModelica User's Guide (PDF)* - Opens the OpenModelica User's Guide (PDF).
- *OpenModelica System Documentation* - Opens the OpenModelica System Documentation.
- *OpenModelica Scripting Documentation* - Opens the OpenModelica Scripting Documentation.
- *Modelica Documentation* - Opens the Modelica Documentation.
- *OMSimulator User's Guide* - Opens the OMSimulator User's Guide.
- *About OMEdit* - Shows the information about OpenModelica Connection Editor.

## 3.14 Modeling a Model

### 3.14.1 Creating a New Modelica Class

Creating a new Modelica class in OMEdit is rather straightforward. Choose any of the following methods,

- Select File > New > New Modelica Class from the menu.
- Click on New Modelica Class toolbar button.
- Click on the Create New Modelica Class button available at the left bottom of Welcome Perspective.
- Press Ctrl+N.

### 3.14.2 Opening a Modelica File

Choose any of the following methods to open a Modelica file,

- Select File > Open Model/Library File(s) from the menu.
- Click on Open Model/Library File(s) toolbar button.
- Click on the Open Model/Library File(s) button available at the right bottom of Welcome Perspective.
- Press Ctrl+O.

(Note, for editing Modelica system files like MSL (not recommended), see *Editing Modelica Standard Library*)

### 3.14.3 Opening a Modelica File with Encoding

Select File > Open/Convert Modelica File(s) With Encoding from the menu. It is also possible to convert files to UTF-8.

### 3.14.4 Model Widget

For each Modelica class one Model Widget is created. It has a statusbar and a view area. The statusbar contains buttons for navigation between the views and labels for information. The view area is used to display the icon, diagram and text layers of Modelica class. See Figure 3.9.

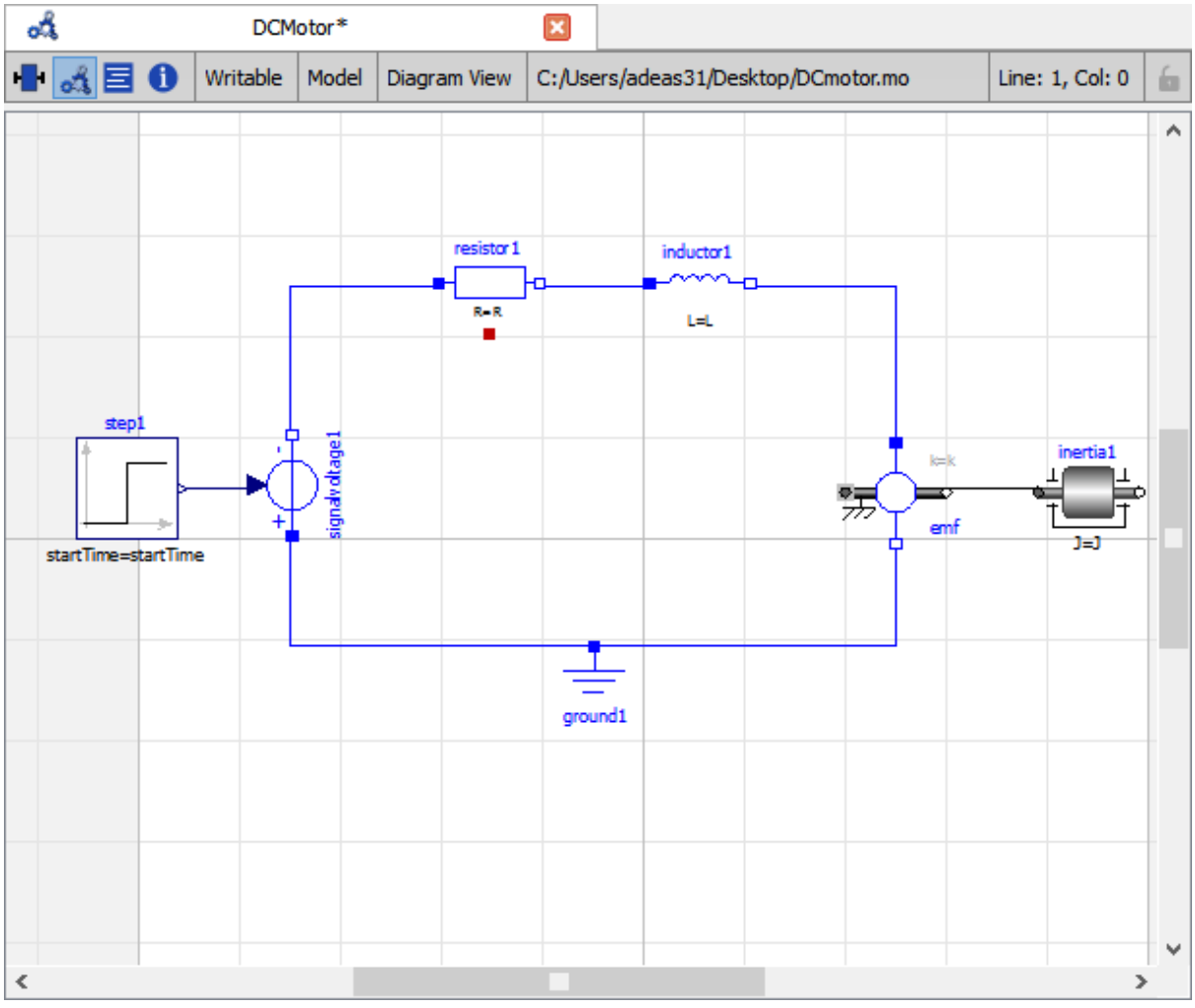



Figure 3.9: Model Widget showing the Diagram View.

### 3.14.5 Adding Component Models

Drag the models from the Libraries Browser and drop them on either Diagram or Icon View of Model Widget.

### 3.14.6 Making Connections

In order to connect one component model to another the user first needs to enable the connect mode (  ) from the toolbar.

Move the mouse over the connector. The mouse cursor will change from arrow cursor to cross cursor. To start the connection press left button and move while keeping the button pressed. Now release the left button. Move towards the end connector and click when cursor changes to cross cursor.

### 3.14.7 Class Diagram

To see the UML class diagram of a class, right-click it in the Libraries Browser and choose *Class Diagram*, see Figure 3.10. The diagram shows the class, the classes it extends and the classes it uses, with their components and modifiers, see *UML Class and Instance Diagrams*. It opens in the Class Diagram window, which has a tab for each class.

- *Depth* sets how many levels of used classes are shown, 0 shows only the class and its base classes.
- *Show modifiers* shows or hides the modifiers and bindings.
- *Layout* arranges the classes with the class on top, with the base classes on top, or in rows by inheritance.
- *Refresh* draws the diagram again, after the class was changed.
- *Save* saves the diagram as a draw.io file, which can be edited in draw.io.

A click on a class in the diagram opens it, and a click on a line in a class, e.g. a component, opens the text view of the class at the line that declares it, see Figure 3.11.

## 3.15 Simulating a Model

The simulation process in OMEdit is split into three main phases:

1. The Modelica model is translated into C/C++ code. The model is first instantiated by the frontend, which turns it into a flat set of variables, parameters, equations, algorithms, and functions. The backend then analyzes the mathematical structure of the flat model, applies symbolic simplifications and determines how the equations can be solved efficiently. Finally, based on this information, model-specific C/C++ code is generated. This part of the process can be influenced by setting *Translation Flags* (a.k.a. *Command Line Options*), e.g. deciding which kind of structural simplifications should be performed during the translation phase.
2. The C/C++ code is compiled and linked into an executable simulation code. Additional *C/C++ compiler flags* can be given to influence this part of the process, e.g. by setting compiler optimizations such as `-O3`. Since multiple C/C++ source code files are generated for a given model, they are compiled in parallel by OMEdit, exploiting the power of multi-core CPUs.
3. The simulation executable is started and produces the simulation results in a *.mat* or *.csv* file. The runtime behavior can be influenced by *Simulation Flags*, e.g. by choosing specific solvers, or changing the output file name. Note that it it possible to re-simulate a model multiple times, changing parameter values from the Variables Browser and/or changing some Simulation Flags. In this case, only Phase 3. is repeated, skipping Phases 1. and 2., which enables much faster iterations.

The simulation options for each model are stored inside the OMEdit data structure. They are set according to the following sequence,

- Each model has its own translation and simulation options.
- If the model is opened for the first time then the translation and simulation options are set to defaults, that can be customized in Tools | Options | Simulation.

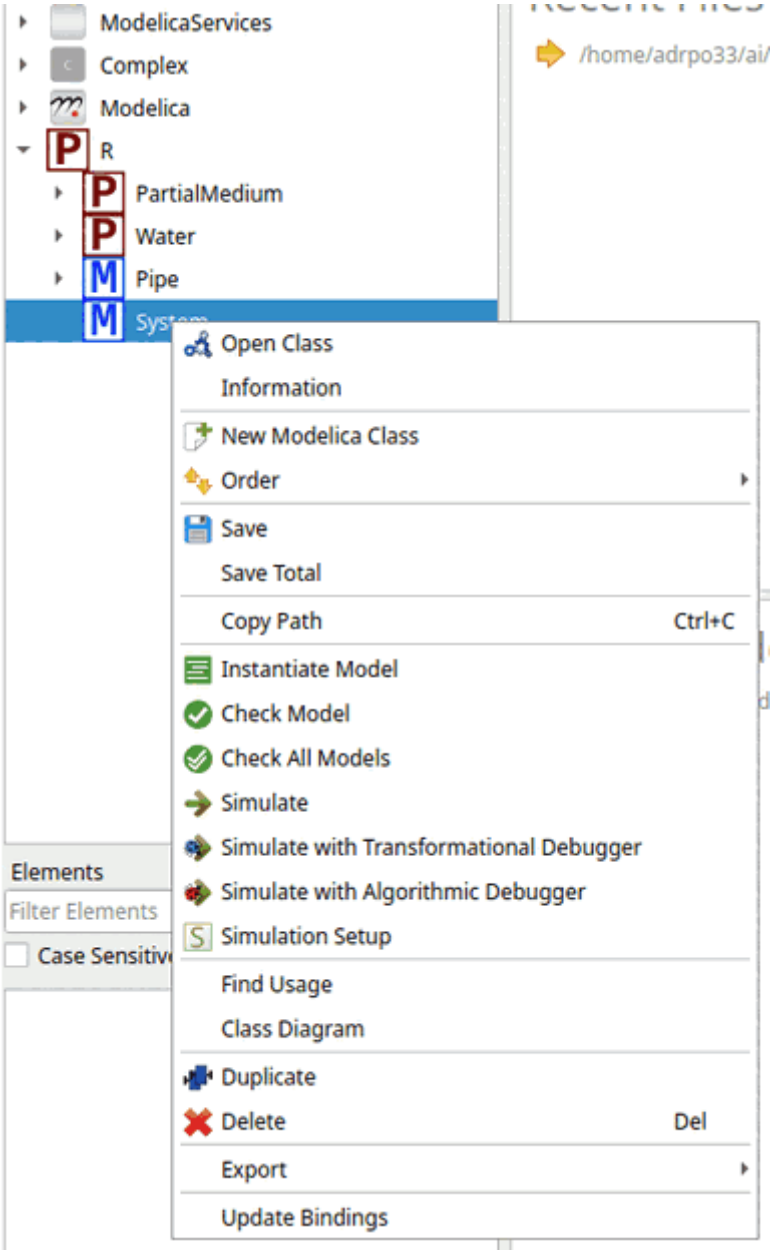



Figure 3.10: The Class Diagram entry of the Libraries Browser menu.

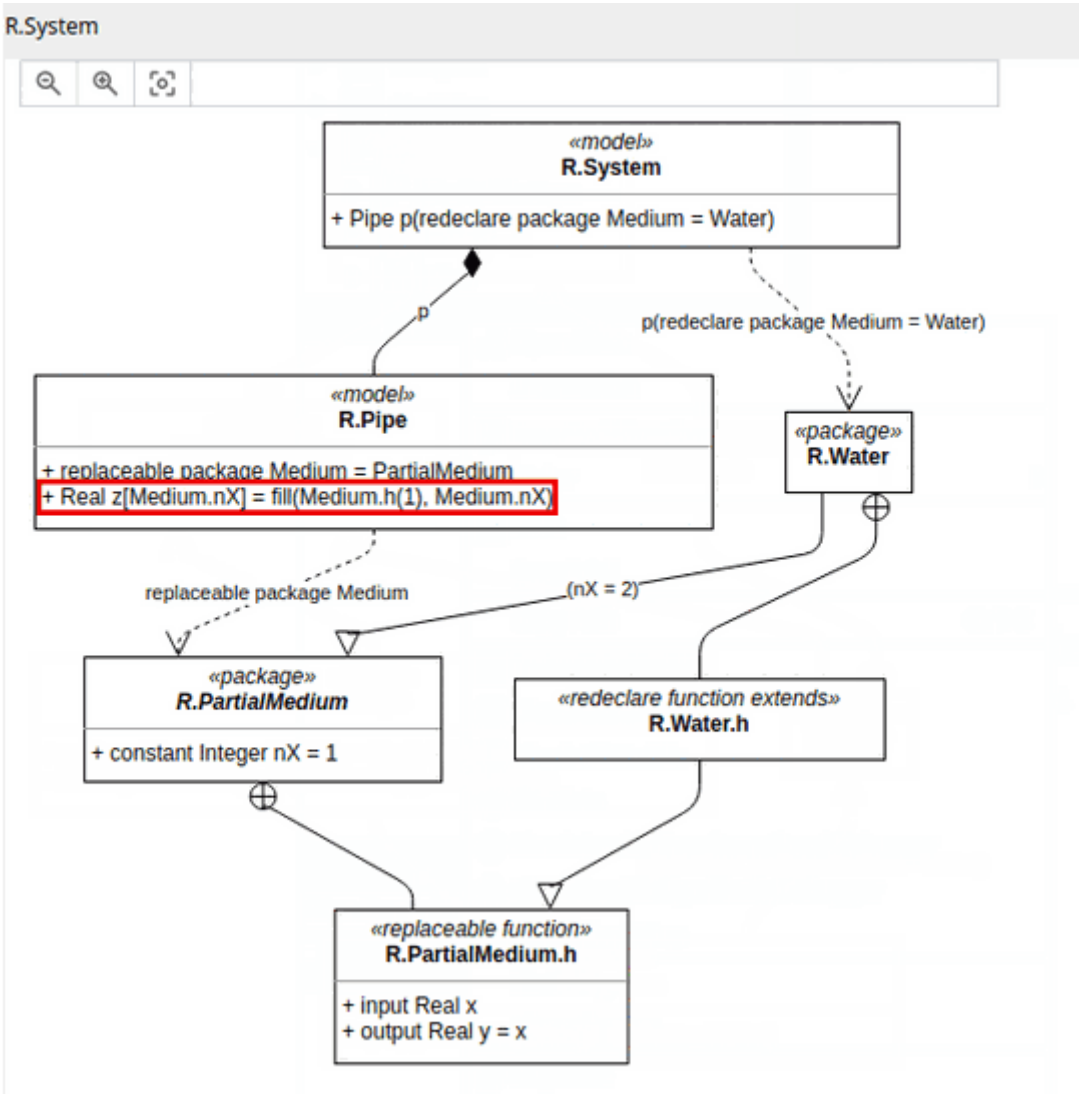



Figure 3.11: The class diagram of a model with a redeclared medium. A click on the highlighted component opens the text view of `R.Pipe` at line 18.

- `experiment`, `__OpenModelica_commandLineOptions` and `__OpenModelica_simulationFlags` annotations are applied if the model contains them.
- After that all the changes done via Simulation Setup window for a certain model are preserved for the whole session. If you want to use the same settings in future sessions then you should store them inside `experiment`, `__OpenModelica_commandLineOptions`, and `__OpenModelica_simulationFlags` annotations.

The OMEdit Simulation Setup can be launched by,

- Selecting Simulation > Simulation Setup from the menu. (requires a model to be active in ModelWidget)
- Clicking on the Simulation Setup toolbar button. (requires a model to be active in ModelWidget)
- Right clicking the model from the Libraries Browser and choosing Simulation Setup.

### 3.15.1 General

- Simulation Interval
- *Start Time* - the simulation start time.
- *Stop Time* - the simulation stop time.
- *Number of Intervals* - the simulation number of intervals.
- *Interval* - the length of one interval (i.e., stepsize)
- Integration
  - *Method* - the simulation solver. See section *Integration Methods* for solver details.
  - *Tolerance* - the simulation tolerance.
  - *Jacobian* - the jacobian method to use.
  - DASSL/IDA Options
  - *Root Finding* - Activates the internal root finding procedure of dassl.
  - *Restart After Event* - Activates the restart of dassl after an event is performed.
  - *Initial Step Size*
  - *Maximum Step Size*
  - *Maximum Integration Order*
- *C/C++ Compiler Flags (Optional)* - the optional C/C++ compiler flags.
- *Number of Processors* - the number of processors used to build the simulation.
- *Build Only* - only builds the class.
- *Launch Transformational Debugger* - launches the transformational debugger.
- *Launch Algorithmic Debugger* - launches the algorithmic debugger.
- *Launch Animation* - launches the 3d animation window.

### 3.15.2 *Interactive Simulation*

- Simulate with steps (makes the interactive simulation synchronous; plots nicer curves at the expense of performance)
- Simulation server port

### 3.15.3 *Translation Flags*

### 3.15.4 Simulation Flags

- *Model Setup File (Optional)* - specifies a new setup XML file to the generated simulation code.
- *Initialization Method (Optional)* - specifies the initialization method.
- *Equation System Initialization File (Optional)* - specifies an external file for the initialization of the model.
- *Equation System Initialization Time (Optional)* - specifies a time for the initialization of the model.
- *Clock (Optional)* - the type of clock to use.
- *Linear Solver (Optional)* - specifies the linear solver method.
- *Non Linear Solver (Optional)* - specifies the nonlinear solver.
- *Linearization Time (Optional)* - specifies a time where the linearization of the model should be performed.
- *Output Variables (Optional)* - outputs the variables a, b and c at the end of the simulation to the standard output.
- *CPU Time* - dumps the cpu-time into the result file.
- *Enable All Warnings* - outputs all warnings.
- *Logging (Optional)*
- *LOG_STDOUT* - standard output stream. This stream is always active, can be disabled with -lv=-LOG_STDOUT
- *LOG_ASSERT* - This stream is always active, can be disabled with -lv=-LOG_ASSERT
- *LOG_DASSL* - additional information about dassl solver.
- *LOG_DASSL_STATES* - outputs the states at every dassl call.
- *LOG_DEBUG* - additional debug information.
- *LOG_DELAY* - Debug information for delay operator.
- *LOG_DIVISION* - Log division by zero.
- *LOG_DSS* - outputs information about dynamic state selection.
- *LOG_DSS_JAC* - outputs jacobian of the dynamic state selection.
- *LOG_DT* - additional information about dynamic tearing.
- *LOG_DT_CONS* - additional information about dynamic tearing (local and global constraints).
- *LOG_EVENTS* - additional information during event iteration.
- *LOG_EVENTS_V* - verbose logging of event system.
- *LOG_GBODE* - Information about GBODE solver.
- *LOG_GBODE_V* - Verbose information about GBODE solver.
- *LOG_GBODE_NLS* - Log non-linear solver process of GBODE solver.
- *LOG_GBODE_NLS_V* - Verbose log non-linear solver process of GBODE solver.
- *LOG_GBODE_STATES* - Output states at every GBODE call.
- *LOG_INIT* - additional information during initialization.
- *LOG_INIT_HOMOTOPY* - Log homotopy initialization.
- *LOG_INIT_V* - Verbose information during initialization.
- *LOG_IPOPT* - information from Ipopt.
- *LOG_IPOPT_FULL* - more information from Ipopt.

- *LOG_IPOPT_JAC* - check jacobian matrix with Ipopt.
- *LOG_IPOPT_HESSE* - check hessian matrix with Ipopt.
- *LOG_IPOPT_ERROR* - print max error in the optimization.
- *LOG_JAC* - Outputs the jacobian matrix used by ODE solvers.
- *LOG_LS* - logging for linear systems.
- *LOG_LS_V* - verbose logging of linear systems.
- *LOG_NLS* - logging for nonlinear systems.
- *LOG_NLS_V* - verbose logging of nonlinear systems.
- *LOG_NLS_HOMOTOPY* - logging of homotopy solver for nonlinear systems.
- *LOG_NLS_JAC* - outputs the jacobian of nonlinear systems.
- *LOG_NLS_JAC_TEST* - tests the analytical jacobian of nonlinear systems.
- *LOG_NLS_NEWTON_DIAGNOSTICS* - Log Newton diagnostics. A Diagnostic method to figure out which individual initial guess values are more likely to be causing the convergence failure of Newton-type iterative nonlinear solvers.
- *LOG_NLS_RES* - outputs every evaluation of the residual function.
- *LOG_NLS_EXTRAPOLATE* - outputs debug information about extrapolate process.
- *LOG_RES_INIT* - outputs residuals of the initialization.
- *LOG_RT* - additional information regarding real-time processes.
- *LOG_SIMULATION* - additional information about simulation process.
- *LOG_SOLVER* - additional information about solver process.
- *LOG_SOLVER_V* - verbose information about the integration process.
- *LOG_SOLVER_CONTEXT* - context information during the solver process.
- *LOG_SOTI* - final solution of the initialization.
- *LOG_SPATIALDISTR* - logging of internal operations for spatialDistribution.
- *LOG_STATS* - additional statistics about timer/events/solver.
- *LOG_STATS_V* - additional statistics for LOG_STATS.
- *LOG_SUCCESS* - This stream is always active, can be disabled with -lv=-LOG_SUCCESS.
- *LOG_SYNCHRONOUS* - Log clocks and sub-clocks for synchronous features.
- *LOG_ZEROCROSSINGS* - additional information about the zero-crossings.
- *Additional Simulation Flags (Optional)* - specify any other simulation flag.

### 3.15.5 Output

- *Output Format* - the simulation result file output format.
- *Single Precision* - Output results in single precision (only for mat output format).
- *File Name Prefix (Optional)* - the name is used as a prefix for the output files.
- *Result File (Optional)* - the simulation result file name.
- *Variable Filter (Optional)* - only output variables with names fully matching the regular expression.
- *Protected Variables if not encrypted* - adds the protected variables in result file.
- *Equidistant Time Grid* - output the internal steps given by dassl instead of interpolating results into an equidistant time grid as given by stepSize or numberOfIntervals.

- *Store Variables at Events* - adds the variables at time events.
- *Show Generated File* - displays the generated files in a dialog box.

The Variable Filter takes a regular expression input and only saves in the simulation results file those variables whose names fully match it. Here are some simple examples:

- `.*` matches any variable (default choice)
- `xy.*` matches variables starting with `xy`
- `.*yz` matches variables ending with `yz`
- `abc\.def.*` matches variables starting with `abc.def`. Note that the `.` character is a regex meta-character, so it must be escaped by a `\`
- `.*body\.a_0\[1\]` matches variables ending with `body.a_0[1]`. Note that `.`, `[`, and `]` must be escaped
- `x\[.*\]` matches all elements of array `x`
- `x\[[2-4]\]` matches elements 2, 3, and 4 of array `x`
- `abc.*|def.*` matches variables starting with `abc` or `def`
- `.*der\(.*\)` matches all derivatives in the model. Note that `(` and `)` must be escaped

Please note that all the model variables will still be shown in the Variables Browser tree; however, only those for which results were actually saved will have a checkbox to plot them.

### 3.15.6 CSV-File Data Input

When simulating Modelica models with top-level inputs (input variables or input connectors), these inputs are assumed to be equal to their start value by default. However, it is possible to feed them with input signals obtained from CSV (Comma-Separated Value) input data files, by means of the *-csvInput* simulation flag, that can be set in the *Additional Simulation Flags (Optional)* field of the Simulation Flags tab. For example, setting `-csvInput=myinput.csv` causes the runtime executable to read such input data from the `myinput.csv` file.

CSV files should contain the names of the input variables in the first row, beginning with `time` on the first column, and the values of such variables for each point in time in subsequent rows, with non-decreasing time values. The variable names should be enclosed by quotation marks in case they contain spaces, to avoid ambiguities. The default separator for data items within each row is the comma, but it is also possible to use other separators, e.g., space, tab, or semi-colon; in this case, the file should start with the separator specification `"sep=x"` (including the quotation marks), where `x` is the separator character.

For example, assume your model has three top-level inputs named `u1`, `u2`, and `u3`. These are valid CSV input files:

```
time, u3, u2, u1
0.0, 0.0, 0.0, 0.0
1.0, 0.0, 0.0, 0.0
2.0, 0.0, 0.0, 1.0

"sep=;" time; u3; u2; u1
0.0; 0.0; 0.0; 0.0
1.0; 0.0; 0.0; 0.0
2.0; 0.0; 0.0; 1.0

"sep= " "time" "u3" "u2" "u1"
0.0 0.0 0.0 0.0
1.0 0.0 0.0 0.0
2.0 0.0 0.0 1.0
```

Note that input labels need not be lexicographically ordered, the association between the columns and the inputs is given by the first row.

The CSV-file provides the values of the top level inputs at the specified points in time; linear interpolation is used to provide intermediate values between any two subsequent data points. Discontinuous inputs can be obtained by providing two consecutive rows with the same time value, containing the left limit values and the right limit values.

Unless an absolute pathname is provided for the CSV-files, OMEdit will load it from the sub-directory of the working directory which has the same name of the model, where all the other input and output data files are located.

### 3.15.7 Data Reconciliation

- *Algorithm* - data reconciliation algorithm.
- *Measurement Input File* - measurement input file.
- *Correlation Matrix Input File* - correlation matrix file.
- *Epsilon*

## 3.16 Calibrating an SSP Model

OMSimulator can fit the parameters of an SSP model to reference data, e.g. measurements. The problem is a `Calibration` activity of the UQ layered standard, in a UQ file stored in the SSP: the parameters to fit with their initial values and bounds, the simulated variables to compare and a CSV file with the reference data. How the fit works and the options it reads from the UQ file are described in *Parameter Calibration*.

To calibrate an SSP model that is open in OMEdit, right-click it in the Libraries Browser and choose *Calibrate...*, see Figure 3.12. The dialog asks for:

- *Calibration Activity* - the id of the Calibration activity. Empty means the only Calibration activity of the UQ file.
- *UQ File* - the UQ file inside the SSP, e.g. `extra/uq.xml`. Empty means the UQ file the SSP references.
- *Calibrated Model* - the SSP file the calibrated model is written to, by default `<model>.calibrated.ssp` in the working directory.

*Calibrate* exports the model like *Simulate* does and runs `OMSimulator --calibrate` on it. The output of OMSimulator is shown in the dialog while it runs, and closing the dialog stops the calibration. The calibrated SSP contains the fitted parameter values, as `<activity>_calibrated.ssv` next to the UQ file, and the `ResultSet` of the activity with the RMSE of each observed variable.

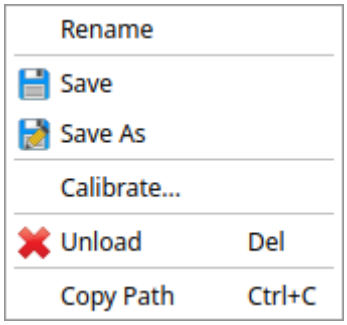



Figure 3.12: The Calibrate entry of the Libraries Browser menu of an SSP model.

The same calibration can be run from the command line:

```
OMSimulator model.ssp --calibrate cal_01 --calibrationOutput calibrated.ssp
```

Calibration needs the Python packages numpy and scipy. *Calibrate...* is not available in the web version of OMEdit.

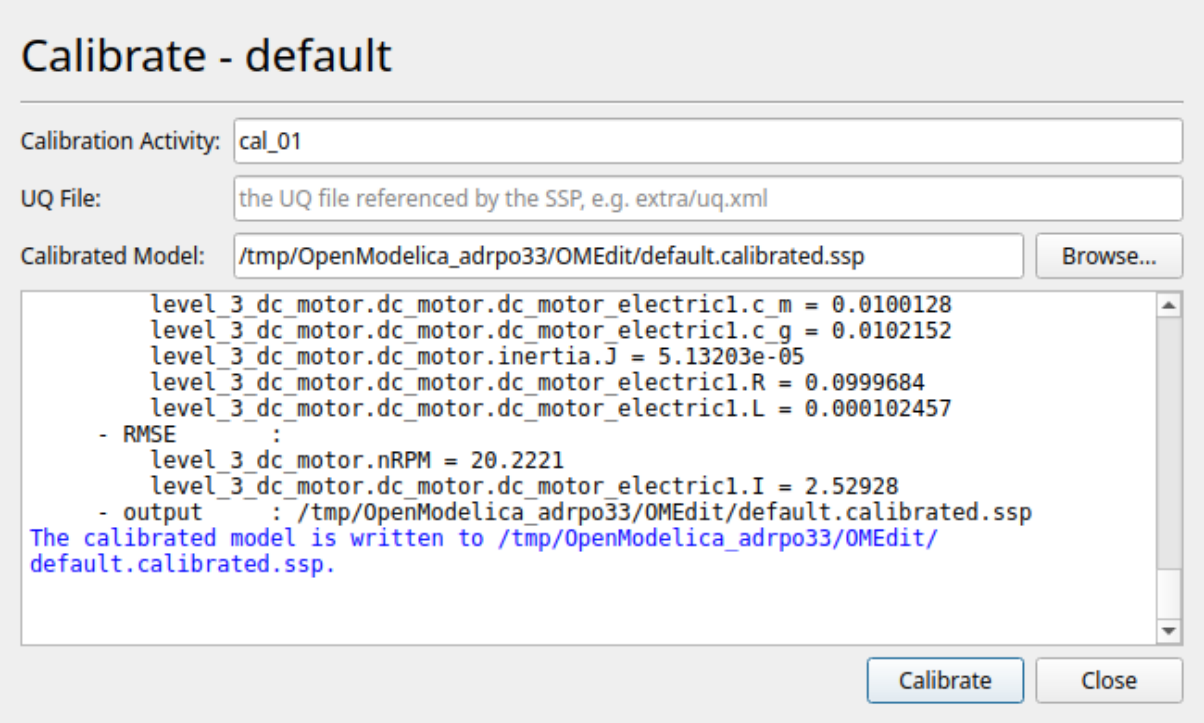



Figure 3.13: The calibration of a DC motor model, an SSP with three FMUs, against noisy measurements of its current and speed: the fitted parameters, the RMSE of the observed variables and the calibrated SSP.

## 3.17 2D Plotting

Successful simulation of model produces the result file which contains the instance variables that are candidate for plotting. Variables Browser will show the list of such instance variables. Each variable has a checkbox, checking it will plot the variable. See Figure 3.7. To get several plot windows tiled horizontally or vertically use the menu items *Tile Windows Horizontally* or *Tile Windows Vertically* under *View Menu*.

### 3.17.1 Types of Plotting

The plotting type depends on the active Plot Window. By default the plotting type is Time Plot.

#### Time Plot

Plots the variable over the simulation time. You can have multiple Time Plot windows by clicking on New Plot Window toolbar button ( ).

#### Plot Parametric

Draws a two-dimensional parametric diagram, between variables x and y, with $y$ as a function of $x$. You can have multiple Plot Parametric windows by clicking on the New Plot Parametric toolbar button ( ).

Select the x-axis variable while holding down the shift key, release the shift key and then select y-axis variables. One or many y-axis variables can be selected against one x-axis variable. To select a new x-axis variable press and hold the shift key again.

Unchecking the x-axis variable will uncheck all y-axis variables linked to it.

#### Array Plot

Plots an array variable so that the array elements' indexes are on the x-axis and corresponding elements' values are on the y-axis. The time is controlled by the slider above the variable tree. Right click the result file in variable browser and select *Enable Time Controls* to enable the slider. When an array is present in the model, it has a principal array node in the variable tree. To plot this array as an Array Plot, match the principal node. The principal node may be expanded into particular array elements. To plot a single element in the Time Plot, match the element. A new Array Plot window is opened using the New Array Plot Window toolbar button (  ).

#### Array Parametric Plot

Plots the first array elements' values on the x-axis versus the second array elements' values on the y-axis. The time is controlled by the slider above the variable tree. Right click the result file in variable browser and select *Enable Time Controls* to enable the slider. To create a new Array Parametric Plot, press the New Array Parametric Plot Window toolbar button (  ), then match the principle array node in the variable tree view to be plotted on the x-axis and match the principle array node to be plotted on the y-axis.

#### Diagram Window

Shows the active ModelWidget as a read only diagram. You can only have one Diagram Window. To show it click on Diagram Window toolbar button (  ).

### 3.17.2 Plot Window

A plot window shows the plot curve of instance variables. Several plot curves can be plotted in the same plot window. See Figure 3.7.

#### Plot Window Menu

- *Auto Scale* - Automatically scales the horizontal and vertical axes.
- *Fit in View* - Adjusts the plot canvas to according to the size of plot curves.
- *Save* - Saves the plot to file system as .png, .svg or .bmp.
- *Print* - Prints the plot.
- *Grid* - Shows grid lines.
- *Detailed Grid* - Shows detailed grid lines.
- *No Grid* - Hides grid lines.
- *Log X* - Logarithmic scale of the horizontal axis.
- *Log Y* - Logarithmic scale of the vertical axis.
- *Setup* - Shows a setup window.
    - *Variables* - List of all plotted variables.
        - *General* - Variable general information.
        - *Legend* - Display name for legend.
        - *File* - File name where variable data is stored.
        - *Appearance* - Visual settings of variable.
        - *Color* - Display color.
        - *Pattern* - Line pattern of curve.
        - *Thickness* - Line thickness of curve.
        - *Hide* - Hide/Show the curve.
        - *Toggle Sign* - Toggles the sign of curve.

    - *Plot on Right Y-Axis* - Display curve on right-side y-axis.
- *Titles* - Plot, axes and footer titles settings.
- *Legend* - Sets legend position and font.
- *Range* - Automatic or manual axes range.
    - *Auto Scale* - Automatically scales the horizontal and vertical axes.
    - *X-Axis*
    - *Minimum* - Minimum value for x-axis.
    - *Maximum* - Maximum value for x-axis.
    - *Y-Axis*
    - *Minimum* - Minimum value for y-axis.
    - *Maximum* - Maximum value for y-axis.
    - *Prefix Units* - Automatically pick the right prefix for units.

## 3.18 Re-simulating a Model

The *Variables Browser* allows manipulation of changeable parameters for re-simulation. After changing the parameter values user can click on the re-simulate toolbar button (  ), or right click the model in Variables Browser and choose re-simulate from the menu.

## 3.19 3D Visualization

Since OpenModelica 1.11 , OMEdit has built-in 3D visualization, which replaces third-party libraries (such as Modelica3D) for 3D visualization.

### 3.19.1 Running a Visualization

The 3d visualization is based on Qt Quick 3D. In order to run the visualization simply right click the class in Libraries Browser an choose "**Simulate with Animation**" as shown in Figure 3.14.

One can also run the visualization via Simulation > Simulate with Animation from the menu.

When simulating a model in animation mode, the flag *+d=visxml* is set. Hence, the compiler will generate a scene description file *_visual.xml* which stores all information on the multibody shapes. This scene description references all variables which are needed for the animation of the multibody system. When simulating with *+d=visxml*, the compiler will always generate results for these variables.

### 3.19.2 Viewing a Visualization

After the successful simulation of the model, the visualization window will show up automatically as shown in Figure 3.15.

The animation starts with pushing the *play* button. The animation is played until stopTime or until the *pause* button is pushed. By pushing the *previous* button, the animation jumps to the initial point of time. Points of time can be selected by moving the *time slider* or by inserting a simulation time in the *Time-box*. The speed factor of animation in relation to realtime can be set in the *Speed-dialog*. Other animations can be opened by using the *open file* button and selecting a result file with a corresponding scene description file.

The 3D camera view can be manipulated as follows:

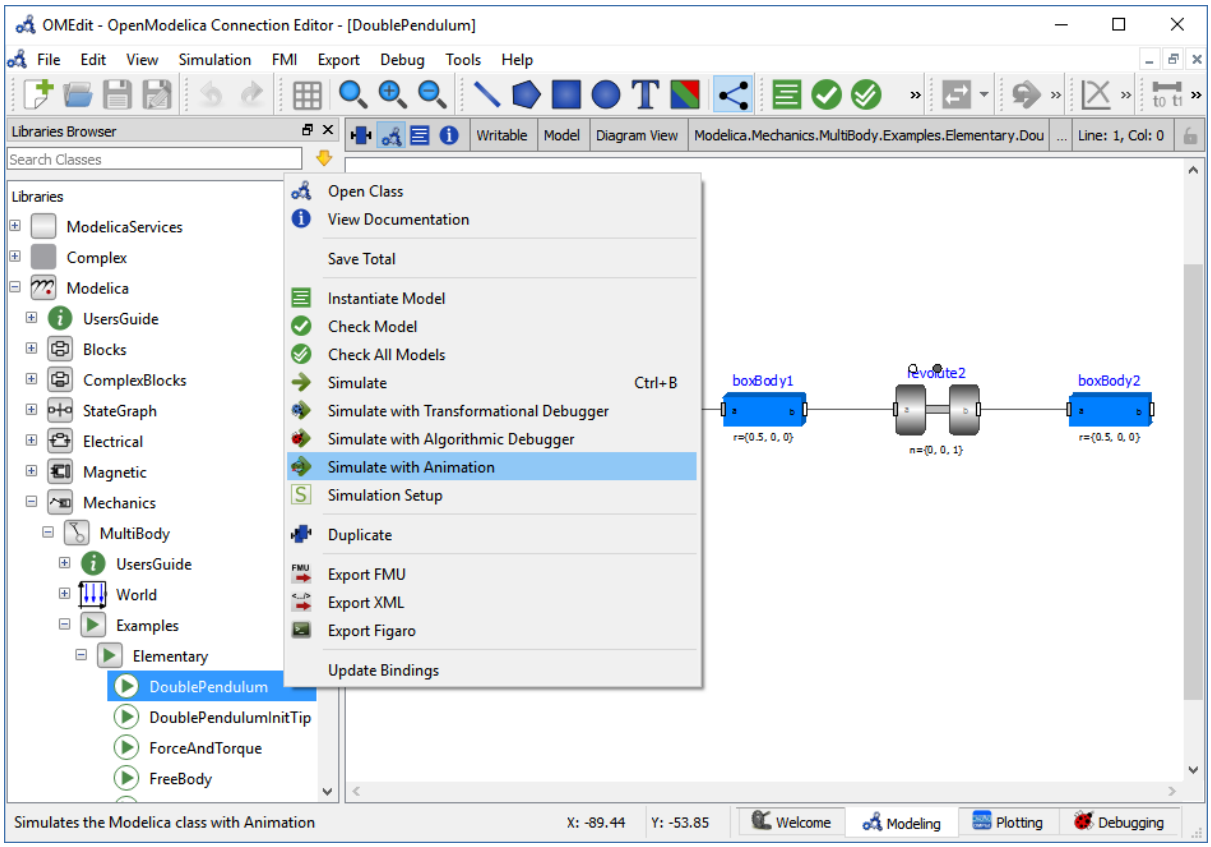



Figure 3.14: OMEdit Simulate with Animation.

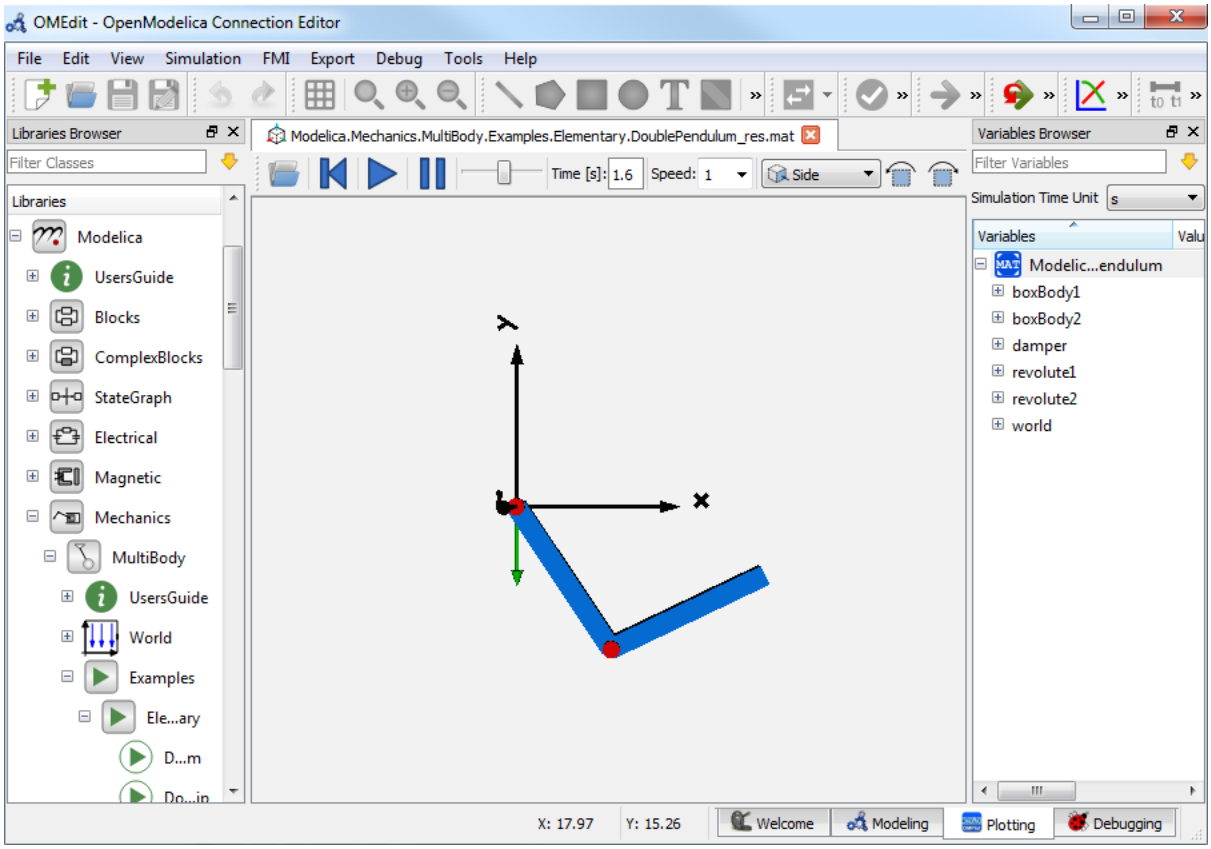


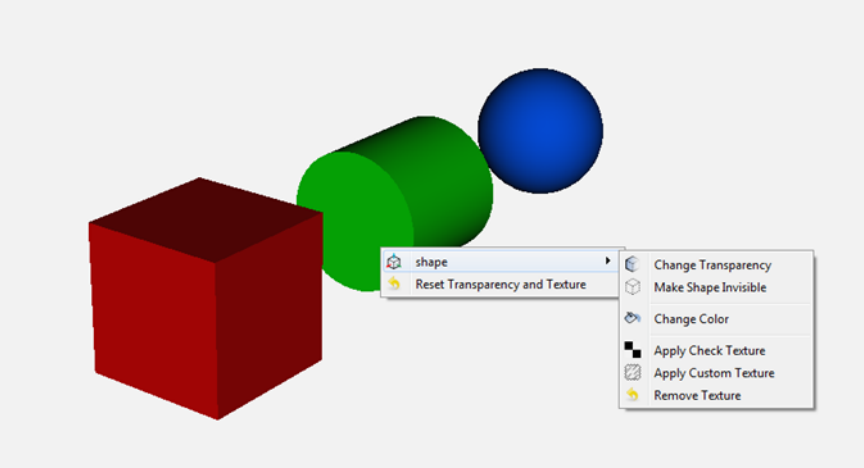

Figure 3.15: OMEdit 3D Visualization.

| Operation | Key | Mouse Action |
|---|---|---|
| Move Closer/Further | none | Wheel |
| Move Closer/Further | Right Mouse Hold | Up/Down |
| Move Up/Down/Left/Right | Middle Mouse Hold | Move Mouse |
| Move Up/Down/Left/Right | Ctrl + Left Mouse Hold | Move Mouse |
| Rotate | Left Mouse Hold | Move Mouse |
| Shape context menu | Right Mouse + Shift | |

Predefined views (Isometric, Side, Front, Top) can be selected and the camera can be orbited left or right in steps with the rotation buttons.

### 3.19.3 Additional Visualization Features

The shapes that are displayed in the viewer can be selected with shift + right click. If a shape is selected, a context menu pops up that offers additional visualization features

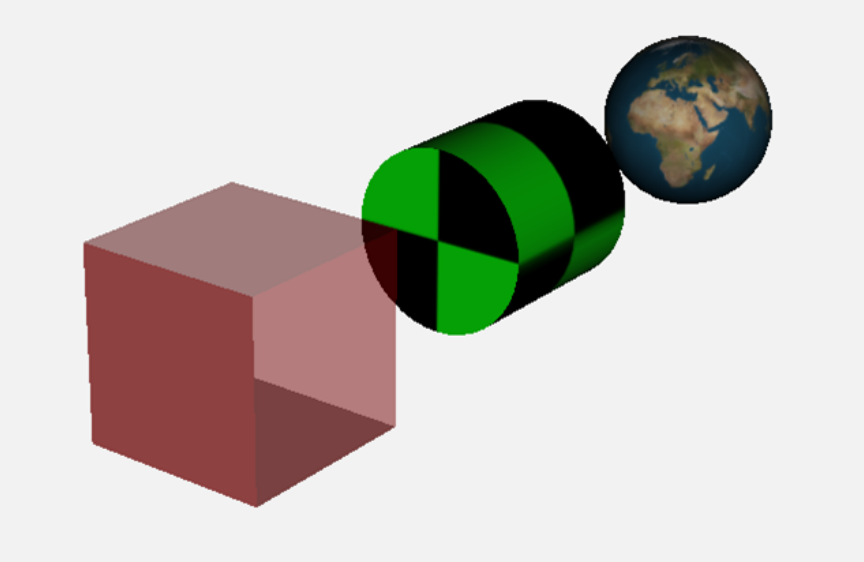



The following features can be selected:

| Menu | Description |
|---|---|
| Change Transparency | The shape becomes either transparent or intransparent. |
| Make Shape Invisible | The shape becomes invisible. |
| Change Color | A color dialog pops up and the color of the shape can be set. |
| Apply Check Texture | A checked texture is applied to the shape. |
| Apply Custom Texture | A file selection dialog pops up and an image file can be selected as a texture. |
| Remove Texture | Removes the current texture of the shape. |

## 3.20 Animation of Realtime FMUs

Instead of a result file, OMEdit can load Functional Mock-up Units to retrieve the data for the animation of multi-body systems. Just like opening a mat-file from the animation-plotting view, one can open an FMU-file. Necessarily, the FMU has to be generated with the *+d=visxml* flag activated, so that a scene description file is generated in the same directory as the FMU. Currently, only FMU 1.0 and FMU 2.0 model exchange are supported. When choosing an FMU, the simulation settings window pops up to choose solver and step size. Afterwards, the model initializes and can be simulated by pressing the play button.



### 3.20.1 Interactive Realtime Animation of FMUs

FMUs can be simulated with realtime user interaction. A possible solution is to equip the model with an interaction model from the Modelica_DeviceDrivers library (https://github.com/modelica/Modelica_DeviceDrivers). The realtime synchronization is done by OMEdit so no additional time synchronization model is necessary.

## 3.21 Interactive Simulation

**Warning**

Interactive simulation is an experimental feature.

Interactive simulation is enabled by selecting interactive simulation in the simulation setup.

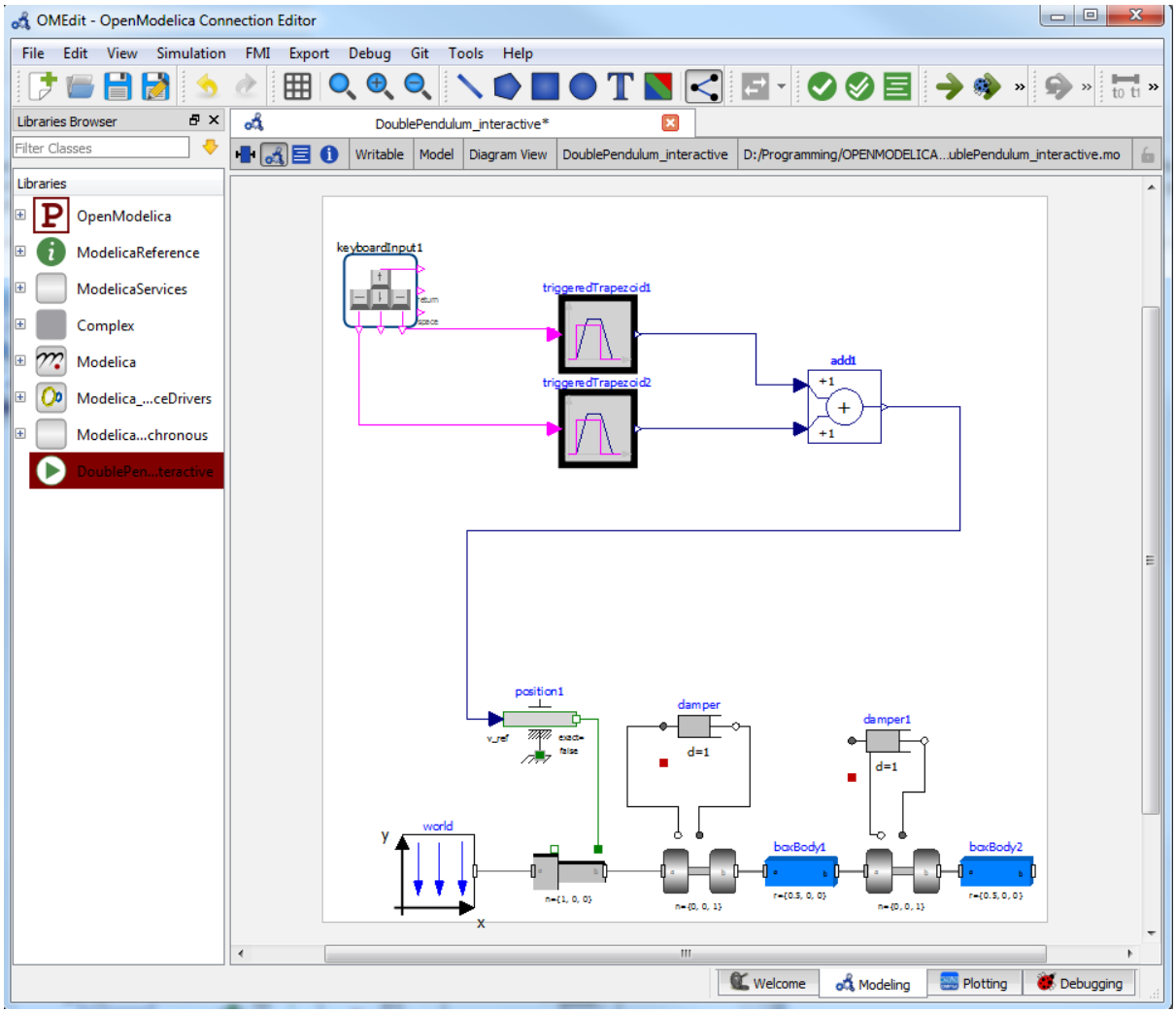
There are two main modes of execution: asynchronous and synchronous (simulate with steps). The difference is that in synchronous (step mode), OMEdit sends a command to the simulation for each step that the simulation should take. The asynchronous mode simply tells the simulation to run and samples variables values in real-time; if the simulation runs very fast, fewer values will be sampled.

When running in asynchronous mode, it is possible to simulate the model in real-time (with a scaling factor just like simulation flag *-rt*, but with the ability to change the scaling factor during the interactive simulation). In the synchronous mode, the speed of the simulation does not directly correspond to real-time.

## 3.22 How to Create User Defined Shapes - Icons

Users can create shapes of their own by using the shape creation tools available in OMEdit.

- *Line Tool* - Draws a line. A line is created with a minimum of two points. In order to create a line, the user first selects the line tool from the toolbar and then click on the Icon/Diagram View; this will start creating a line. If a user clicks again on the Icon/Diagram View a new line point is created. In order to finish the line creation, user has to double click on the Icon/Diagram View.
- *Polygon Tool* - Draws a polygon. A polygon is created in a similar fashion as a line is created. The only difference between a line and a polygon is that, if a polygon contains two points it will look like a line and if a polygon contains more than two points it will become a closed polygon shape.
- *Rectangle Tool* - Draws a rectangle. The rectangle only contains two points where first point indicates the starting point and the second point indicates the ending the point. In order to create rectangle, the user


OMEdit - OpenModelica Connection Editor
File Edit View Simulation FMI Export Debug Git Tools Help
Libraries Browser
Filter Classes
Libraries
OpenModelica
ModelicaReference
ModelicaServices
Complex
Modelica
Modelica_...ceDrivers
Modelica...chronous
DoublePen...teractive
DoublePendulum_interactive*
Writable
Model
Diagram View
DoublePendulum_interactive
D:/Programming/OPENMODELICA...ublePendulum_interactive.mo
keyboardInput1
triggeredTrapezoid1
triggeredTrapezoid2
add1
position1
damper
d=1
damper1
d=1
world
boxBody1
boxBody2
Welcome
Modeling
Plotting
Debugging

has to select the rectangle tool from the toolbar and then click on the Icon/Diagram View, this click will become the first point of rectangle. In order to finish the rectangle creation, the user has to click again on the Icon/Diagram View where he/she wants to finish the rectangle. The second click will become the second point of rectangle.

- *Ellipse Tool* - Draws an ellipse. The ellipse is created in a similar way as a rectangle is created.
- *Text Tool* - Draws a text label.
- *Bitmap Tool* - Draws a bitmap container.

The shape tools are located in the toolbar. See Figure 3.16.

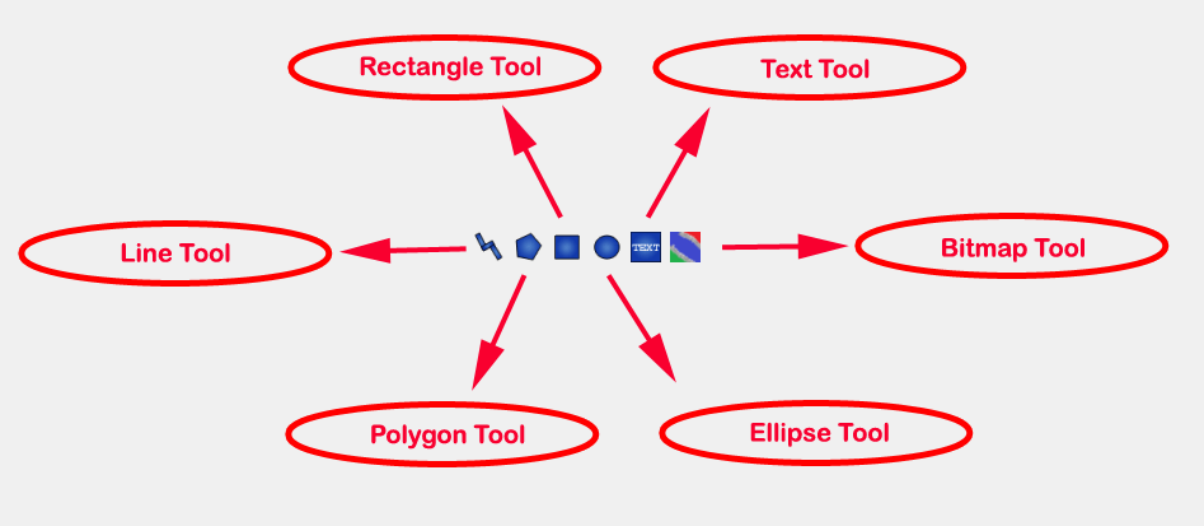



Figure 3.16: User defined shapes.

The user can select any of the shape tools and start drawing on the Icon/Diagram View. The shapes created on the Diagram View of Model Widget are part of the diagram and the shapes created on the Icon View will become the icon representation of the model.

For example, if a user creates a model with name testModel and add a rectangle using the rectangle tool and a polygon using the polygon tool, in the Icon View of the model. The model's Modelica Text will appear as follows:

```
model testModel
  annotation(Icon(graphics = {Rectangle(rotation = 0, lineColor = {0,0,255},␣
↪fillColor = {0,0,255}, pattern = LinePattern.Solid, fillPattern = FillPattern.None,␣
↪lineThickness = 0.25, extent = {{ -64.5,88},{63, -22.5}}),Polygon(points = {{ -47.5,
↪ -29.5},{52.5, -29.5},{4.5, -86},{ -47.5, -29.5}}, rotation = 0, lineColor = {0,0,
↪255}, fillColor = {0,0,255}, pattern = LinePattern.Solid, fillPattern = FillPattern.
↪None, lineThickness = 0.25)}));
end testModel;
```

In the above code snippet of testModel, the rectangle and a polygon are added to the icon annotation of the model. Similarly, any user defined shape drawn on a Diagram View of the model will be added to the diagram annotation of the model.

## 3.23 Global head section in documentation

If you want to use same styles or same JavaScript for the classes contained inside a package then you can define `__OpenModelica_infoHeader` annotation inside the `Documentation` annotation of a package. For example,

```
package P
  model M
```

(continues on next page)

(continued from previous page)

```
    annotation(Documentation(info="<html>
      <a href=\"javascript:HelloWorld()\">Click here</a>
    </html>"));
  end M;
 annotation(Documentation(__OpenModelica_infoHeader="
     <script type=\"text/javascript\">
       function HelloWorld() {
         alert(\"Hello World!\");
       }
     </script>"));
end P;
```

In the above example model `M` does not need to define the javascript function `HelloWorld`. It is only defined once at the package level using the `__OpenModelica_infoHeader` and then all classes contained in the package can use it.

In addition styles and JavaScript can be added from file locations using Modelica URIs. Example:

```
package P
  model M
    annotation(Documentation(info="<html>
      <a href=\"javascript:HelloWorld()\">Click here</a>
    </html>"));
  end M;
 annotation(Documentation(__OpenModelica_infoHeader="
     <script type=\"text/javascript\">
        src=\"modelica://P/Resources/hello.js\">
       }
     </script>"));
end P;
```

Where the file `Resources/hello.js` then contains:

```
function HelloWorld() {
  alert("Hello World!");
}
```

## 3.24 Options

OMEdit allows users to save several options which will be remembered across different sessions of OMEdit. The Options Dialog can be used for reading and writing the options.

### 3.24.1 General Options

- General
- *Language* - Sets the application language.
- *Working Directory* - Sets the application working directory. All files are generated in this directory.
- *Toolbar Icon Size* - Sets the size for toolbar icons.
- *Preserve User's GUI Customizations* - If true then OMEdit will remember its windows and toolbars positions and sizes.
- *Terminal Command* - Sets the terminal command. When user clicks on Tools > Open Terminal then this command is executed.
- *Terminal Command Arguments* - Sets the terminal command arguments.

- *Hide Variables Browser* - Hides the variable browser when switching away from plotting perspective.
- *Activate Access Annotations* - Activates the access annotations for the non-encrypted libraries. Access annotations are always active for encrypted libraries.
- *Create a model.bak-mo backup file when deleting a model*
- *Display errors/warnings when instantiating the graphical annotations* - if true then the errors/warnings are shown when using OMC API for graphical annotations.
- *Enable CRML Support* - Enables the CRML support. The user can create/open .crml files and translate them to Modelica.
- *Color Scheme* - *System*, *Light* or *Dark*. *System* follows the operating system color scheme (Qt 6.5 or later; light otherwise). The `--DarkMode=true` or `--DarkMode=false` command line option overrides this setting.
- Libraries Browser
- *Library Icon Size* - Sets the size for library icons.
- *Max. Library Icon Text Length to Show* - Sets the maximum text length that can be shown in the icon in Libraries Browser.
- *Show Protected Classes* - If enabled then Libraries Browser will also list the protected classes.
- *Show Hidden Classes if not encrypted* - If enabled then Libraries Browser will also list the hidden classes. Ignores the annotation(Protection(access = Access.hide))
- *Synchronize with Model Widget* - If enabled then Libraries Browser will scroll automatically to the active Model Widget i.e., the current model.
- Enable Auto Save - Enables/disables the auto save feature.
- *Auto Save interval* - Sets the auto save interval value. The minimum possible interval value is 60 seconds.
- Welcome Page
- *Horizontal View/Vertical View* - Sets the view mode for welcome page.
- *Show Latest News* - If enabled then the latest news from https://openmodelica.org are shown.
- *Recent Files and Latest News Size* - Sets the display size for recent files and latest news items.
- Optional Features
- *Disable new instance-based graphical editing of models* - Enables/disables the use of instance-based graphical editing. The instance-based graphical editing enables features like parameter-dependent conditional connectors, conditional dialog enable, replaceable classes and models, etc. It also provides much faster rendering than the previously implemented graphical editing framework. This feature has been thoroughly tested, but it could still have some issues; in case the graphical rendering of models fails (blank screen) or is not correct, you can disable the instance-based editing and fall back to the old editing framework. In that case, please open a ticket on the OpenModelica issue tracker so we can fix the issue for the next release.

### 3.24.2 Libraries Options

- General
- *OPENMODELICALIBRARY* - The list of paths searched while loading a library, i.e. the OPENMODELICALIBRARY environment variable (MODELICAPATH in the language specification). Paths are separated by `;` on Windows and `:` on Linux and macOS.
- System libraries loaded automatically on startup - The list of system libraries that are loaded on startup.
- *Load latest Modelica version on startup* - Is true then the latest available version of the Modelica Standard Library is always loaded along with its dependencies.
- User libraries loaded automatically on startup - The list of user libraries/files that are loaded on startup.

### 3.24.3 Text Editor Options

- Format
- *Line Ending* - Sets the file line ending.
- *Byte Order Mark (BOM)* - Sets the file BOM.
- Tabs and Indentation
- *Tab Policy* - Sets the tab policy to either spaces or tabs only.
- *Tab Size* - Sets the tab size.
- *Indent Size* - Sets the indent size.
- Syntax Highlight and Text Wrapping
  - *Enable Syntax Highlighting* - Enable/Disable the syntax highlighting.
  - *Enable Code Folding* - Enable/Disable the code folding. When code folding is enabled multi-line annotations are collapsed into a compact icon (a rectangle containing "...)"). A marker containing a "+" sign becomes available at the left-side of the involved line, allowing the code to be expanded/re-collapsed at will.
  - *Match Parentheses within Comments and Quotes* - Enable/Disable the matching of parentheses within comments and quotes.
  - *Enable Line Wrapping* - Enable/Disable the line wrapping.
- Autocomplete
- *Enable Autocomplete* - Enables/Disables the autocomplete.
- Font
- *Font Family* - Shows the names list of available fonts. Sets the font for the editor.
- *Font Size* - Sets the font size for the editor.

### 3.24.4 Modelica Editor Options

- *Preserve Text Indentation* - If true then uses *diffModelicaFileListings* API call otherwise uses the OMC pretty-printing.
- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.5 Modelica Script Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.6 MetaModelica Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.7 SSP Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.8 CRML Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.9 C/C++ Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.10 HTML Editor Options

- Colors
- *Items* - List of categories used of syntax highlighting the code.
- *Item Color* - Sets the color for the selected item.
- *Preview* - Shows the demo of the syntax highlighting.

### 3.24.11 Graphical Views Options

- General
  - Modeling View Mode
  - *Tabbed View/SubWindow View* - Sets the view mode for modeling.
  - Default View
  - *Icon View/DiagramView/Modelica Text View/Documentation View* - If no preferredView annotation is defined then this setting is used to show the respective view when user double clicks on the class in the Libraries Browser.
  - *Move connectors together on both icon and diagram layers*

### 3.24.12 Simulation Options

- Simulation
  - Translation Flags
  - *Matching Algorithm* - sets the matching algorithm for simulation.
  - *Index Reduction Method* - sets the index reduction method for simulation.
  - *Show additional information from the initialization process* - prints the information from the initialization process

- *Evaluate all parameters (faster simulation, cannot change them at runtime)* - makes the simulation more efficient but you have to recompile the model if you want to change the parameter instead of re-simulate.
- *Enable analytical jacobian for non-linear strong components* - enables analytical jacobian for non-linear strong components without user-defined function calls.
- *Enable parallelization of independent systems of equations (Experimental)*
- *Enable old frontend for code generation*
- *Enable FMU Import* - See *FMI Import - SSP*.
- *Profiling* - creates a profiling HTML file.
- *Additional Translation Flags* - sets the translation flags see *Options*
- *Target Language* - sets the target language in which the code is generated.
- *Target Build* - sets the target build that is used to compile the generated code.
- *C Compiler* - sets the C compiler for compiling the generated code.
- *CXX Compiler* - sets the CXX compiler for compiling the generated code.
- *Use static linking* - if true then static linking is used for simulation executable. The default is dynamic linking. This option is only available on Windows.
- *Post compilation command* - if not empty allows to run a command after the compilation step. A possible use-case is to be able to sign the binaries before execution to comply with the security policy. The command is run in the same folder where the simulation executable is created. The interpreter executable must be passed to run shell scripts, eg on Windows: *powershell.exe -File C:script.ps1*
- *Ignore __OpenModelica_commandLineOptions annotation* - if true then ignores the __OpenModelica_commandLineOptions annotation while running the simulation.
- *Ignore __OpenModelica_simulationFlags annotation* - if true then ignores the __OpenModelica_simulationFlags annotation while running the simulation.
- *Save class before simulation* - if true then always saves the class before running the simulation.
- *Switch to plotting perspective after simulation* - if true then GUI always switches to plotting perspective after the simulation.
- *Close completed simulation output windows before simulation* - if true then the completed simulation output windows are closed before starting a new simulation.
- *Delete intermediate compilation files* - if true then the files generated during the compilation are deleted automatically.
- *Delete entire simulation directory of the model when OMEdit is closed* - if true then the entire simulation directory is deleted on quit.
- Output
- *Structured* - Shows the simulation output in the form of tree structure.
- *Formatted Text* - Shows the simulation output in the form of formatted text.
- *Display Limit* - Sets the display limit for simulation output. A link to log file is shown once the limit is reached.

### 3.24.13 Messages Options

- General
- *Output Size* - Specifies the maximum number of rows the Message Browser may have. If there are more rows then the rows are removed from the beginning.
- *Reset messages number before simulation* - Resets the messages counter before starting the simulation.

- *Clear messages browser before checking, instantiation & simulation* - If enabled then the message browser is cleared before checking, instantiation & simulation of model.
- *Do not automatically enlarge message browser when a new message is available* - If enabled then the message browser will not be enlarged instead the tabbar shown will start blinking indicating that a new message is available.
- Font and Colors
- *Font Family* - Sets the font for the messages.
- *Font Size* - Sets the font size for the messages.
- *Notification Color* - Sets the text color for notification messages.
- *Warning Color* - Sets the text color for warning messages.
- *Error Color* - Sets the text color for error messages.

### 3.24.14 Notifications Options

- Notifications
  - *Always quit without prompt* - If true then OMEdit will quit without prompting the user.
  - *Show item dropped on itself message* - If true then a message will pop-up when a class is dragged and dropped on itself.
  - *Show model is partial and component is added as replaceable message* - If true then a message will pop-up when a partial class is added to another class.
  - *Show component is declared as inner message* - If true then a message will pop-up when an inner component is added to another class.
  - *Show save model for bitmap insertion message* - If true then a message will pop-up when user tries to insert a bitmap from a local directory to an unsaved class.
  - *Always ask for the dragged component name* - If true then a message will pop-up when user drag & drop the component on the graphical view.
  - *Always ask for what to do with the text editor error* - If true then a message will always pop-up when there is an error in the text editor.
  - If new frontend for code generation fails
  - *Always ask for old frontend*
  - *Try with old frontend once*
  - *Switch to old frontend permanently*
  - *Keep using new frontend*

### 3.24.15 Line Style Options

- Line Style
- *Color* - Sets the line color.
- *Pattern* - Sets the line pattern.
- *Thickness* - Sets the line thickness.
- *Start Arrow* - Sets the line start arrow.
- *End Arrow* - Sets the line end arrow.
- *Arrow Size* - Sets the start and end arrow size.
- *Smooth* - If true then the line is drawn as a Bezier curve.

### 3.24.16 Fill Style Options

- Fill Style
- *Color* - Sets the fill color.
- *Pattern* - Sets the fill pattern.

### 3.24.17 Plotting Options

- General
- *Auto Scale* - Sets whether to auto scale the plots or not.
- *Prefix Units* - Automatically pick the right prefix for units for the new plot windows. For existing plot windows use the *Plot Window Menu*.
- Plotting View Mode
- *Tabbed View/SubWindow View* - Sets the view mode for plotting.
- Curve Style
- *Pattern* - Sets the curve pattern.
- *Thickness* - Sets the curve thickness.
- Variable filter
- *Filter Interval* - Delay in filtering the variables. Set the value to 0 if you don't want any delay.
- Font Size - sets the font size for plot window items
- *Title*
- *Vertical Axis Title*
- *Vertical Axis Numbers*
- *Horizontal Axis Title*
- *Horizontal Axis Numbers*
- *Footer*
- *Legend*

### 3.24.18 Figaro Options

- Figaro
- *Figaro Library* - the Figaro library file path.
- *Tree generation options* - the Figaro tree generation options file path.
- *Figaro Processor* - the Figaro processor location.

### 3.24.19 CRML Options

- CRML
- *Compiler Jar* - the compiler jar file of CRML.
- *Compiler Arguments* - arugments to the compiler process.
- *Processor* - the CRML translator.
- *Modelica Library Paths* - list of Modelica library paths that are needed to run the translated model.

### 3.24.20 Debugger Options

- Algorithmic Debugger
- *GDB Path* - the gnu debugger path
- *GDB Command Timeout* - timeout for gdb commands.
- *GDB Output Limit* - limits the GDB output to N characters.
- *Display C frames* - if true then shows the C stack frames.
- *Display unknown frames* - if true then shows the unknown stack frames. Unknown stack frames means frames whose file path is unknown.
- *Clear old output on a new run* - if true then clears the output window on new run.
- *Clear old log on new run* - if true then clears the log window on new run.
- Transformational Debugger
- *Always show Transformational Debugger after compilation* - if true then always open the Transformational Debugger window after model compilation.
- *Generate operations in the info xml* - if true then adds the operations information in the info xml file.

### 3.24.21 FMI Options

- Export
  - Version
    - *1.0* - Sets the FMI export version to 1.0.

> **Warning**
>
> Deprecated and will be removed in a future version of OpenModelica

    - *2.0* - Sets the FMI export version to 2.0.x
    - *3.0* - Sets the FMI export version to 3.0.x

> **Warning**
>
> Experimental support

  - Type
  - *Model Exchange* - Sets the FMI export type to Model Exchange (ME).
  - *Co-Simulation* - Sets the FMI export type to Co-Simulation (CS).
  - *Scheduled Execution* - Sets the FMI export type to Scheduled Execution (SE), needs at least FMI version 3.0.
  - *Model Exchange and Co-Simulation* - Sets the FMI export type to Model Exchange and Co-Simulation.
  - *FMU Name* - Sets a prefix for generated FMU file.
  - *Move FMU* - Moves the generated FMU to a specified path.
  - Platforms: See *Platforms*.
  - Solver for Co-Simulation
  - *Explicit Euler*
  - *CVODE*

- *Model Description Filters* - Sets the variable filter for model description file, see *--fmifilter*.
- *Include Modelica based resources via loadResource*
- *Include Source Code* - Sets if the exported FMU can contain source code. Model Description Filter "blackBox" will override this, because black box FMUs do never contain their source code.
- *Generate Debug Symbols* - Generates a FMU with debug symbols.

- Import
- *Delete FMU directory and generated model when OMEdit is closed* - If true then the temporary FMU directory that is created for importing the FMU will be deleted.

### 3.24.22 OMSimulator/SSP Options

- General
- *Command Line Options* - sets the OMSimulator command line options.
- *Logging Level* - OMSimulator logging level.

### 3.24.23 Sensitivity Optimization Options

- General
- *OMSens Backend Path* - sets the OMSens backend.
- *python* - sets the Python executable to run OMSens scripts.

### 3.24.24 Language Server Options

OMEdit is a client of the *Modelica Language Server* and provides:

- **Hover** - documentation of the symbol under the mouse as a tooltip.
- **Go to definition** - Ctrl+Click a symbol, or use *Go to Definition* from the right-click menu, to jump to its declaration, also across files. OMEdit falls back to its built-in class navigation if the server cannot resolve the symbol.

The feature is on by default and can be turned off here.

- Language Server Protocol (LSP)
  - *Language Server Protocol (LSP)* - when this group is checked, OMEdit starts the language server process and connects to it.
  - *Server Executable* - path to the language server executable. Leave it blank (recommended) to run the server installed with OpenModelica. Use *Download...* below to fetch a different release, *Browse* to select a server you already have, or *Auto Detect* to search for one.
  - *Restart Server* - stops the language server and starts it again. The library list is kept in step with OMC automatically, so this is only needed if the server stopped after repeated crashes, or if a library changed on disk. It acts immediately; changes to the fields above are applied when you click *OK*.
  - *Download...* - fetches a standalone language server and points *Server Executable* at it. The drop-down next to the button chooses the release: the version marked *(recommended)* is the one installed with OMEdit, and *Latest release* takes the newest release published on GitHub.

  The libraries the server searches are the ones loaded in OMEdit; there is no separate list to maintain. Loading a library makes it resolvable for *Go to Definition* and hover, and unloading it removes it again.

  - *Log language server messages to the Messages Browser* - when checked, messages from the language server are shown in the Messages Browser, prefixed with `LSP`.

Hover information is shown as a tooltip. Navigation works both with Ctrl+Click and from the editor right-click menu (*Go to Definition*, marked with the language server icon while the server is running). Enabling or disabling the language server takes effect immediately; a restart is not required.

**The language server installed with OpenModelica**

OpenModelica installs a Modelica language server alongside OMEdit, and it is what runs when *Server Executable* is left blank - which is the default, so there is nothing to set up. It brings its own runtime, so nothing else has to be installed.

It is installed in `lib/omedit/ls/modelica` (`share/omedit/ls/modelica` on Windows) as three files: the server itself and the two `.wasm` files it parses Modelica with. They belong together - a server without them starts, and then answers nothing.

**Using a different server**

*Download...* on the options page fetches another release of the same standalone server and points *Server Executable* at it. It is installed under your user configuration directory, beside `omedit.ini`, so no administrator rights are needed.

You can also point *Server Executable* at a server you built yourself - which is how to try a change to the language server before it is released. Keep `tree-sitter-modelica.wasm` and `web-tree-sitter.wasm` in the same directory as the binary; without them the server starts but reports nothing, and OMEdit says so in the Messages Browser.

**If the server stops**

If the server process exits unexpectedly, OMEdit restarts it automatically after a short delay, up to 5 times within a 3 minute window. Past that it stops retrying and reports the failure as an error message. Every crash and restart attempt is appended to `languageserver_crash.log` in OMEdit's temporary directory (*Tools* > *Open Temporary Directory*), so the log can be attached to a bug report.

**The language server is a separate project.** modelica-language-server has its own repository and issue tracker. File LSP-behavior bugs there: bad hover text, missed definitions, the process crashing. OMEdit failing to start or manage the process is still an OMEdit issue. The same server is also available for Visual Studio Code and other editors, see *Modelica Language Server*.

## 3.25 __OpenModelica_commandLineOptions Annotation

OpenModelica specific annotation to define the command line options needed to simulate the model. For example if you always want to simulate the model with a specific matching algorithm and index reduction method instead of the default ones then you can write the following code,

```
model Test
  annotation(__OpenModelica_commandLineOptions = "--matchingAlgorithm=BFSB --
↪indexReductionMethod=dynamicStateSelection");
end Test;
```

The annotation is a space separated list of options where each option is either just a command line flag or a flag with a value.

In OMEdit open the Simulation Setup and set the Translation Flags then in the bottom check *Save translation flags inside model i.e., __OpenModelica_commandLineOptions annotation* and click on OK.

If you want to ignore this annotation then use *setCommandLineOptions("--ignoreCommandLineOptionsAnnotation=true")*. In OMEdit *Tools* > *Options* > *Simulation* check *Ignore __OpenModelica_commandLineOptions annotation*.

## 3.26 __OpenModelica_simulationFlags Annotation

OpenModelica specific annotation to define the simulation options needed to simulate the model. For example if you always want to simulate the model with a specific solver instead of the default DASSL and would also like to see the cpu time then you can write the following code,

```
model Test
  annotation(__OpenModelica_simulationFlags(s = "ida", cpu = "()"));
end Test;
```

The annotation is a comma separated list of options where each option is a simulation flag with a value. For flags that doesn't have any value use *()* (See the above code example).

In OMEdit open the Simulation Setup and set the Simulation Flags then in the bottom check *Save simulation flags inside model i.e., __OpenModelica_simulationFlags annotation* and click on OK.

If you want to ignore this annotation then use *setCommandLineOptions("--ignoreSimulationFlagsAnnotation=true")*. In OMEdit *Tools > Options > Simulation* check *Ignore __OpenModelica_simulationFlags annotation*.

## 3.27 Global and Local Flags

There is a large number of optional settings and flags to influence the way OpenModelica generates the simulation code (*Compiler flags*, a.k.a. Translation flags or Command Line Options) and the way the simulation executable is run (*Simulation Flags*).

The global default settings can be accessed and changed with the *Tools > Options* menu. It is also possible to reset them to factory state by clicking on the `Reset` button of the *Tools > Options* dialog window.

When you start OMEdit and you simulate a model for the first time, the model-specific simulation session settings are initialized by copying the global default settings, and then by applying any further settings that are saved in the model within OpenModelica-specific `__OpenModelica_commandLineOptions` and `__OpenModelica_simulationFlags` annotations. Note that the latter may partially override the former, if they give different values to the same flags.

You can change those model-specific settings at will with the Simulation Setup window. Any change you make will be remembered until the end of the simulation session, i.e. until you close OMEdit. This is very useful to experiment with different settings and find the optimal ones, or to investigate bugs by turning on logging options, etc. If you check the `Save translation flags` and `Save simulation flags` options in the simulation setup, those settings will be saved in the model within the corresponding OpenModelica-specific annotations, so that you can get the same behavior when you start a new session later on, or if someone else loads the model on a different computer. Otherwise, all of those changes will be forgotten when you exit OMEdit.

If you change the global default settings after running some models, the simulation settings of those models will be reset as if you closed OMEdit and restarted a new session: the new global options will first be applied, and then any further setting saved in the OpenModelica-specific annotations will be applied, possibly overriding the global options if the same flags get different values from the annotations. Any model-specific settings that you may have changed with Simulation Setup up to that point will be lost, unless you saved them in the OpenModelica-specific annotations before changing the global default settings.

## 3.28 Debugger

For debugging capability, see *Debugging*.

## 3.29 Editing Modelica Standard Library

By default OMEdit loads the Modelica Standard Library (MSL) as a system library. System libraries are read-only. If you want to edit MSL you need to load it as user library instead of system library. We don't recommend editing MSL but if you really need to and understand the consequences then follow these steps,

- Go to *Tools* > *Options* > *Libraries*.
- Remove Modelica & ModelicaReference from list of system libraries.
- Uncheck *force loading of Modelica Standard Library*.
- Add *$OPENMODELICAHOME/lib/omlibrary/Modelica X.X/package.mo* under user libraries.
- Restart OMEdit.

## 3.30 Install Library

A new library can be installed with the help of the *package manager*. Click *File->Manage Libraries->Install Library* to open the install library dialog. OMEdit lists the libraries that are available for installation through the package manager.

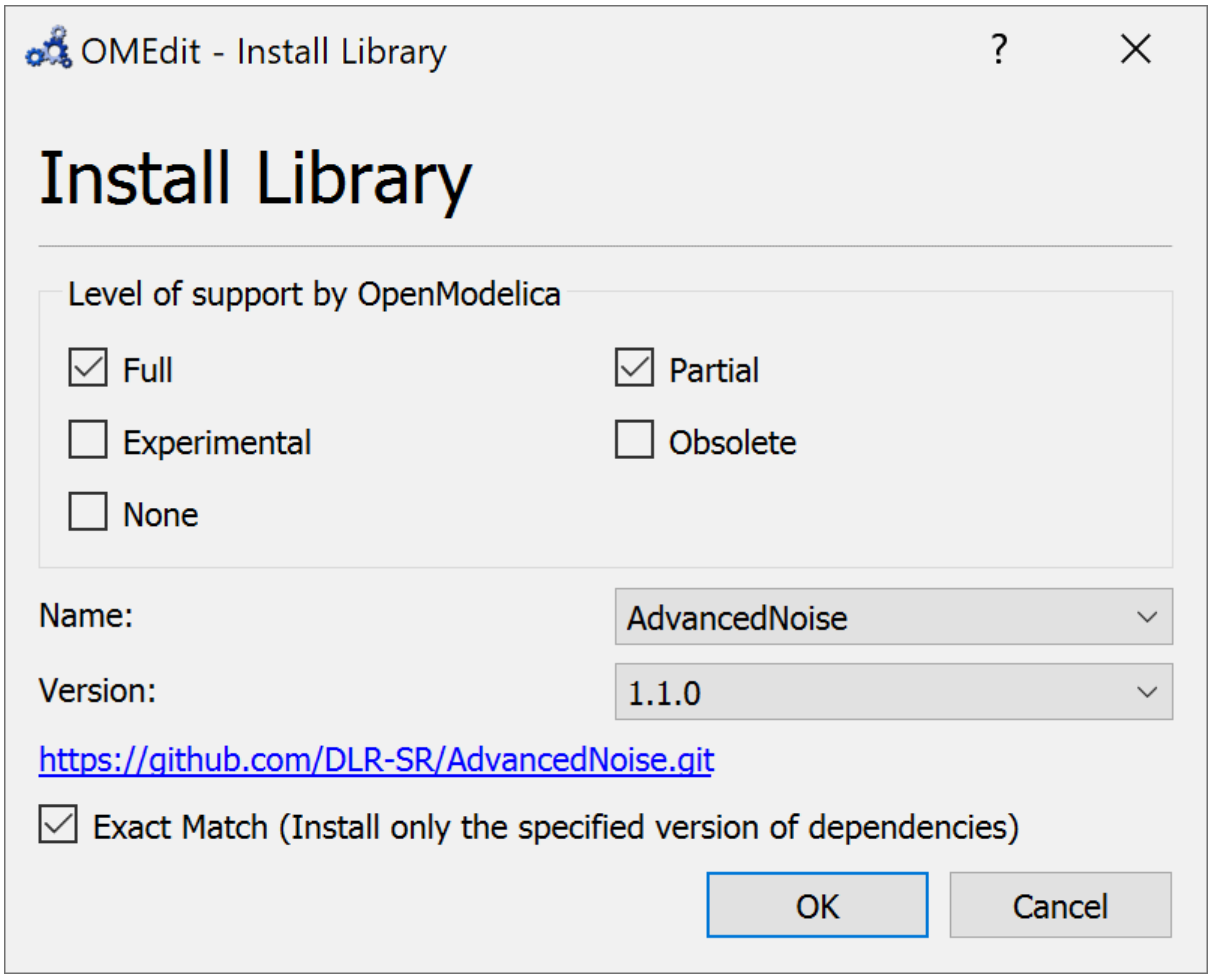



Figure 3.17: Install Library.

## 3.31 Convert Libraries using Conversion Scripts

In order to convert the libraries right-click the model/package in the *Libraries Browser* and choose *Convert to newer versions of used libraries*. OMEdit will read the used libraries from the uses-annotation and list any new version of the library that provide the conversion using the conversion script.

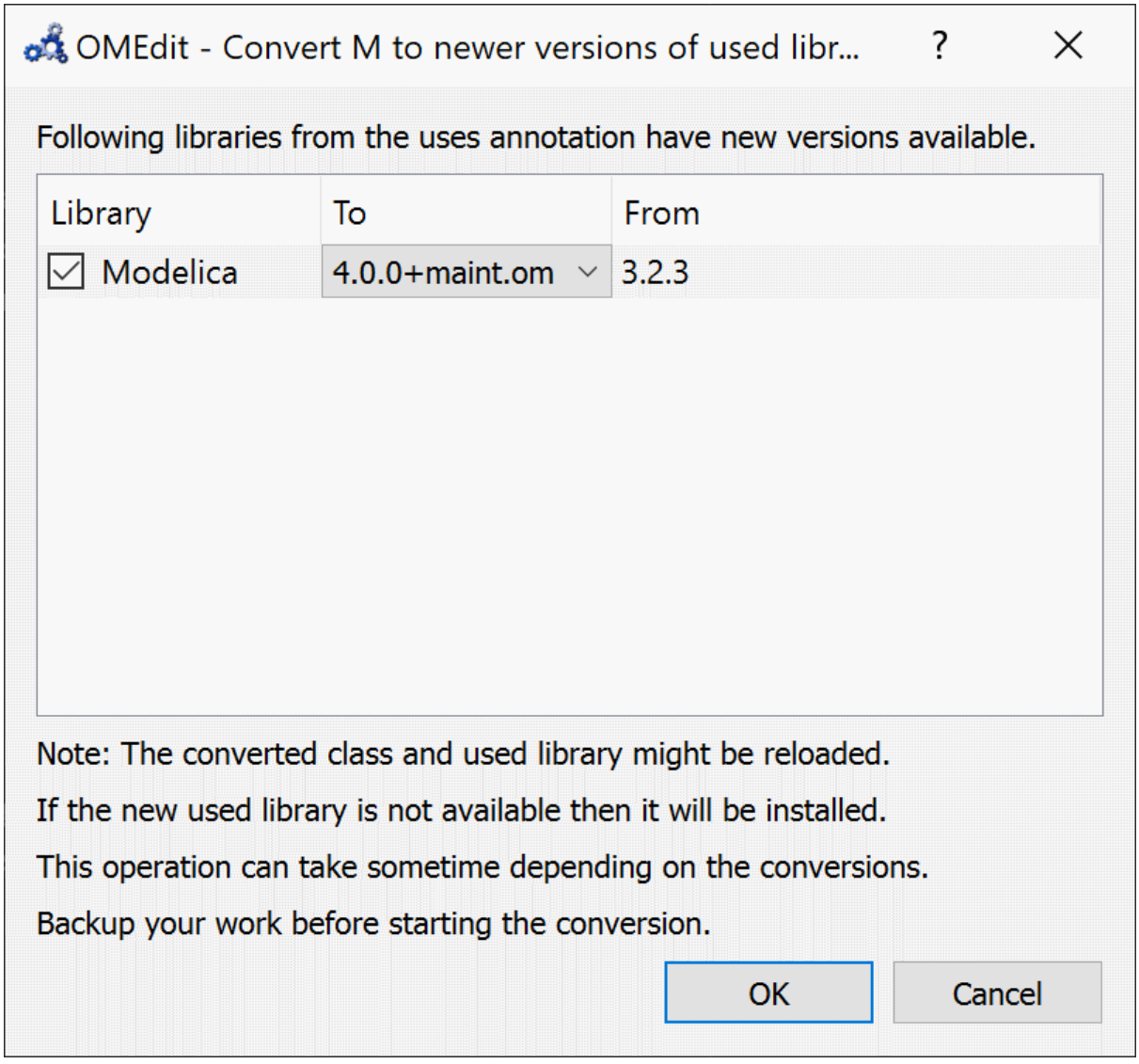



Figure 3.18: Converts the model/package to newer version of used libraries.

## 3.32 State Machines

### 3.32.1 Creating a New Modelica State Class

Follow the same steps as defined in *Creating a New Modelica Class*. Additionally make sure you check the *State* checkbox.

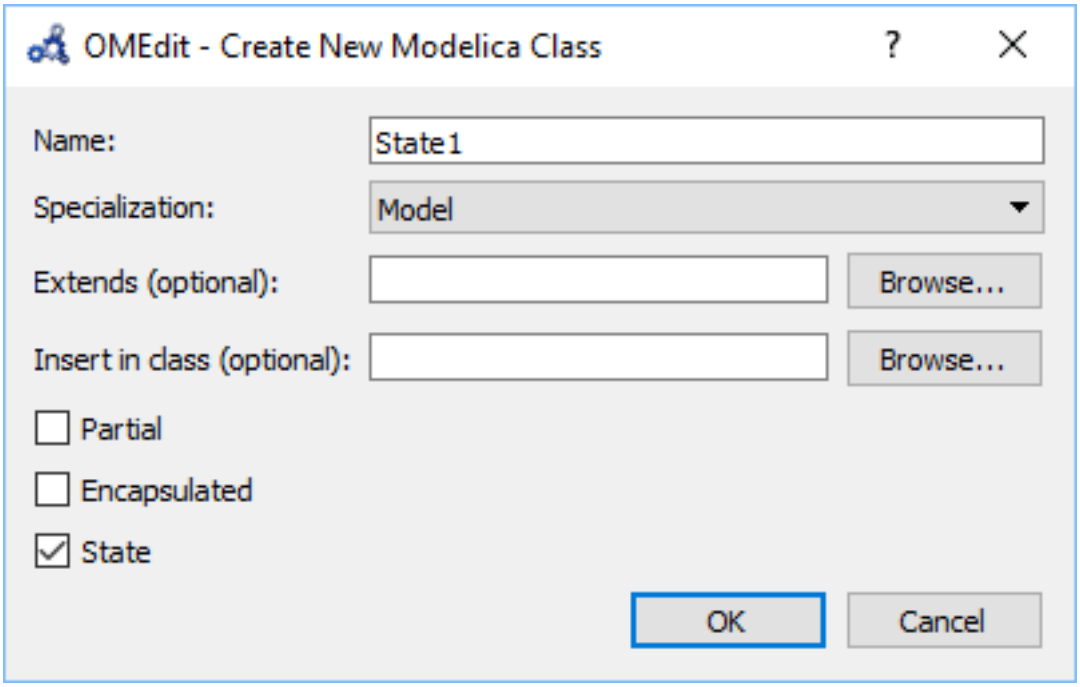



Figure 3.19: Creating a new Modelica state.

### 3.32.2 Making Transitions

In order to make a transition from one state to another the user first needs to enable the transition mode ( ) from the toolbar.

Move the mouse over the state. The mouse cursor will change from arrow cursor to cross cursor. To start the transition press left button and move while keeping the button pressed. Now release the left button. Move towards the end state and click when cursor changes to cross cursor.

A *Create Transition* dialog box will appear which allows you to set the transition attributes. Cancelling the dialog will cancel the transition.

Double click the transition or right click and choose *Edit Transition* to modify the transition attributes.

### 3.32.3 State Machines Simulation

Support for Modelica state machines was added in the Modelica Language Specification v3.3. A subtle problem can occur if Modelica v3.2 libraries are loaded, e.g., the Modelica Standard Library v3.2.2, because in this case OMC automatically switches into Modelica v3.2 compatibility mode. Trying to simulate a state machine in Modelica v3.2 compatibility mode results in an error. It is possible to use the OMC flag *--std=latest* in order to ensure (at least) Modelica v3.3 support. In OMEdit this can be achieved by setting that flag in the *Tools* > *Options* > *Simulation* dialog.

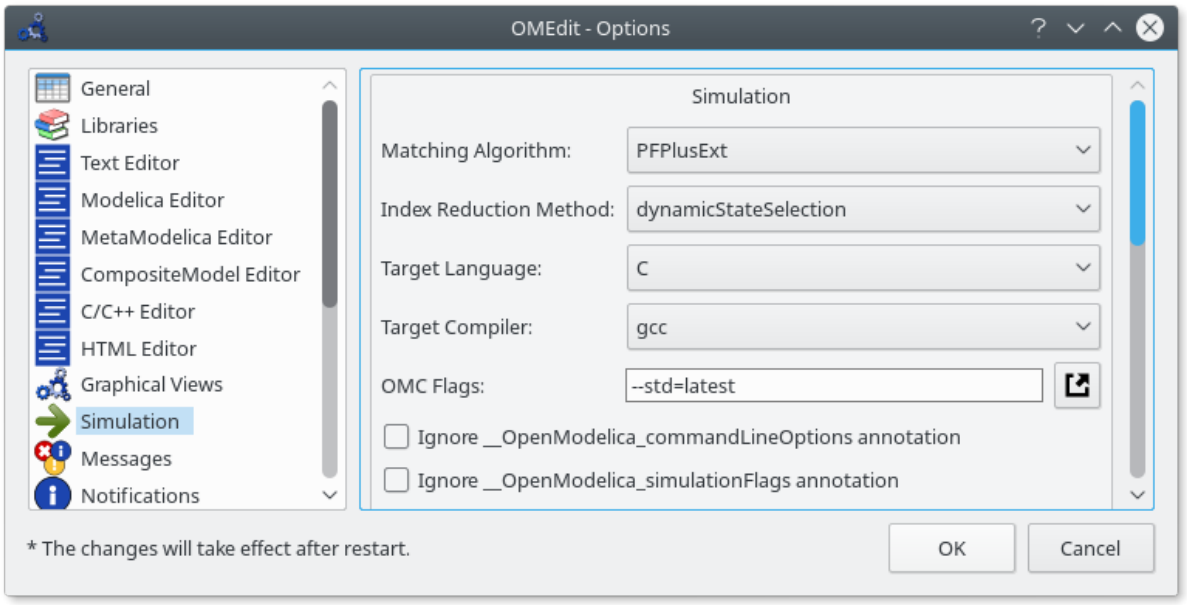



Figure 3.20: Ensure (at least) Modelica v3.3 support.

### 3.32.4 State Machines Debugger

Modelica state machines debugger is implemented as a visualization, which allows the user to run the state machines simulation as an animation.

A special Diagram Window is developed to visualize the active and inactive states. The active and inactive value of the states are stored in the OpenModelica simulation result file. After the successful simulation, of the state machine model, OMEdit reads the start, stop time values, and initializes the visualization controls accordingly.

The controls allows the easy manipulation of the visualization,

- Rewind - resets the visualization to start.
- Play - starts the visualization.
- Pause - pauses the visualization.
- Time - allows the user to jump at any specific time.
- Speed - speed of the visualization.
- Slider - controls the time.

The visualization is based on the simulation result file. All three formats of the simulation result file are supported i.e., mat, csv and plt where mat is a matlab file format, csv is a comma separated file and plt is an ordered text file.

## 3.33 Using OMEdit as Text Editor

OMEdit can be be used as a Text editor. Currently support for editing MetaModelica,Modelica and C/C++ are available with syntax highlighting and autocompletion of keywords and types. Additionaly the Modelica and MetaModelica files are provided with autocompletion of code-snippets along with keywords and types. The users can load the directory from file menu *File > Open Directory*. which opens the Directory structure in the Libraries-browser.

After the directory is opened in the Libraries-browser, the users can expand the directory structure and click the file which opens in the texteditor.

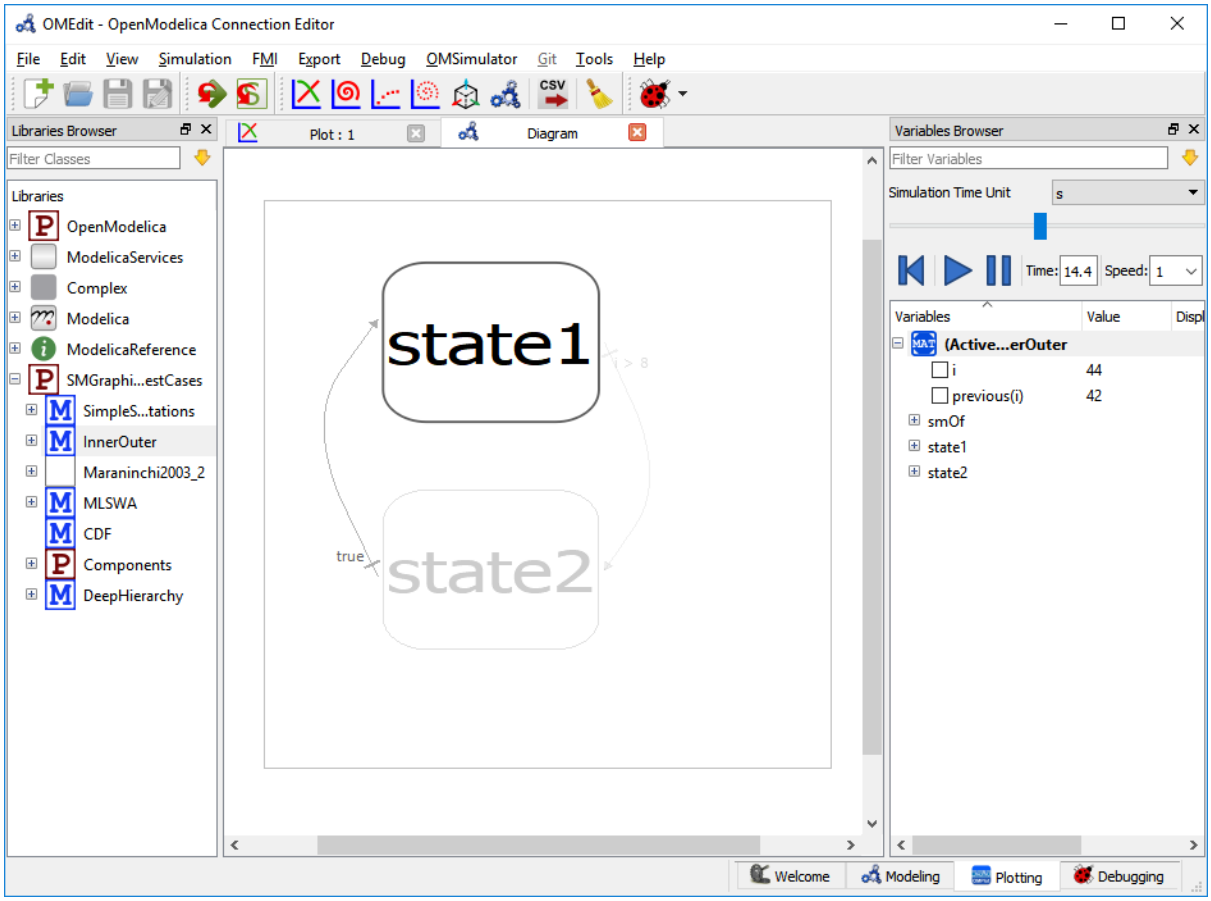



Figure 3.21: State machine debugger in OMEdit.

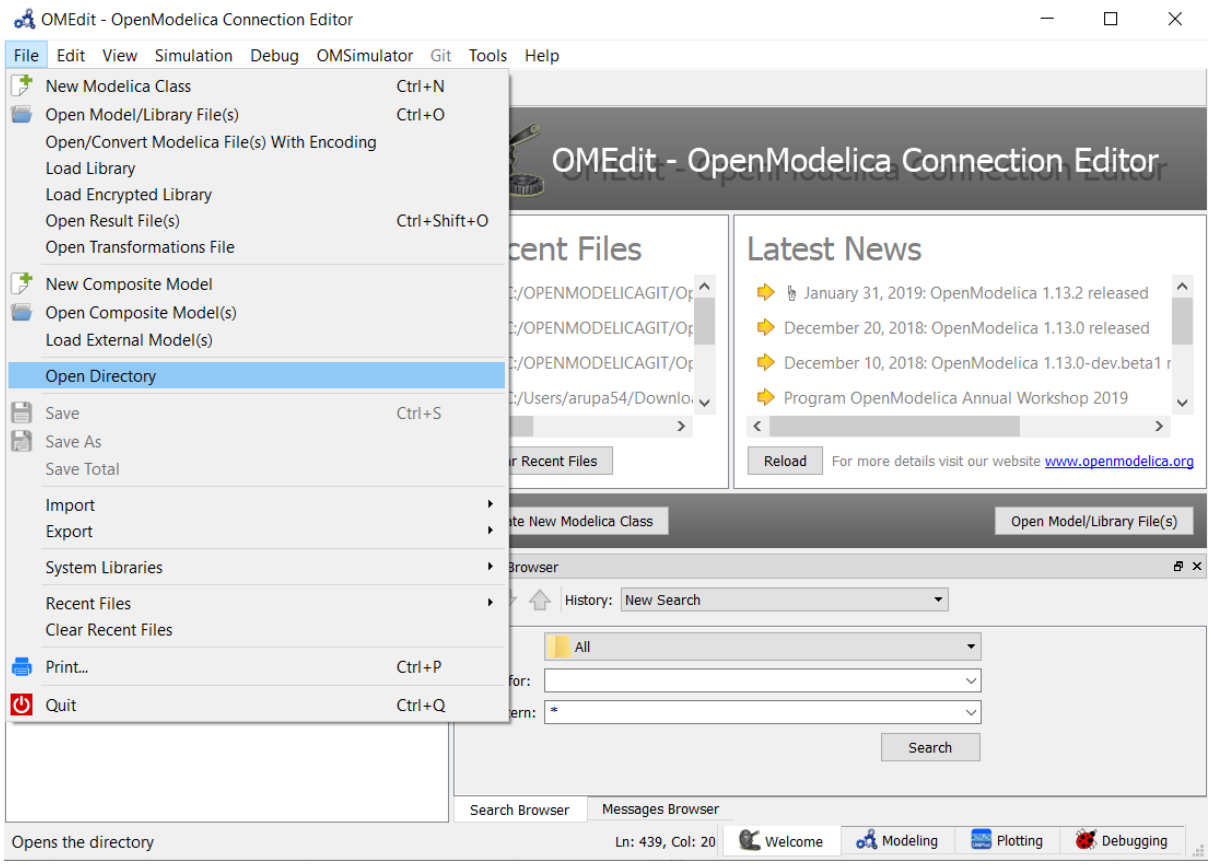



Figure 3.22: open-directory

### 3.33.1 Advanced Search

Support to search in OMEdit texteditor is available. The search browser can be enabled by selecting View > Windows > Search browser or through shortcut keys (ctrl+h).

The users can start the search by loading the directory they want to search and fill in the text to be searched for and file pattern if needed and click the search button.

After the search is completed the results are presented to the users in a separate window, The search results contains the following

1) The name of the files where the searched word is matched
2) The line number and text of the matched word.

The users can click the line number or the matched text and it will automatically open the file in the texteditor and move the cursor to matched line number of the text.

The users can perform multiple searches and go back to old search results using search histroy option.

## 3.34 Temporary Directory, Log Files and Working Directory

On Unix/Linux systems temporary directory is the path in the *TMPDIR* environment variable or */tmp* if *TMPDIR* is not defined appended with directory paths *OpenModelica<USERNAME>/OMEdit* so the complete path is usually */tmp/OpenModelica<USERNAME>/OMEdit*.

On Windows its the path in the *TEMP* or *TMP* environment variable appended with directory paths *OpenModelica/OMEdit* so the complete path is usually *%TEMP%/OpenModelica/OMEdit*.

All the log files are always generated in the temporary directory. Choose *Tools* > *Open Temporary Directory* to open the temporary directory.

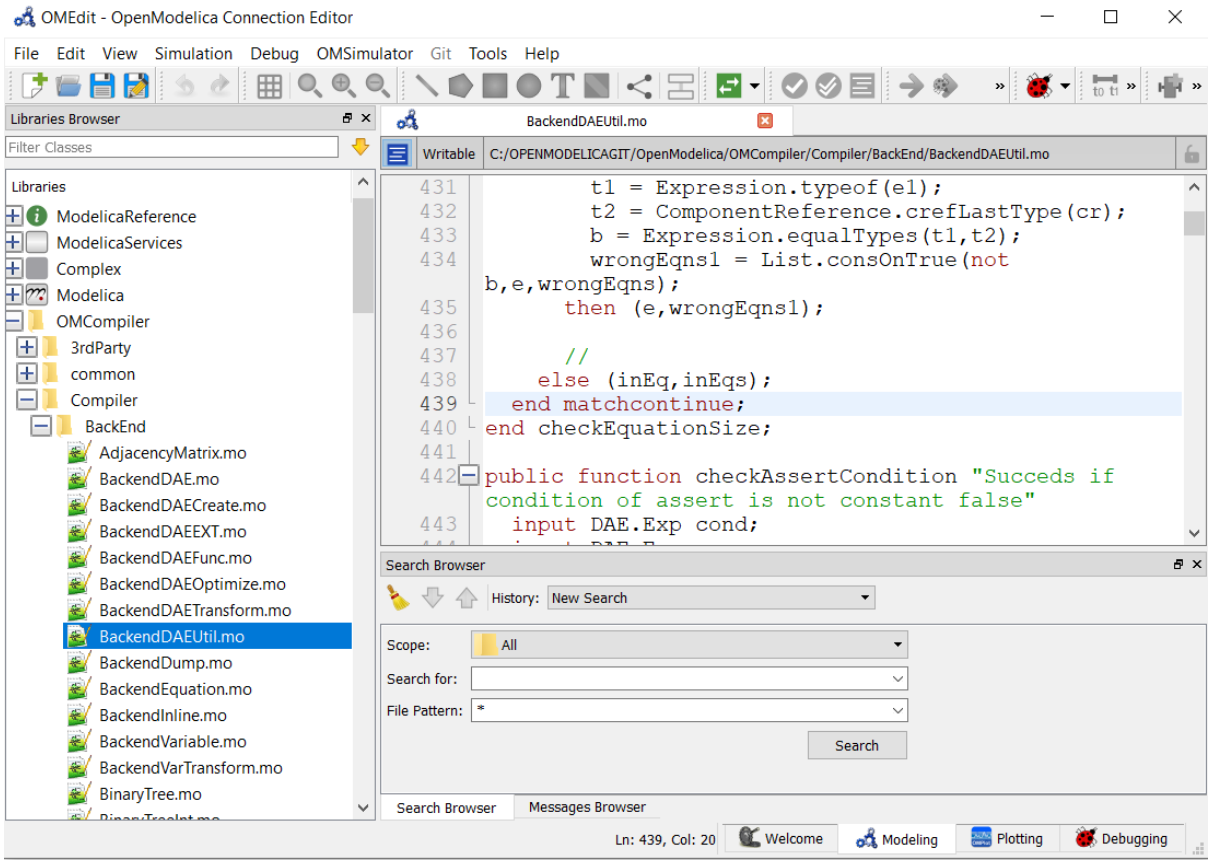



Figure 3.23: openfile in texteditor

By default the working directory has the same path as the temporary directory. You can change the working directory from *Tools* > *Options* > *General* see section *General Options*.

For each simulation a new directory with the model name is created in the working directory and then all the simulation intermediate and results files are generated in it.

## 3.35 High DPI Settings

When the text is too big / too small to read there are options to change the font size used in OMEdit, see *Text Editor Options*.

If you are using a high-resolution screen (1080p, 4k and more) and the app is blurry or the overall proportions of the different windows are off, it can help to change the DPI settings.

On Windows it is possible to change the scaling factor to adjust the size of text, apps and other times, but the default setting might not be appropriate for OMEdit e.g., on compact notebooks with high resolution screens.

You can either change the scaling factor for the whole Windows system or only change the scaling used for OMEdit. This is done by changing the *Compatibility* settings for *High DPI settings for OMEdit.exe* with the following steps:

1. Press *Windows-Key* and type *OpenModelica Connection Editor* and right-click on the app and *Open file location*, Figure 3.28.
2. Right-click on *OpenModelica Connection Editor* and open *Properties*.
3. In the properties window go to tab *Compatibility* and open *Change high DPI settings*. In the *High DPI settings for OMEdit.exe* choose *Use the settings to fix scaling problems for this program instead of the one in Settings* and *Override high DPI scaling behavior.Scaling performed by:* and choose *System* from the drop-down menu, Figure 3.29.

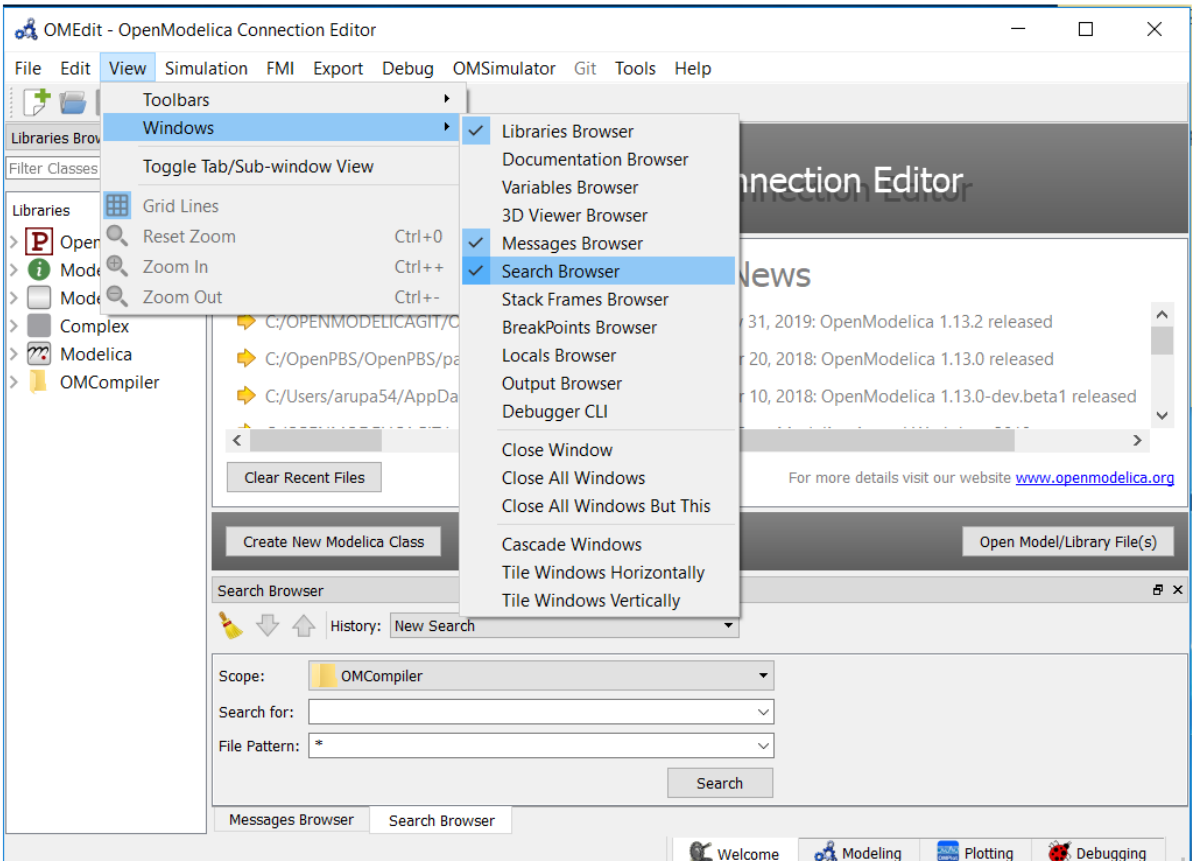



Figure 3.24: Enable omedit search browser

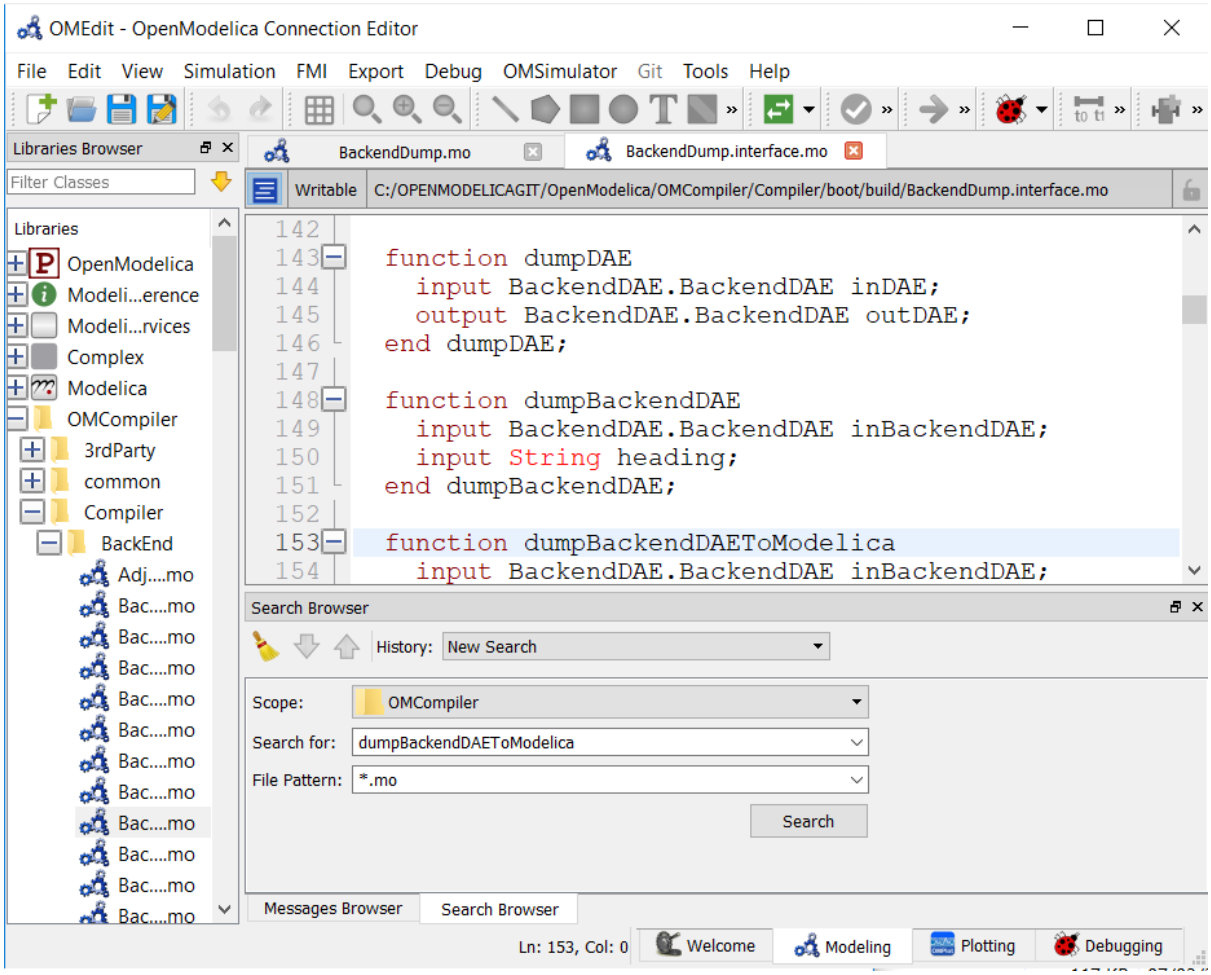



Figure 3.25: Start search in search browser

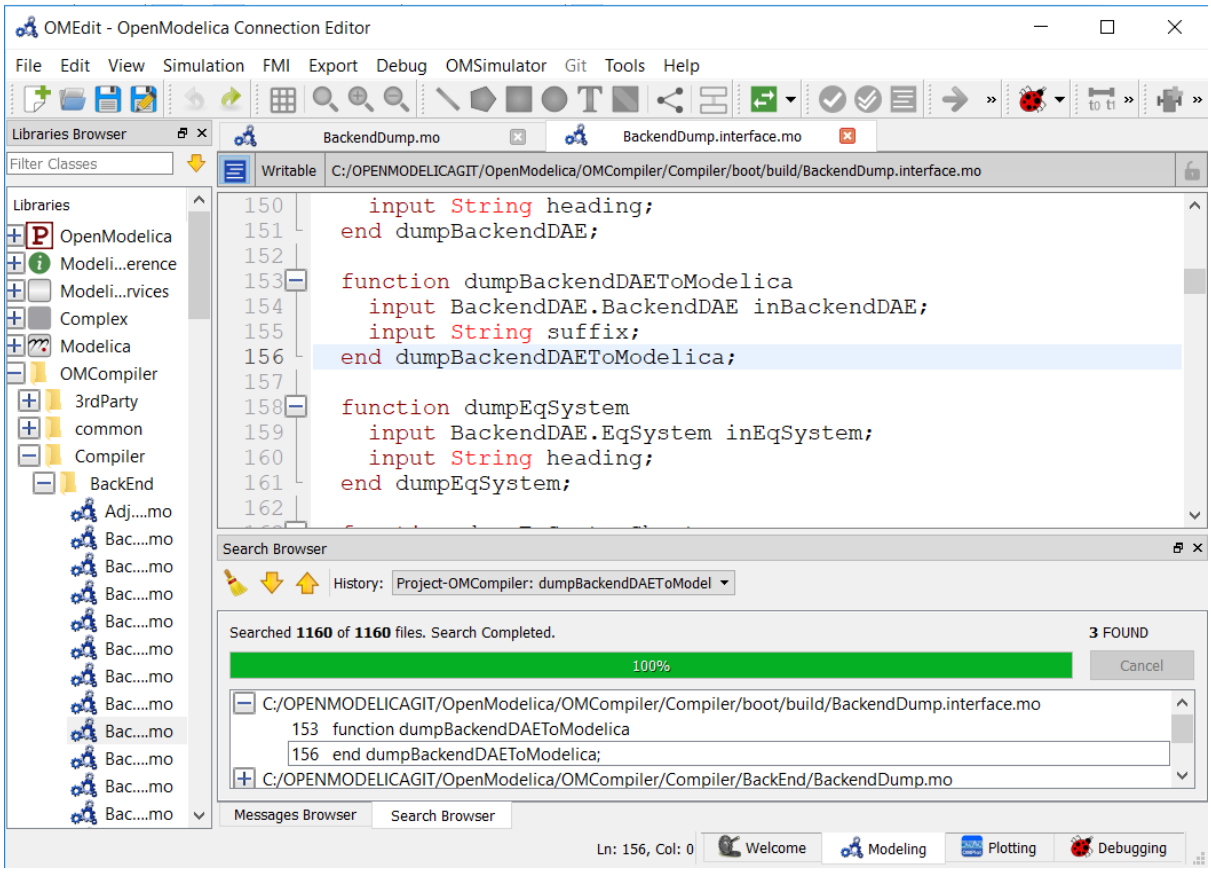



Figure 3.26: Search Results

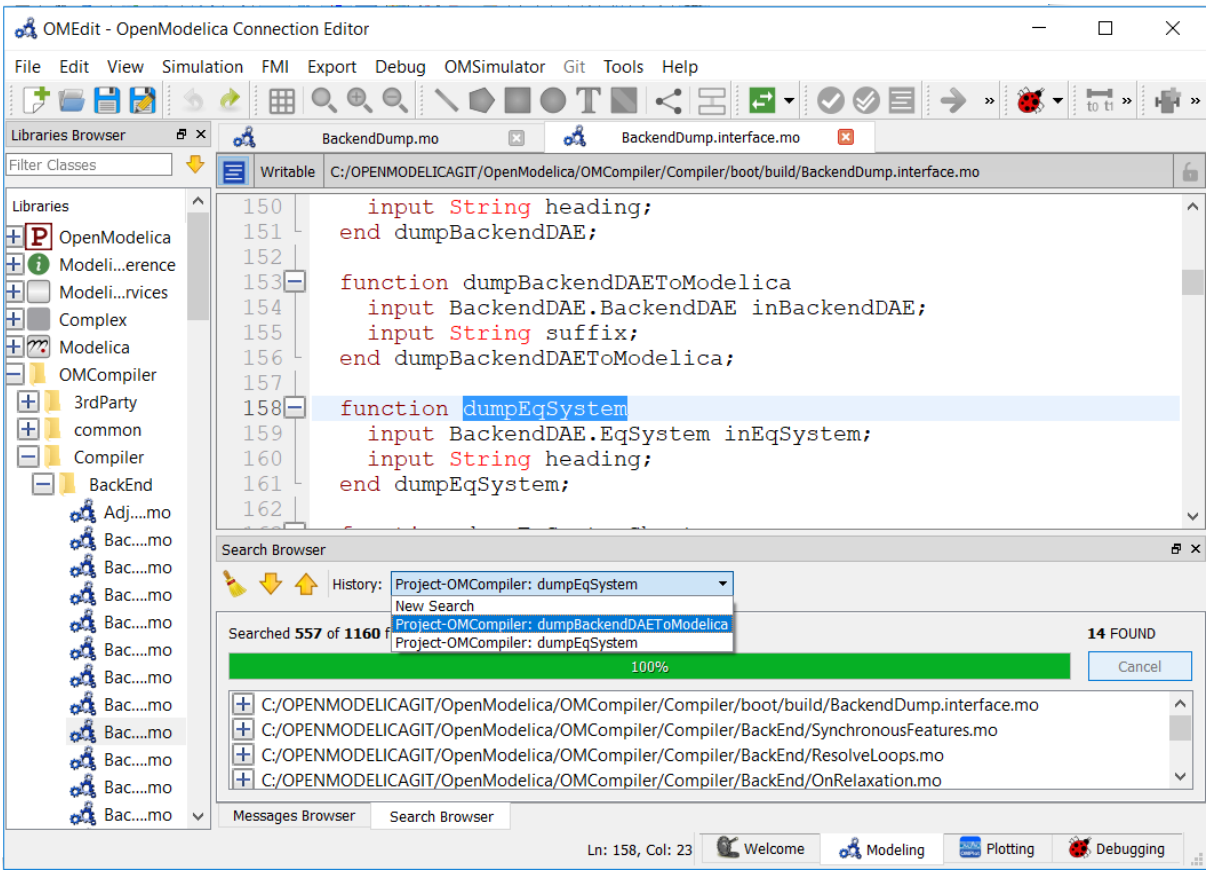



Figure 3.27: Search History

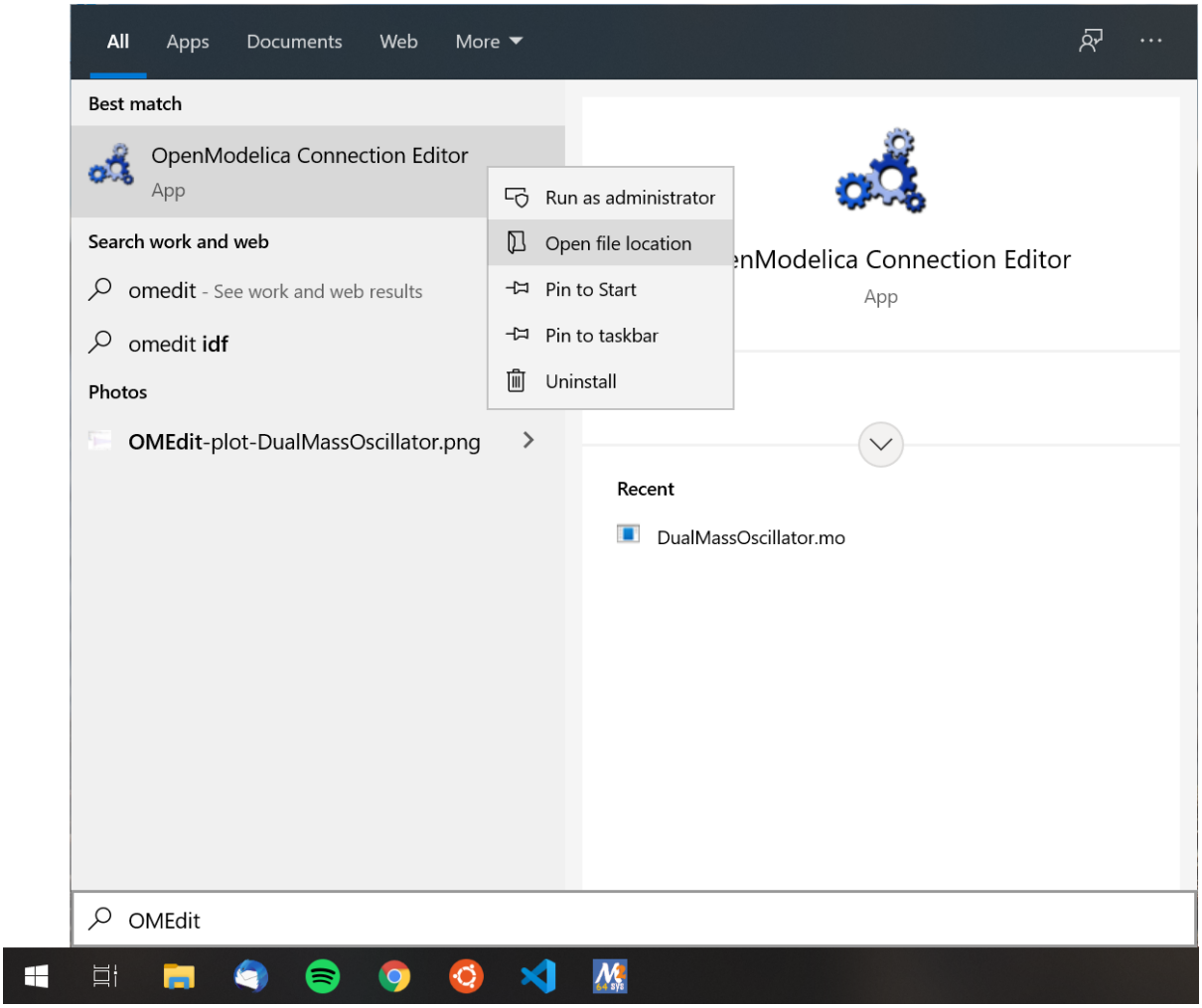



Figure 3.28: Open file location of OpenModelica Connection Editor

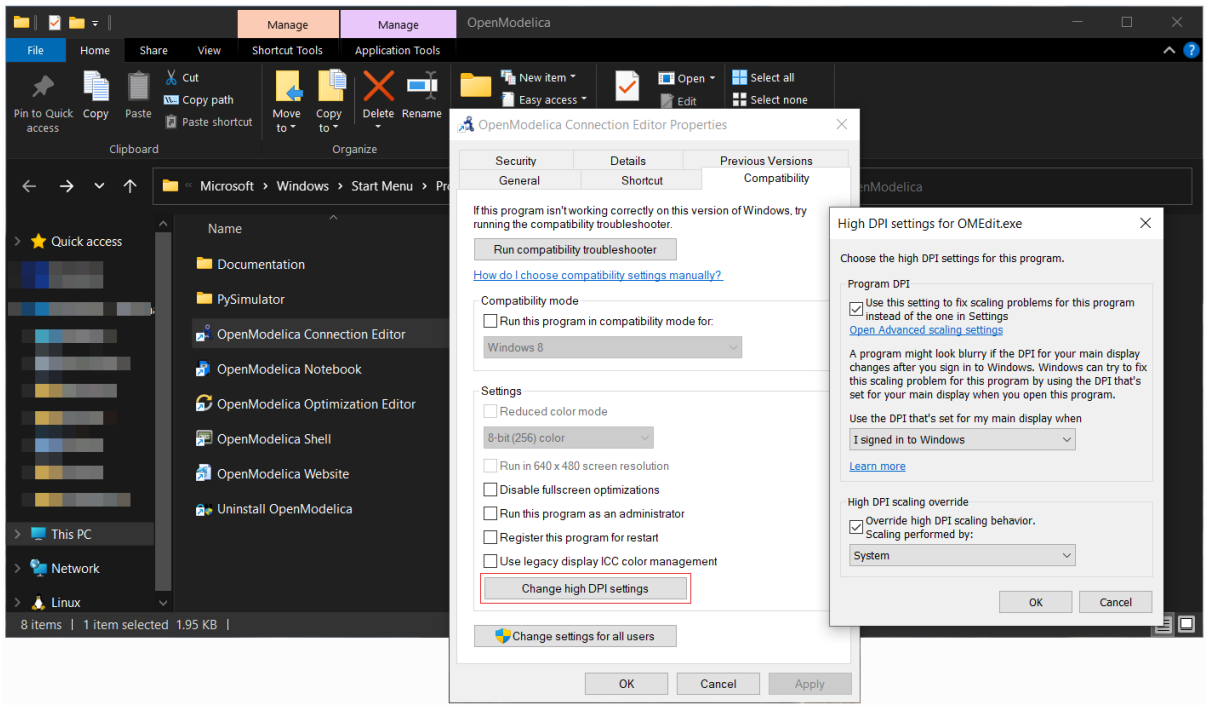



Figure 3.29: Change high DPI settings for OMEdit.exe

CHAPTER

FOUR

# MODELICA LANGUAGE SERVER

The Modelica Language Server provides editor features for Modelica files, such as hover information and *Go to Definition*, to any text editor that speaks the Language Server Protocol (LSP). It is developed by the OpenModelica project, but as a separate program with its own repository, releases and issue tracker.

The language server is not tied to one editor. OpenModelica ships it with OMEdit, and the same server is published as an extension for Visual Studio Code. Both are *clients* of one and the same server.

## 4.1 The Language Server Protocol

Without the Language Server Protocol, every editor has to implement its own support for every language. LSP splits this into two programs:

- The **language server** knows the language. It parses Modelica files, keeps track of the classes and components declared in them and answers questions about them.
- The **language client** is the editor. It shows the text, reacts to the user and asks the server whenever it needs language knowledge - for example when the mouse hovers over a name.

Client and server are separate processes. The client starts the server as a child process and the two exchange JSON-RPC messages over a pipe; nothing goes over the network. There are three kinds of messages:

- *Requests* expect an answer, e.g. `textDocument/hover` or `textDocument/definition`.
- *Responses* answer a request.
- *Notifications* are one-way, e.g. `textDocument/didChange` sent by the client whenever the text in the editor changes.

## 4.2 Features

The server parses Modelica with tree-sitter-modelica. It does not use the OpenModelica Compiler, so it is fast and works on incomplete or erroneous code, but it does not instantiate or check models the way the compiler does.

The language server provides:

- **Hover** - documentation and declaration of the symbol under the mouse.
- **Go to declaration and definition** - navigate to where a class or component is declared, also across files and into loaded libraries.
- **Document outline** - the classes and components of a file.

Newer releases add more features, some of which are off by default and have to be enabled by the client: Modelica syntax diagnostics, code completion, document formatting, semantic highlighting and highlighting of all references to a symbol. Which client uses which feature depends on the client; see the README and the release notes for the current feature list and the settings that control them.

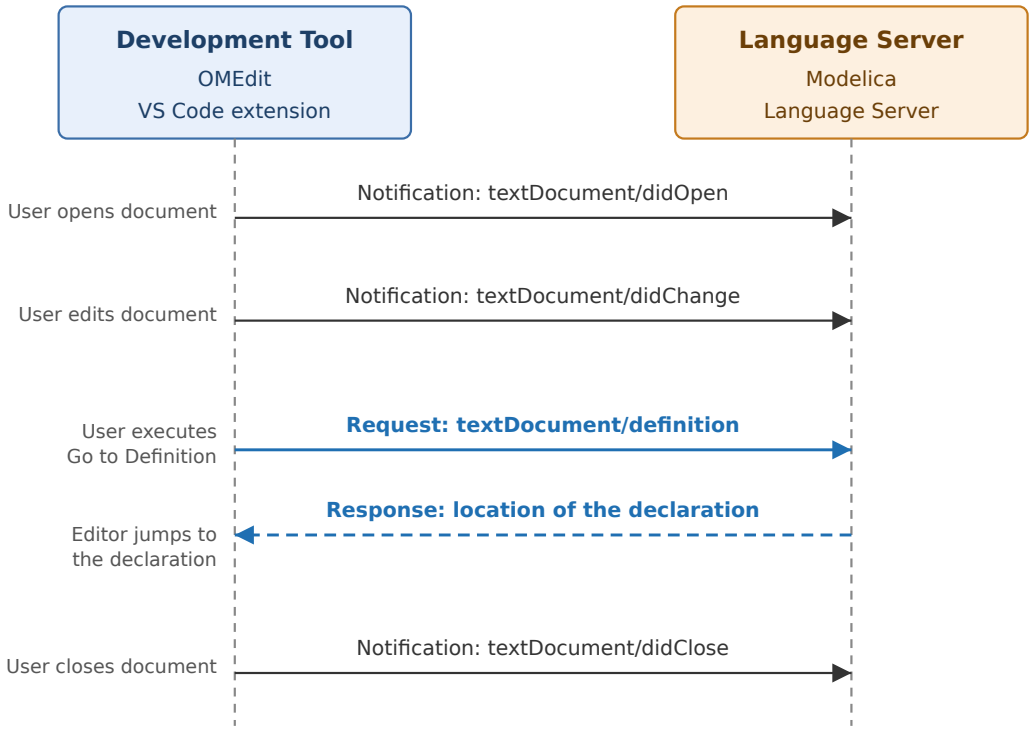



Figure 4.1: Messages exchanged between a development tool and the Modelica Language Server while a document is edited and *Go to Definition* is used.

## 4.3 Clients

### 4.3.1 OMEdit

OMEdit has a built-in language client and OpenModelica installs the language server with it, so it works without any setup. OMEdit uses the server for hover tooltips and *Go to Definition* in its text editor and passes the libraries loaded in OMEdit to the server.

How to enable or disable the language server, choose a different server version and diagnose problems is described in *Language Server Options*.

### 4.3.2 Visual Studio Code

The *Modelica Language Server* extension brings the server to Visual Studio Code. Install it from the Visual Studio Marketplace or, for VS Code compatible editors such as VSCodium, from the Open VSX Registry. The extension contains its own copy of the server, so OpenModelica does not need to be installed.

Libraries outside the opened folder, such as the Modelica Standard Library, are made known to the server with the `modelica.libraries` setting, a list of library root directories, or with the *Modelica: Load Library* command:

```
{
  "modelica.libraries": [
    "/home/user/.openmodelica/libraries/Modelica 4.0.0+maint.om"
  ]
}
```

The libraries installed by the OpenModelica package manager are in `~/.openmodelica/libraries/` on Linux and macOS and in `%APPDATA%\OpenModelica\libraries\` on Windows.

For syntax highlighting, install the MetaModelica extension in addition.

### 4.3.3 Other Editors

Any editor with an LSP client, e.g. Neovim, Emacs or Helix, can use the server. Each release provides a standalone executable for Linux, macOS and Windows that brings its own runtime. Download it together with `tree-sitter-modelica.wasm` and `web-tree-sitter.wasm` and keep all three files in the same directory - without the two `.wasm` files the server starts but answers nothing. Then configure the editor to start `modelica-language-server --stdio` for files with the extension `.mo` and pass the library directories in `initializationOptions` as described above, e.g.

```
{
  "modelicaPath": [
    "/home/user/.openmodelica/libraries/Modelica 4.0.0+maint.om"
  ]
}
```

## 4.4 Reporting Issues

Problems with the language server itself - wrong hover text, missing or wrong definitions, crashes of the server process - belong in the modelica-language-server issue tracker. Problems with how OMEdit starts or uses the server belong in the OpenModelica issue tracker.

CHAPTER

FIVE

# UML CLASS AND INSTANCE DIAGRAMS

OpenModelica draws two kinds of UML diagrams of Modelica code:

- A **class diagram** shows the classes as they are written: a class, the classes it extends and the classes it uses, each once, with the modifiers declared in it. It is made from the code alone, without instantiating it, so it works for packages, partial classes and functions too.
- An **instance diagram** shows a model as it is instantiated: the model and its components, each instance as a box of its own, with the values its parameters have in that instance, and the connections between them.

Both are made by the compiler with the scripting functions *getClassDiagram* and *getInstanceDiagram*, so they can be used from scripts, OMShell, OMNotebook and the other clients. OMEdit shows the class diagram of a class in its *Class Diagram window*.

## 5.1 Formats

Both functions return the diagram as text, or write it to the file given as `fileName` and return the file name. `format` is one of:

- `"plantuml"` (the default): PlantUML text, to be rendered with PlantUML.
- `"mermaid"`: Mermaid text. GitHub and GitLab show a `mermaid` code block in Markdown as a diagram, which is handy for issues, pull requests and the README of a library.
- `"drawio"`: a draw.io (diagrams.net) file, which can be opened, rearranged and edited in draw.io. In it every class and every line in the box of a class links to the code, e.g. `modelica://Tanks.Tank?lineNumber=8&element=k`; OMEdit follows these links.

The examples below use this package:

```
package Tanks
  partial model Vessel
    parameter Real area = 1 "Base area";
    Real level(start = 0);
  end Vessel;
  model Tank
    extends Vessel(area = 2);
    parameter Real k = 0.5 "Outflow coefficient";
    Real qIn, qOut;
  equation
    area*der(level) = qIn - qOut;
    qOut = k*sqrt(max(level, 0));
  end Tank;
  model TwoTanks
    parameter Real k = 0.4;
    Tank t1(k = k), t2(area = 3);
  equation
    t1.qIn = 1;
```

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```
    t2.qIn = t1.qOut;
  end TwoTanks;
end Tanks;
```

## 5.2 Class Diagrams

```
>>> getClassDiagram(Tanks.TwoTanks, fileName = "TwoTanks-class.mmd", format = "mermaid
↪")
"TwoTanks-class.mmd"
```

Listing 5.1: TwoTanks-class.mmd

```
classDiagram
  class Tanks_TwoTanks["Tanks.TwoTanks"] {
    <<model>>
    + parameter Real k = 0.4
    + Tank t1#40;k = k#41;
    + Tank t2#40;area = 3#41;
  }
  class Tanks_Tank["Tanks.Tank"] {
    <<model>>
    + parameter Real k = 0.5
    + Real qIn
    + Real qOut
  }
  class Tanks_Vessel["Tanks.Vessel"] {
    <<partial model>>
    + parameter Real area = 1
    + Real level#40;start = 0#41;
  }
  Tanks_TwoTanks *-- Tanks_Tank : t1
  Tanks_TwoTanks *-- Tanks_Tank : t2
  Tanks_Vessel <|-- Tanks_Tank : #40;area = 2#41;
```

Mermaid reads a member with parentheses as a method, so the parentheses of modifiers are written as the codes `#40;` and `#41;`, which Mermaid shows as `(` and `)`. `TwoTanks` is composed of two `Tank` components, labelled with their names, and `Tank` is a generalization of the partial `Vessel`, labelled with the modifiers of its `extends`. Each class is shown once, with the components and modifiers declared in it, so `area = 2` and `area = 3` appear where they are written, not as the values of the instances.

The options of *getClassDiagram*:

- `depth` (default 1): how many levels of used classes to include, i.e. the types of the components and the classes replaceable classes default to, are constrained by or are redeclared as. With `depth = 0` the diagram has only the class and its base classes, which are always included.
- `exclude` (default `{"Modelica.Icons"}`): classes and packages to leave out.
- `showModifiers` (default `true`): `false` leaves out the modifiers and bindings.

Replaceable classes, redeclarations and class extends (`redeclare model extends`) are shown as well: the stereotype of a class tells how it is declared, e.g. «`replaceable package`», a class extends is a generalization of the class it replaces, and constraining classes and redeclarations are dependencies. In this package, modelled after Modelica.Media, `Pipe` has a replaceable medium, `System` redeclares it as `Water`, and `Water` redefines the function `h` of the partial medium with a class extends:

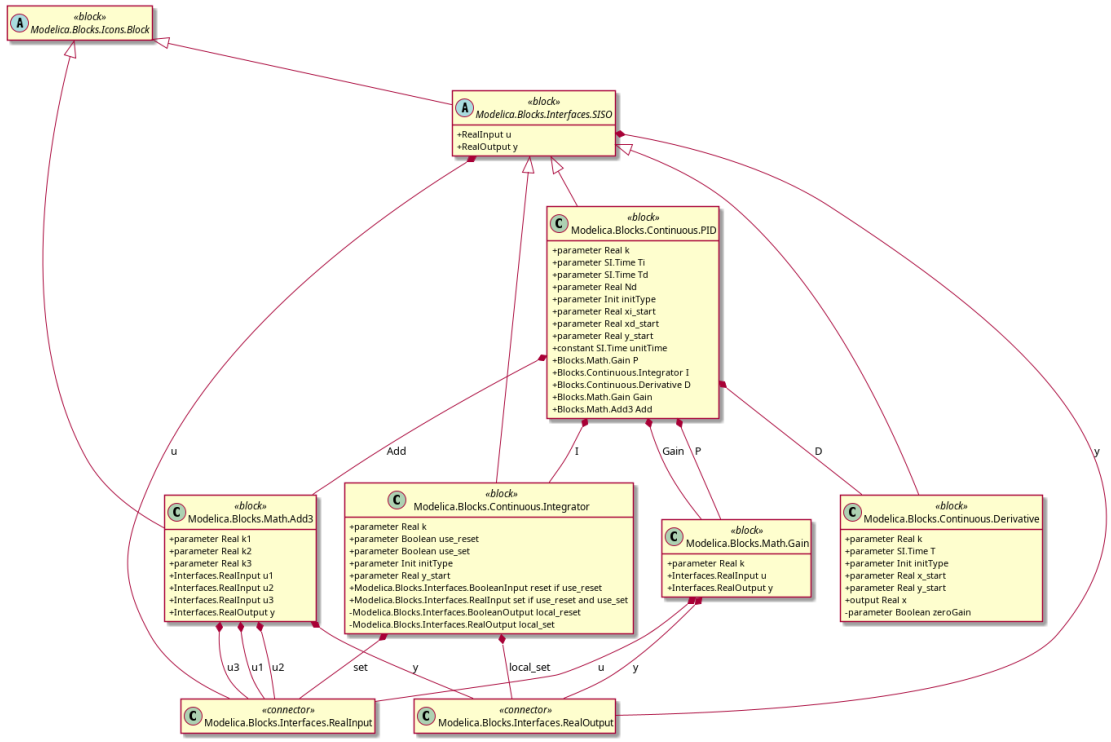



Figure 5.1: `getClassDiagram(Modelica.Blocks.Continuous.PID, showModifiers = false)` rendered with PlantUML.

```
package R
  partial package PartialMedium
    constant Integer nX = 1;
    replaceable function h
      input Real x;
      output Real y = x;
    end h;
  end PartialMedium;
  package Water
    extends PartialMedium(nX = 2);
    redeclare function extends h
    algorithm
      y := 2*x;
    end h;
  end Water;
  model Pipe
    replaceable package Medium = PartialMedium;
    Real z[Medium.nX] = fill(Medium.h(1), Medium.nX);
  end Pipe;
  model System
    Pipe p(redeclare package Medium = Water);
  end System;
end R;
```

This makes the diagram useful to understand the structure of a library such as Modelica.Media:

```
getClassDiagram(Modelica.Media.Water.StandardWater, fileName = "Water.drawio",
                format = "drawio", depth = 2)
```

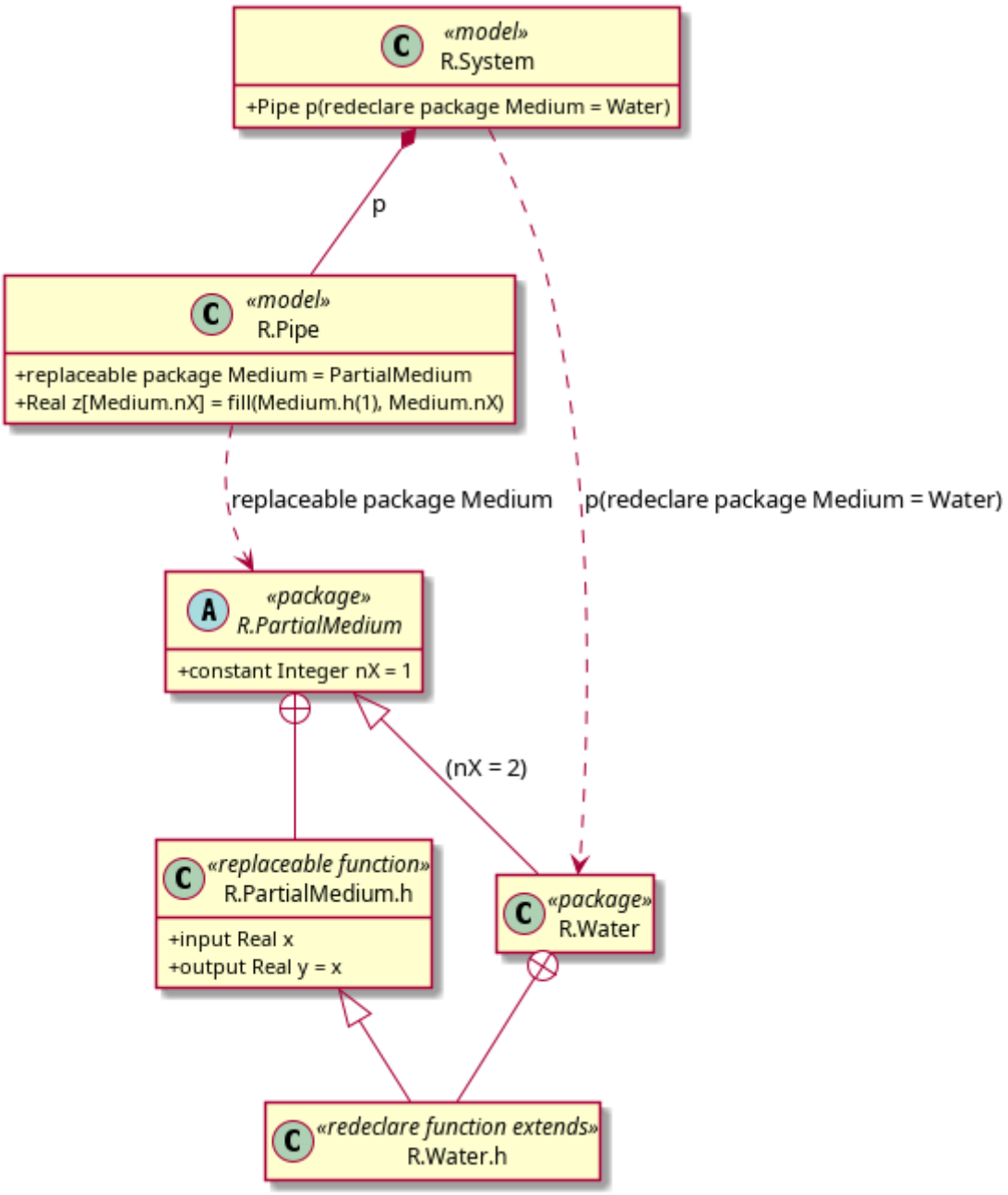



Figure 5.2: `getClassDiagram(R.System)` rendered with PlantUML: the dashed arrows are the replaceable package and its redeclaration, `R.Water.h` extends the function it redeclares, and the nested classes are attached to the package they are declared in.

## 5.3 Instance Diagrams

```
>>> getInstanceDiagram(Tanks.TwoTanks, fileName = "TwoTanks-instance.mmd", format =
↪"mermaid")
"TwoTanks-instance.mmd"
```

Listing 5.2: TwoTanks-instance.mmd

```
classDiagram
  class I_Tanks_TwoTanks["Tanks.TwoTanks"] {
    <<model>>
    + parameter Real k = 0.4
  }
  class I_t1["t1 : Tanks.Tank"] {
    <<model>>
    + parameter Real area = 2
    + parameter Real k = k #40;= 0.4#41;
  }
  class I_t2["t2 : Tanks.Tank"] {
    <<model>>
    + parameter Real area = 3
    + parameter Real k = 0.5
  }
  I_Tanks_TwoTanks *-- I_t1 : t1
  I_Tanks_TwoTanks *-- I_t2 : t2
```

Each component that is an instance of a class is a box named after its path and class, e.g. `t1 : Tanks.Tank`. The box has the parameters and constants of the instance, including the inherited ones, with their binding as written and, when it is not a literal, the value it evaluates to in this instance, e.g. `k = k (= 0.4)`. Variables are not shown.

The options of *getInstanceDiagram*:

- `depth` (default 1): how many levels of components are drawn as boxes of their own. Components below that, and connectors, are lines in the box of the instance they are in.
- `exclude`: classes and packages whose instances are left out.
- `showConnections` (default `true`): the connect equations are drawn as associations between the boxes of the components they connect, labelled with the connectors.
- `showProtected` (default `false`): also show the protected elements, marked with `-`.
- `expandArrays` (default `false`): an array of components is one box, e.g. `r[10] : Resistor`; with `true` each element gets a box of its own with its own values, for arrays of known size with at most 100 elements.

For a model built from library components, `depth = 1` shows the components of the model, and a higher depth the components inside them:

```
loadModel(Modelica, {"4.1.0"});
getInstanceDiagram(Modelica.Electrical.Analog.Examples.ChuaCircuit,
                   fileName = "ChuaCircuit.puml")
```

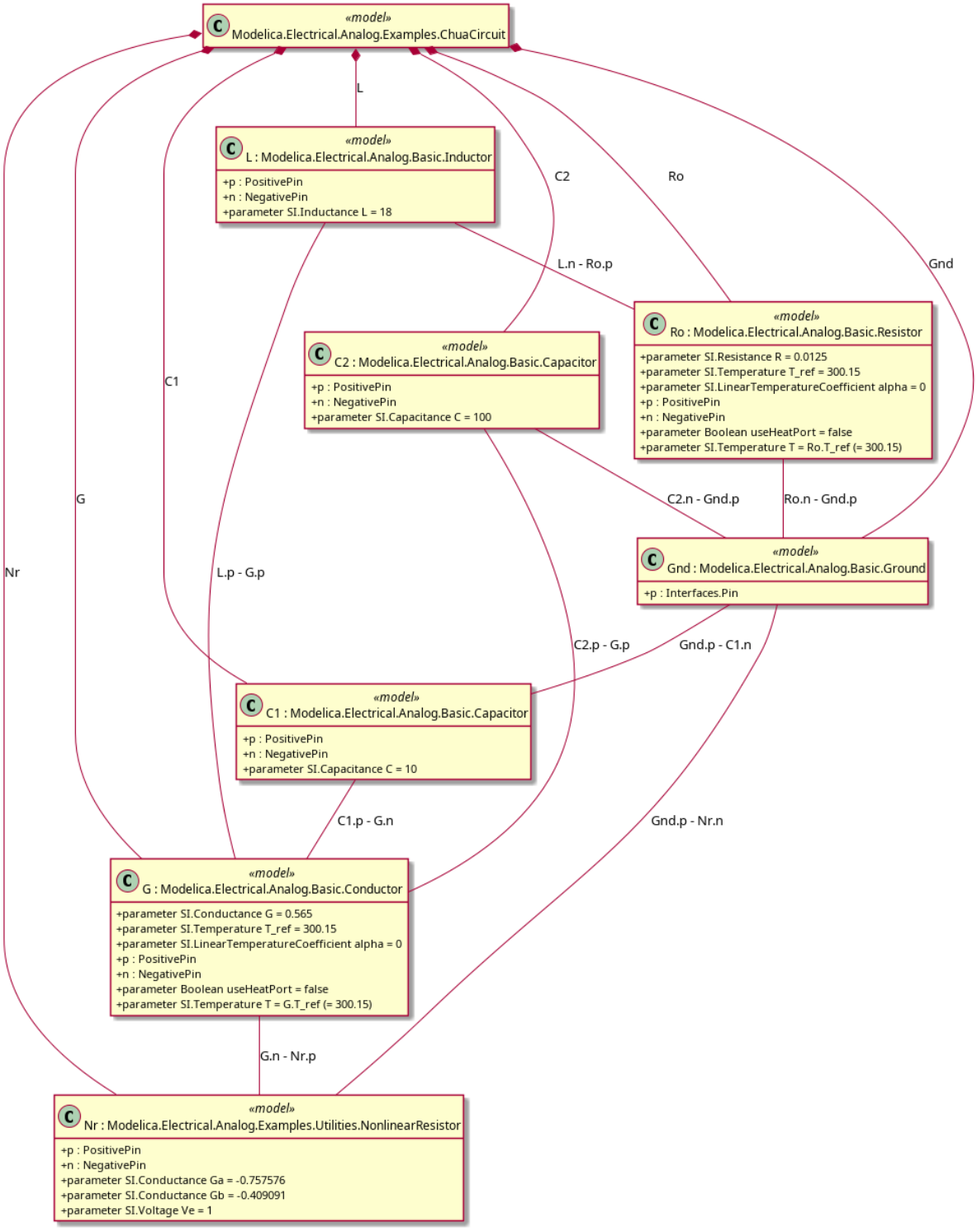



Figure 5.3: The instance diagram of Modelica.Electrical.Analog.Examples.ChuaCircuit rendered with PlantUML: the values of the parameters in each component, and the connections labelled with the connectors.

CHAPTER

SIX

# PROPERTY PROBES AND CODEPROBER

CodeProber, from Lund University, is a *property probing* tool: it shows the source code of a program in a browser editor, and a right-click on any part of it creates a *probe*, a small window with a property of that part, as the compiler computes it. Probes stay open and are updated whenever the code is edited, so they show live how a change affects what the compiler does with the code.

OpenModelica provides what such a tool needs through two scripting functions:

- *getProbeTree* returns the *probe tree* of a file: its classes, elements, equations, statements and names, with their positions in the file and the properties that can be asked for each of them.
- *evaluateProbe* evaluates one property of one node of that tree.

All the knowledge is in omc. A client, like the CodeProber one, only maps the tree and the results to its user interface, so a new property only has to be added to the compiler.

## 6.1 The Probe Tree

The tree follows the structure of the parsed file. Its nodes have a `kind`: `StoredDefinition` (the file), `ClassDefinition`, `ComponentDeclaration`, `ComponentClause` (several components declared together), `ExtendsClause`, `ImportClause`, `Equation` and `Statement`, and the names in them, declared or used, are `Ident` leaves. Every node has an `id`, the indices of the children on the way from the root, e.g. `0.0.2.3` for the fourth element of the third class of the first class of the file, its span in the file, and the names of its `properties`. For a file that does not parse, `root` is `null` and `errors` has the syntax errors.

The file has to be loaded first. The examples below use a small circuit, ProbeCircuit.mo:

```
package EQ
  connector Pin
    Real v;
    flow Real i;
  end Pin;
  model R
    parameter Real r = 2;
    Pin p, n;
  equation
    p.v - n.v = r*p.i;
    p.i + n.i = 0;
  end R;
  model V
    Pin p, n;
  equation
    p.v - n.v = sin(time);
    p.i + n.i = 0;
  end V;
  model G
    Pin p;
```

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```
  equation
    p.v = 0;
  end G;
  model B
    V src;
    R r1(r = 3), r2;
    G gnd;
  equation
    connect(src.p, r1.p);
    connect(r1.n, r2.p);
    connect(r2.n, src.n);
    connect(src.n, gnd.p);
  end B;
end EQ;
```

`getProbeTree("ProbeCircuit.mo", prettyPrint = true)` returns the tree as JSON. This is the node of the equation `p.v - n.v = r*p.i` of `R`, with only the first of its seven children, the `Ident` of the first `p`:


```
{
  "id": "0.0.2.3",
  "kind": "Equation",
  "label": "=",
  "lineStart": 10,
  "columnStart": 5,
  "lineEnd": 10,
  "columnEnd": 22,
  "properties": ["simEquations", "jacobianEquations", "bltBlock", "cCode", "text",
↪"hover"],
  "children": [
    {
      "id": "0.0.2.3.0",
      "kind": "Ident",
      "label": "p",
      "lineStart": 10,
      "columnStart": 5,
      "lineEnd": 10,
      "columnEnd": 5,
      "properties": ["definition", "role", "text", "hover"],
      "children": []
    }
  ]
}
```


## 6.2 Properties

`evaluateProbe(fileName, nodeId, property, contextModel)` returns the property as a JSON list of items. An item is a `text`, a `node` (a link to another node of the tree), a diagnostic (`severity`, span and `message`) or an `arrow` between two spans.


```
>>> evaluateProbe("ProbeCircuit.mo", "0.0.5.4", "connectionEquations")
{"node":"0.0.5.4", "property":"connectionEquations", "result":[{"text":"'src.p.v' =
↪'r1.p.v';"}, {"text":"'r1.p.i' + 'src.p.i' = 0.0;"}]}
```


The properties are:

- On every node: `text` and `hover`.

- On the file: `errors` (names that cannot be found and the messages of *checkModel* of its models, at their positions), `topClasses`, `contextModel` and `omcVersion`.
- On names: `definition` (the node that declares the name), `uses`, `useArrows` and `role`.
- On classes: `dependsOn`, `checkModel`, `flatModelica` (the class as Base Modelica) and `modelInstance` (the JSON of *getModelInstance*).
- From the translation of a model: `simVariables`, `simEquations`, `jacobianEquations`, `cCode` (the generated C function of each simulation equation), `translationMessages`, `flatDeclarations` and `connectionEquations`. The simulation equations are shown with the symbolic operations that made them, e.g. how an equation was solved.
- `blt` of a class: the blocks of the initial and the regular equations in the order they are solved, assignments and systems of equations with their iteration variables and torn and residual equations, each linked to the equation of the file it comes from. `bltBlock` of an equation or a statement: the blocks its simulation equations are in, which shows the other equations of the same algebraic loop.
- `stateSelection` of a class or component: the states, the dummy states chosen by index reduction, with the variable they equal and the steps that made them so, and the `stateSelect` attributes.

The translation properties need a model to translate. It is `contextModel` if given, otherwise the model the node is in. An equation of `R` is translated as part of the whole circuit with `contextModel = "EQ.B"`:

```
>>> evaluateProbe("ProbeCircuit.mo", "0.0.2.3", "hover", "EQ.B")
{"node":"0.0.2.3", "property":"hover", "result":[{"text":"eq 4 [initial, torn] r2.p.i␣
↪:= (src.p.v - r1.n.v) / r1.r"}, {"text":"eq 5 [initial, residual] r2.r * r2.p.i -␣
↪r1.n.v"}, {"text":"eq 10 [regular, torn] r1.n.v := src.p.v - r1.r * r2.p.i"}, {"text
↪":"eq 11 [regular, residual] r2.r * r2.p.i - r1.n.v"}]}
```

The translation is kept in the temporary directory, under a hash of the name and the contents of the file, so a model is translated once for each version of the file, and probes on an unchanged file are answered right away.

## 6.3 Using CodeProber

CodeProber runs as a local web server, given a jar file that connects it to a compiler. A prototype that connects it to omc can be downloaded from https://build.openmodelica.org/omc/codeprober/, with instructions. It needs Java 11 or newer and an OpenModelica nightly build.

In the browser, a right-click on a name or an equation, *Create Probe*, and the choice of a property opens a probe. Diagnostics like the `errors` of the file are shown as squiggles in the editor and arrows like `useArrows` as arrows between the lines.

CodeProber also has *text probes*: a comment like

```
connect(src.p, r1.p); // [[Equation.connectionEquations~="'src.p.v' = 'r1.p.v';"]]
```

asserts that a property of the node on that line contains the given text. CodeProber checks these assertions in the editor, and `codeprober.jar --test` checks them from the command line, which turns them into regression tests of what the compiler does with a model.

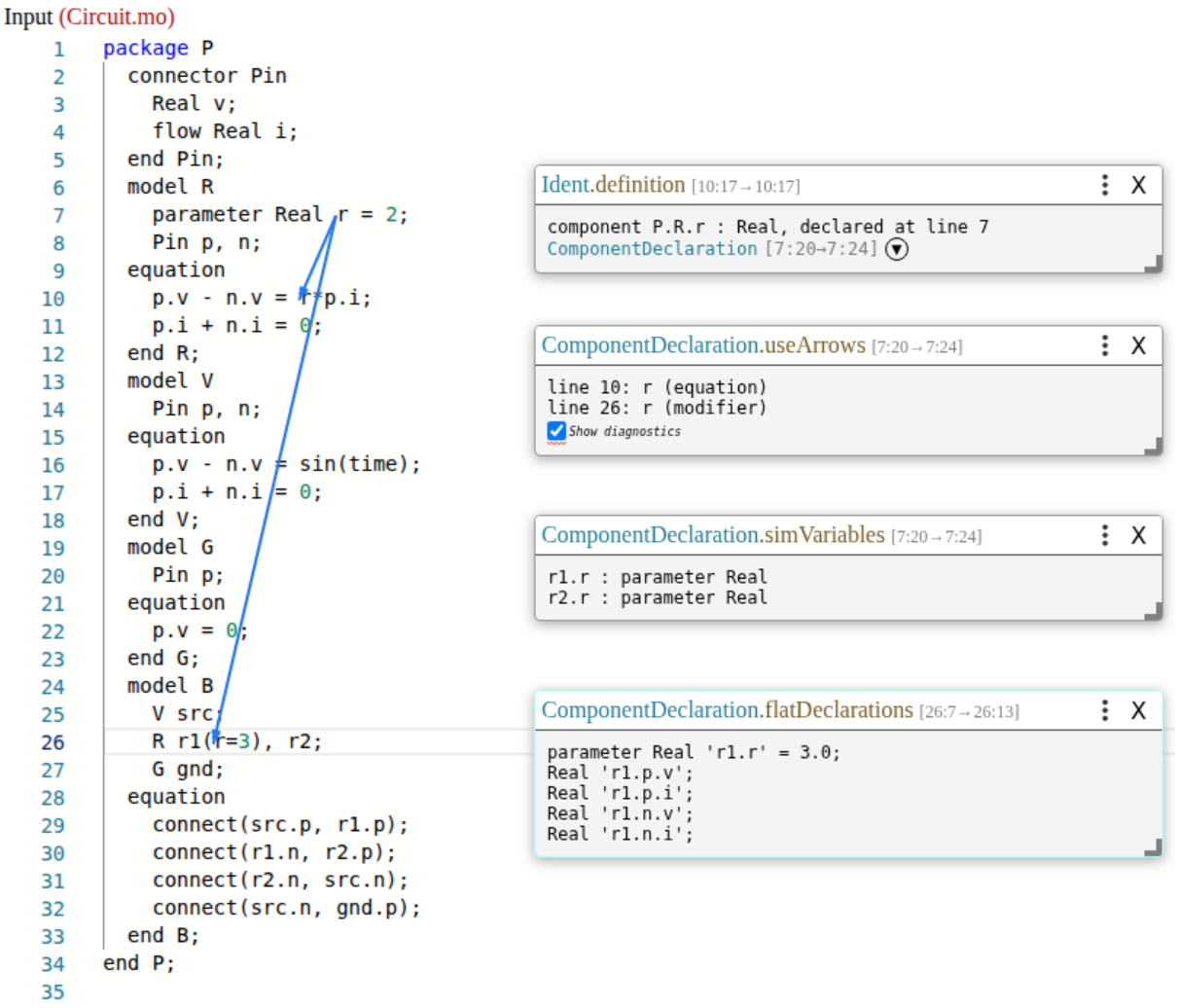



Figure 6.1: Probes on the parameter `r`: its definition, its uses drawn as arrows, the simulation variables it becomes in the translated model, and the flat declarations of the component `r1` that modifies it.

Input (Circuit.mo)

```
1  package P
2    connector Pin
3      Real v;
4      flow Real i;
5    end Pin;
6    model R
7      parameter Real r = 2;
8      Pin p, n;
9    equation
10     p.v - n.v = r*p.i;
11     p.i + n.i = 0;
12   end R;
13   model V
14     Pin p, n;
15   equation
16     p.v - n.v = sin(time);
17     p.i + n.i = 0;
18   end V;
19   model G
20     Pin p;
21   equation
22     p.v = 0;
23   end G;
24   model B
25     V src;
26     R r1(r=3), r2;
27     G gnd;
28   equation
29     connect(src.p, r1.p);
30     connect(r1.n, r2.p);
31     connect(r2.n, src.n);
32     connect(src.n, gnd.p);
33   end B;
34 end P;
35
```

Equation.simEquations [10:5→10:21]

```
eq 4 [initial, torn] r2.p.i := (src.p.v - r1.n.v) / r1.r
    solved: src.p.v - r1.n.v = r1.r * r2.p.i  =>  r2.p.i = (src.p.v - r1.n.v) / r1.r
    substitution: r1.r * r1.p.i  =>  r1.r * r2.p.i
    substitution: r1.p.v - r1.n.v  =>  src.p.v - r1.n.v
eq 5 [initial, residual] r2.r * r2.p.i - r1.n.v
    simplify: r1.n.v - 0.0 = r2.r * r2.p.i  =>  r1.n.v = r2.r * r2.p.i
    substitution: r2.p.v - r2.n.v  =>  r1.n.v - 0.0
eq 10 [regular, torn] r1.n.v := src.p.v - r1.r * r2.p.i
    solved: src.p.v - r1.n.v = r1.r * r2.p.i  =>  r1.n.v = src.p.v - r1.r * r2.p.i
    substitution: r1.r * r1.p.i  =>  r1.r * r2.p.i
    substitution: r1.p.v - r1.n.v  =>  src.p.v - r1.n.v
eq 11 [regular, residual] r2.r * r2.p.i - r1.n.v
    simplify: r1.n.v - 0.0 = r2.r * r2.p.i  =>  r1.n.v = r2.r * r2.p.i
    substitution: r2.p.v - r2.n.v  =>  r1.n.v - 0.0
```

Equation.cCode [10:5→10:21]

```
// P.B_03lsy.c
/*
equation index: 4
type: SIMPLE_ASSIGN
r2.p.i = (src.p.v - r1.n.v) / r1.r
*/
void P_B_eqFunction_4(DATA *data, threadData_t *threadData)
{
  const int equationIndexes[2] = {1,4};
  (data->localData[0]->realVars[3] /* r2.p.i variable */) = DIVISION_SIM((data->localDat
  threadData->lastEquationSolved = 4;
  _return: OMC_LABEL_UNUSED ;
}

// P.B_03lsy.c
/*
equation index: 10
type: SIMPLE_ASSIGN
r1.n.v = src.p.v - r1.r * r2.p.i
*/
void P_B_eqFunction_10(DATA *data, threadData_t *threadData)
{
  const int equationIndexes[2] = {1,10};
  (data->localData[0]->realVars[2] /* r1.n.v variable */) = (data->localData[0]->realVa
  threadData->lastEquationSolved = 10;
  _return: OMC_LABEL_UNUSED ;
}
```

Figure 6.2: The simulation equations of an equation of R, with the symbolic operations that made them, and the C functions generated for them.

Input (Broken.mo)

```
1  package Q
2    connector Pin
3      Real v;
4      flow Real i;
5    end Pin;
6    model R
7      parameter Real r = 2;
8      Pin p, n;
9    equation
10     p.v - n.v = r*p.i;
11     p.i + n.i = 0;
12   end R;
13   model B
14     R r1(r=3), r2;
15     Variable r2.x not found in scope B. StoredDefinition.l:errors
16     eq
17     unresolved name r2.x StoredDefinition.l:errors
18     View Problem (Alt+F8)   No quick fixes available
19     connect(r1.p, r2.x);
20     g.v = sin(time);
21   end B;
22 end Q;
23
```

StoredDefinition.errors [1:1→23:5]

```
warn 19:22-19:22: unresolved name r2.x
err 19:5-19:24: Variable r2.x not found in scope B.
Show diagnostics
```

Figure 6.3: The errors of a file: a connector that does not exist, as a probe and as a squiggle in the editor.

CHAPTER

SEVEN

# 2D PLOTTING

This chapter covers the 2D plotting available in OpenModelica via OMNotebook, OMShell and command line script. The plotting is based on OMPlot application. See also OMEdit *2D Plotting*.

## 7.1 Example

```
model HelloWorld
  Real x(start = 1, fixed = true);
  parameter Real a = 1;
equation
  der(x) = - a * x;
end HelloWorld;
```

To create a simple time plot the above model HelloWorld is simulated. To reduce the amount of simulation data in this example the number of intervals is limited with the argument numberOfIntervals=5. The simulation is started with the command below.

```
>>> simulate(HelloWorld, outputFormat="csv", startTime=0, stopTime=4,␣
↪numberOfIntervals=5)
record SimulationResult
    resultFile = "«DOCHOME»/HelloWorld_res.csv",
    simulationOptions = "startTime = 0.0, stopTime = 4.0, numberOfIntervals = 5,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'HelloWorld', options = '',␣
↪outputFormat = 'csv', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.0024385830000000002,
    timeBackend = 0.0047555440000000004,
    timeSimCode = 8.587190000000001e-4,
    timeTemplates = 0.0031935880000000002,
    timeCompile = 0.43882931599999997,
    timeSimulation = 0.011802794,
    timeTotal = 0.46203827899999994
end SimulationResult;
```

When the simulation is finished the file *HelloWorld_res.csv* contains the simulation data:

Listing 7.1: HelloWorld_res.csv

```
"time","x","der(x)"
0,1,-1
0.8,0.4493289092712475,-0.4493289092712475
1.6,0.2018973974273906,-0.2018973974273906
```

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```
2.4,0.09071896372718975,-0.09071896372718975
3.2,0.04076293845066793,-0.04076293845066793
4,0.01831609502171534,-0.01831609502171534
4,0.01831609502171534,-0.01831609502171534
```

Use *plot(x)* to plot the diagram using OMPlot.

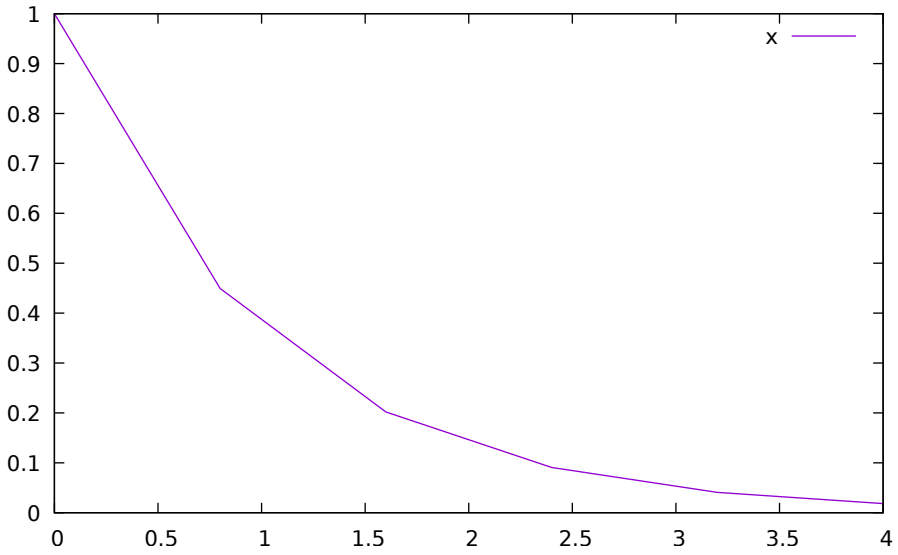



Figure 7.1: Simple 2D plot of the HelloWorld example.

By re-simulating and saving results at many more points, for example using the default 500 intervals, a much smoother plot can be obtained. Note that the default solver method dassl has more internal points than the output points in the initial plot. The results are identical, except the detailed plot has a smoother curve.

```
>>> 0==system("./HelloWorld -stepSize=0.008")
true
>>> res:=strtok(readFile("HelloWorld_res.csv"), "\n");
>>> res[end]
"4,0.01831609502171534,-0.01831609502171534"
```

## 7.2 Plot Command Interface

Plot command have a number of optional arguments to further customize the the resulting diagram.

```
>>> list(OpenModelica.Scripting.plot,interfaceOnly=true)
"function plot
  input VariableNames vars \"The variables you want to plot\";
  input Boolean externalWindow = false \"Opens the plot in a new plot window\";
  input String fileName = \"<default>\" \"The filename containing the variables.
↪<default> will read the last simulation result\";
  input String title = \"\" \"This text will be used as the diagram title.\";
  input String grid = \"simple\" \"Sets the grid for the plot i.e., simple, detailed,␣
↪none or xonly.\";
  input Boolean logX = false \"Determines whether or not the horizontal axis is␣
↪logarithmically scaled.\";
  input Boolean logY = false \"Determines whether or not the vertical axis is␣
↪logarithmically scaled.\";
```

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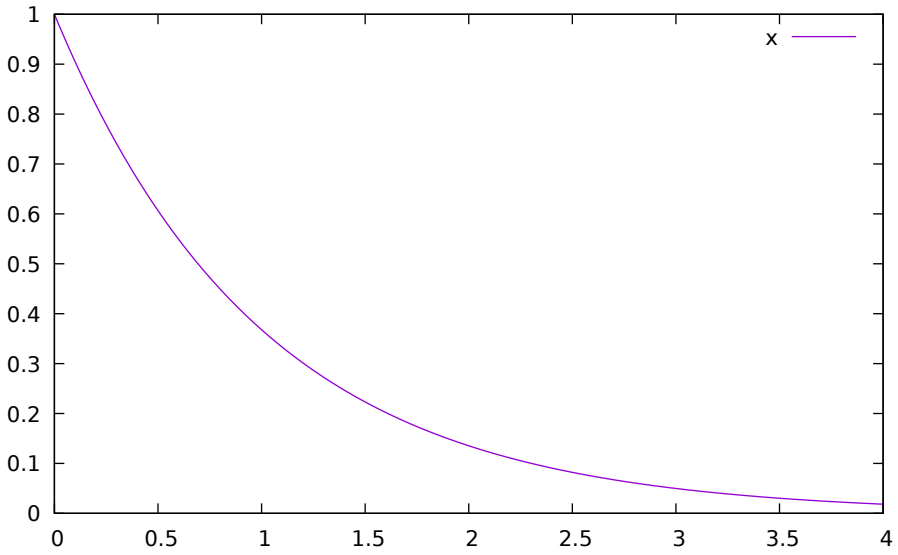



Figure 7.2: Simple 2D plot of the HelloWorld example with a larger number of output points.

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```
  input String xLabel = \"time\" \"This text will be used as the horizontal label in␣
↪the diagram.\";
  input String yLabel = \"\" \"This text will be used as the left vertical label in␣
↪the diagram.\";
  input Real xRange[2] = {0.0, 0.0} \"Determines the horizontal interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.\";
  input Real yRange[2] = {0.0, 0.0} \"Determines the left vertical interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.\";
  input Real curveWidth = 1.0 \"Sets the width of the curve.\";
  input Integer curveStyle = 1 \"Sets the style of the curve. SolidLine=1, DashLine=2,
↪ DotLine=3, DashDotLine=4, DashDotDotLine=5, Sticks=6, Steps=7.\";
  input String legendPosition = \"top\" \"Sets the POSITION of the legend i.e., left,␣
↪right, top, bottom, none.\";
  input String footer = \"\" \"This text will be used as the diagram footer.\";
  input Boolean autoScale = true \"Use auto scale while plotting.\";
  input Boolean forceOMPlot = false \"if true launches OMPlot and doesn't call␣
↪callback function even if it is defined.\";
  input String yAxis = \"L\" \"Sets the variable to be plotted on the left (L) or␣
↪right (R) y-axis.\";
  input String yLabelRight = \"\" \"This text will be used as the right vertical␣
↪label in the diagram.\";
  input Real yRangeRight[2] = {0.0, 0.0} \"Determines the right vertical interval␣
↪that is visible in the diagram. {0,0} will select a suitable range.\";
  output Boolean success \"Returns true on success\";
end plot;"
```

CHAPTER

EIGHT

# OPENMODELICA COMPILER

The OpenModelica Compiler (OMC) consists of a frontend, backend, code generation and the runtimes.

1. **Lexical Analysis**

   Keywords, operators and identifiers are extracted from the model.

2. **Parsing**

   An abstract syntax tree represented in Meta-Modelica is created from the operators and identifiers.

3. **Semantic Analysis**

   The abstract syntax tree gets tested for semantic errors.

4. **Intermediate Representation**

   Translation of the abstract syntax tree to an intermediate representation called SCode in MetaModelica. This is further processed by the frontend producing DAE intermediate representation code.

5. **Symbolic Optimization Backend**

   The intermediate representation gets optimized and preprocessed.

6. **Code Generation**

   Executable code gets generated from the low level intermediate representation.

For more details see [FPA+20]. A full list of compiler flags can be found in *OpenModelica Compiler Flags*.

## 8.1 Frontend Modules

## 8.2 Backend Modules

1. **Pre-Optimization**
   - Partitioning
   - Alias removal
2. **Causalization**
   - Matching
   - Sorting
   - Index reduction
3. **Post-Optimization**
   - Tearing
   - Jacobian

### 8.2.1 Backend DAE Info

With compiler debug flag *backenddaeinfo* it is possible to get additional information from the Backend modules.

- Number of equations / variables
- Number of states
- Information about initialization and simulation system
  - Equation types
  - Equation system details (linear and non-linear)

The output of *backenddaeinfo* can be expanded by using additional compiler debug flags *stateselection* and *discreteinfo*.

**Example**

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
true
>>> setCommandLineOptions("-d=backenddaeinfo,stateselection,discreteinfo")
true
>>> translateModel(BouncingBall)
true
"Notification: Model statistics after passing the front-end and creating the data␣
↪structures used by the back-end:
 * Number of equations: 6
 * Number of variables: 6
Notification: Model statistics after passing the back-end for initialization:
 * Number of independent subsystems: 3
 * Number of states: 0 ()
 * Number of discrete variables: 9 (v_new,$PRE.v_new,flying,$PRE.flying,foo,impact,
↪$whenCondition1,$whenCondition2,$whenCondition3)
 * Number of discrete states: 0 ()
 * Number of clocked states: 0 ()
 * Top-level inputs: 0
Notification: Strong component statistics for initialization (13):
 * Single equations (assignments): 13
 * Array equations: 0
 * Algorithm blocks: 0
 * Record equations: 0
 * When equations: 0
 * If-equations: 0
 * Equation systems (not torn): 0
 * Torn equation systems: 0
 * Mixed (continuous/discrete) equation systems: 0
Notification: Model statistics after passing the back-end for simulation:
 * Number of independent subsystems: 1
 * Number of states: 2 (h,v)
 * Number of discrete variables: 7 ($whenCondition3,$whenCondition2,$whenCondition1,
↪flying,impact,v_new,foo)
 * Number of discrete states: 2 (impact,v)
 * Number of clocked states: 0 ()
 * Top-level inputs: 0
Notification: Strong component statistics for simulation (9):
 * Single equations (assignments): 7
 * Array equations: 0
 * Algorithm blocks: 0
 * Record equations: 0
```

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```
* When equations: 2
* If-equations: 0
* Equation systems (not torn): 0
* Torn equation systems: 0
* Mixed (continuous/discrete) equation systems: 0"
```

## 8.3 Code generation

From the low level intermediate representation from the backend code will be generated. The default code generation target is C and offers the largest model coverage. An alternative is the C++ (*Cpp*) which can produce significant faster executables in some cases.

The target language can be changed with compiler flag *--simCodeTarget*.

Depending on the target the compiler will write code and compile everything into a single simulation executable.

## 8.4 Simulation Runtimes

The generated code is linked with the appropriate runtime.

### 8.4.1 C Runtime

In *Solving Modelica Models* the methods implemented in the C runtime are described. In *C Runtime Simulation Flags* the runtime flags are documented.

### 8.4.2 C++ Runtime

Solver methods and runtime flags are currently undocumented. Refer to the source code

### 8.4.3 References

CHAPTER

NINE

# SOLVING MODELICA MODELS

## 9.1 Integration Methods

By default OpenModelica transforms a Modelica model into an ODE representation to perform a simulation by using numerical integration methods. This section contains additional information about the different integration methods in OpenModelica. They can be selected by the method parameter of the *simulate* command or the *-s simflag*.

The different methods are also called solver and can be distinguished by their characteristic:

- Method
- Explicit vs. implicit
- Suitability for stiff systems
- Usage of sparse methods to solver underlying equation systems
- Integration order
- Step size control: Fixed vs. adaptive

| Solver | Method | Type | System | Sparsity | Order | Step Size |
|---|---|---|---|---|---|---|
| *DASSL* | BDF | imp. | stiff | sparse / dense | adaptive 1-5 | adaptive |
| *IDA* | BDF | imp. | stiff | sparse / dense | adaptive 1-5 | adaptive |
| *CVODE* | Adams- Moulton | imp. | non-stiff | dense | adaptive 1-12 | adaptive |
| *CVODE* | BDF | imp. | stiff | dense | adaptive 1-5 | adaptive |
| *GBODE* | RK | exp. | non-stiff | sparse / dense | 1-14 | adaptive |
| *GBODE* | RK | imp. | stiff | sparse / dense | 1-12 | adaptive |
| *GBODE* | RK | imp. | multi-rate | sparse / dense | 1-14 | adaptive |
| *Euler* | Euler | exp. | non-stiff | dense | 1 | fixed |

A good introduction on this topic may be found in [CK06] and a more mathematical approach can be found in [HNorsettW93].

### 9.1.1 DASSL

DASSL is the default solver in OpenModelica, because of a severals reasons. It is an implicit, higher order, multi-step solver with a step-size control and with these properties it is quite stable for a wide range of models. Furthermore it has a mature source code, which was originally developed in the eighties an initial description may be found in [Pet82].

This solver is based on backward differentiation formula (BDF), which is a family of implicit methods for numerical integration. The used implementation is called DASPK2.0 (see[1]) and it is translated automatically to C by f2c (see[2]).

[1] DASPK Webpage
[2] Cdaskr source

Internal non-linear and linear equation systems are solved using dense methods. If the target model is known to have a sparse structure one of the sparse solvers might be a better alternative.

The following simulation flags can be used to adjust the behavior of the solver for specific simulation problems: *jacobian*, *noRootFinding*, *noRestart*, *initialStepSize*, *maxStepSize*, *maxIntegrationOrder*, *noEquidistantTimeGrid*.

### 9.1.2 IDA

The IDA solver is part of a software family called sundials: SUite of Nonlinear and DIfferential/ALgebraic equation Solvers [HBG+05]. The implementation is based on DASPK with an extended linear solver interface, which includes an interface to the high performance sparse non-lineaer solver KINSOL [HBG+05] and linear solver KLU [DN10].

The simulation flags of *DASSL* are also valid for the IDA solver and furthermore it has the following IDA specific flags: *idaLS*, *idaMaxNonLinIters*, *idaMaxConvFails*, *idaNonLinConvCoef*, *idaMaxErrorTestFails*.

### 9.1.3 CVODE

The CVODE solver is part of sundials: SUite of Nonlinear and DIfferential/ALgebraic equation Solvers [HBG+05]. CVODE solves initial value problems for ordinary differential equation (ODE) systems with variable-order, variable-step multistep methods.

In OpenModelica, CVODE uses a combination of Backward Differentiation Formulas (varying order 1 to 5) as linear multi-step method and a modified Newton iteration with fixed Jacobian as non-linear solver per default. This setting is advised for stiff problems which are very common for Modelica models. For non-stiff problems an combination of an Adams-Moulton formula (varying order 1 to 12) as linear multi-step method together with a fixed-point iteration as non-linear solver method can be chosen.

Both non-linear solver methods are internal functions of CVODE and use its internal direct dense linear solver CVDense. For the Jacobian of the ODE CVODE will use its internal dense difference quotient approximation.

CVODE has the following solver specific flags: *cvodeNonlinearSolverIteration*, *cvodeLinearMultistepMethod*.

### 9.1.4 GBODE

GBODE stands for Generic Bi-rate ordinary differential equation (ODE) solver and is a generic implementation for any Runge-Kutta (RK) scheme [HNorsettW00]. In GBODE there are already many different implicit and explicit RK methods (e.g. SDIRK, ESDIRK, Gauss, Radau, Lobatto, Fehlberg, DOPRI45, Merson) with different approximation order configurable and ready to use. New RK schemes can easily be added, if the corresponding Butcher tableau is available. By default the solver runs in single-rate mode using the embedded RK scheme ESDIRK4 [KC19] with variable-step-size control and efficient event handling.

The bi-rate mode can be utilized using the simulation flag *gbratio*. This flag determines the percentage of fast states with respect to all states. These states will then be automatically detected during integration based on the estimated approximation error and afterwards refined using an appropriate inner step-size control and interpolated values of the slow states.

The solver utilizes by default the sparsity pattern of the ODE Jacobian and solves the corresponding non-linear system in case of an implicit chosen RK scheme using sparse solver KINSOL.

GBODE is highly configurable and the following simulation flags can be used to adjust the behavior of the solver for specific simulation problems: *gbratio*, *gbm*, *gbctrl*, *gbnls*, *gbint*, *gberr*, *gbfm*, *gbfctrl*, *gbfnls*, *gbfint*, *gbferr*.

### 9.1.5 Basic Explicit Solvers

The basic explicit solvers Euler uses a fixed step-size based on the `numberOfIntervals`, the `startTime` and `stopTime` parameters in the *simulate* command: $\text{stepSize} \approx \frac{\text{stopTime} - \text{startTime}}{\text{numberOfIntervals}}$

- euler - Explicit Euler, fixed step size, order 1

### 9.1.6 Deprecated Solvers

The following solvers are deprecated and will be removed in a future version of OpenModelica:

- rungekutta - Classic Runge-Kutta method RK4, explicit, fixed step-size, oder 4

```
old: -s=rungekutta
new: -s=gbode -gbm=rungekutta -gbctrl=const
```

- symSolver - Symbolic inline solver (requires *--symSolver*) - fixed step-size, order 1
- symSolverSsc - Symbolic implicit inline Euler with step-size control (requires *--symSolver*) - step-size control, order 1-2
- qss - A QSS solver

## 9.2 DAE Mode Simulation

Beside the default ODE simulation, OpenModelica is able to simulate models in *DAE mode*. The *DAE mode* is enabled by the flag *--daeMode*. In general the whole equation system of a model is passed to the DAE integrator, including all algebraic loops. This reduces the amount of work that needs to be done in the post optimization phase of the OpenModelica backend. Thus models with large algebraic loops might compile faster in *DAE mode*.

Once a model is compiled in *DAE mode* the simulation can be only performed with *SUNDIALS/IDA* integrator and with enabled *-daeMode* simulation flag. Both are enabled automatically by default, when a simulation run is started.

## 9.3 Initialization

To simulate an ODE representation of an Modelica model with one of the methods shown in *Integration Methods* a valid initial state is needed. Equations from an initial equation or initial algorithm block define a desired initial system.

### 9.3.1 Choosing start values

Only non-linear iteration variables in non-linear strong components require start values. All other start values will have no influence on convergence of the initial system.

Use *-d=initialization* to show additional information from the initialization process. In OMEdit Tools->Options->Simulation->OMCFlags, in OMNotebook call setCommandLineOptions("-d=initialization")

```
model piston
  Modelica.Mechanics.MultiBody.Parts.Fixed fixed1 annotation(
    Placement(visible = true, transformation(origin = {-80, 70}, extent = {{-10, -10},
↪ {10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Parts.Body body1(m = 1)  annotation(
    Placement(visible = true, transformation(origin = {30, 70}, extent = {{-10, -10},
↪{10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Parts.FixedTranslation fixedTranslation1(r = {0.3, 0,␣
↪0})  annotation(
    Placement(visible = true, transformation(origin = {-10, 70}, extent = {{-10, -10},
↪ {10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Parts.FixedTranslation fixedTranslation2(r = {0.8, 0,␣
↪0})  annotation(
    Placement(visible = true, transformation(origin = {10, 20}, extent = {{-10, -10},
↪{10, 10}}, rotation = -90)));
  Modelica.Mechanics.MultiBody.Parts.Fixed fixed2(animation = false, r = {1.1, 0, 0})␣
↪ annotation(
    Placement(visible = true, transformation(origin = {70, -60}, extent = {{-10, -10},
```

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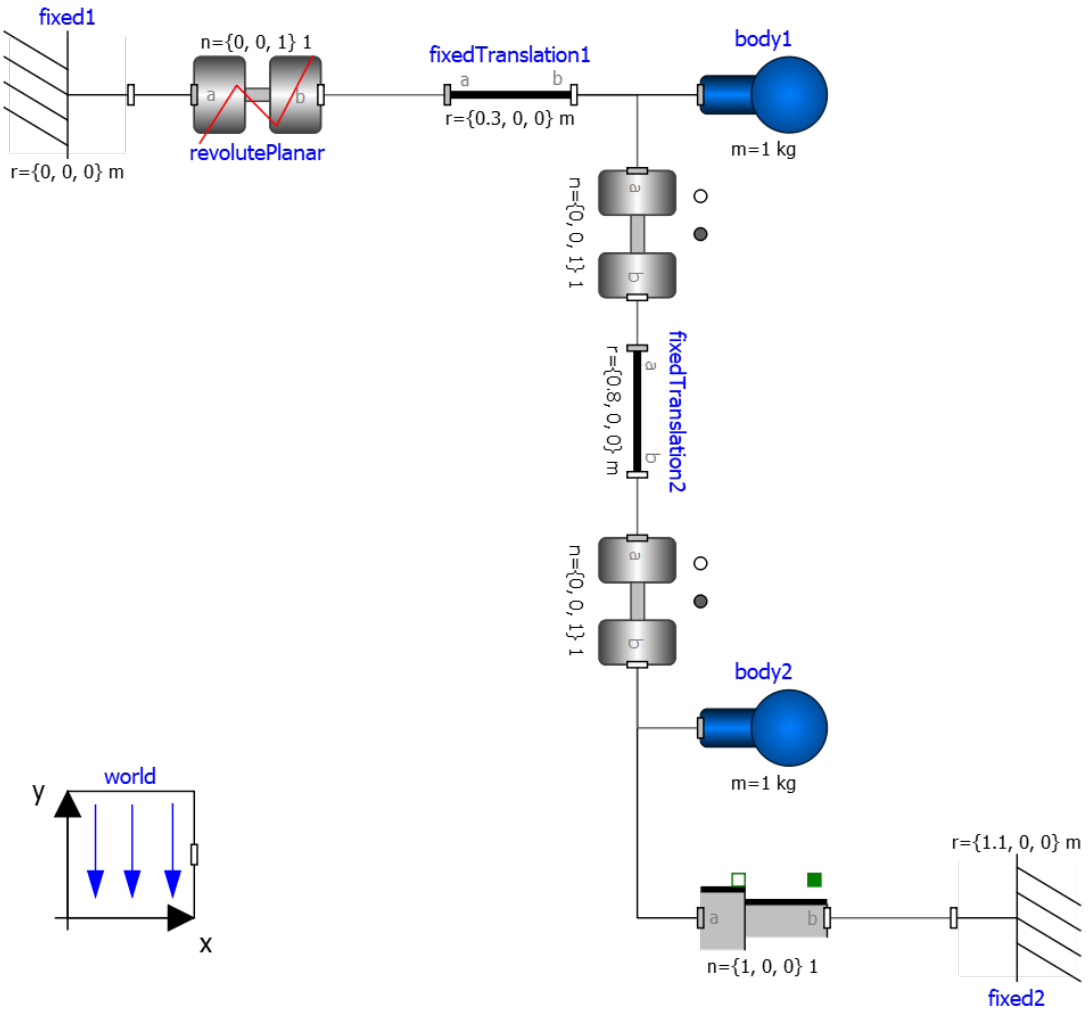



Figure 9.1: piston.mo

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```
↪ {10, 10}}, rotation = 180)));
  Modelica.Mechanics.MultiBody.Parts.Body body2(m = 1)  annotation(
    Placement(visible = true, transformation(origin = {30, -30}, extent = {{-10, -10},
↪ {10, 10}}, rotation = 0)));
  inner Modelica.Mechanics.MultiBody.World world annotation(
    Placement(visible = true, transformation(origin = {-70, -50}, extent = {{-10, -10}
↪, {10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Joints.Prismatic prismatic(animation = true) ␣
↪annotation(
    Placement(visible = true, transformation(origin = {30, -60}, extent = {{-10, -10},
↪ {10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Joints.RevolutePlanarLoopConstraint revolutePlanar␣
↪annotation(
    Placement(visible = true, transformation(origin = {-50, 70}, extent = {{-10, -10},
↪ {10, 10}}, rotation = 0)));
  Modelica.Mechanics.MultiBody.Joints.Revolute revolute1(a(fixed = false),phi(fixed =␣
↪false), w(fixed = false))  annotation(
    Placement(visible = true, transformation(origin = {10, 48}, extent = {{-10, -10},
↪{10, 10}}, rotation = -90)));
  Modelica.Mechanics.MultiBody.Joints.Revolute revolute2 annotation(
    Placement(visible = true, transformation(origin = {10, -10}, extent = {{-10, -10},
↪ {10, 10}}, rotation = -90)));
equation
  connect(prismatic.frame_b, fixed2.frame_b) annotation(
    Line(points = {{40, -60}, {60, -60}, {60, -60}, {60, -60}}, color = {95, 95, 95}
↪));
  connect(fixed1.frame_b, revolutePlanar.frame_a) annotation(
    Line(points = {{-70, 70}, {-60, 70}, {-60, 70}, {-60, 70}}));
  connect(revolutePlanar.frame_b, fixedTranslation1.frame_a) annotation(
    Line(points = {{-40, 70}, {-20, 70}, {-20, 70}, {-20, 70}}, color = {95, 95, 95}
↪));
  connect(fixedTranslation1.frame_b, revolute1.frame_a) annotation(
    Line(points = {{0, 70}, {10, 70}, {10, 58}, {10, 58}}, color = {95, 95, 95}));
  connect(revolute1.frame_b, fixedTranslation2.frame_a) annotation(
    Line(points = {{10, 38}, {10, 38}, {10, 30}, {10, 30}}, color = {95, 95, 95}));
  connect(revolute2.frame_b, prismatic.frame_a) annotation(
    Line(points = {{10, -20}, {10, -20}, {10, -60}, {20, -60}, {20, -60}}));
  connect(revolute2.frame_b, body2.frame_a) annotation(
    Line(points = {{10, -20}, {10, -20}, {10, -30}, {20, -30}, {20, -30}}, color =
↪{95, 95, 95}));
  connect(revolute2.frame_a, fixedTranslation2.frame_b) annotation(
    Line(points = {{10, 0}, {10, 0}, {10, 10}, {10, 10}}, color = {95, 95, 95}));
  connect(fixedTranslation1.frame_b, body1.frame_a) annotation(
    Line(points = {{0, 70}, {18, 70}, {18, 70}, {20, 70}}));
end piston;
```

```
>>> loadModel(Modelica);
>>> setCommandLineOptions("-d=initialization");
>>> buildModel(piston);
"Warning: Parameter body1.r_CM has no value, and is fixed during initialization␣
↪(fixed=true), using available start value (start={0, 0, 0}) as default value.
Warning: Parameter body2.r_CM has no value, and is fixed during initialization␣
↪(fixed=true), using available start value (start={0, 0, 0}) as default value.
Warning: Assuming fixed start value for the following 2 variables:
         $STATESET2.x:VARIABLE(start = /*Real*/($STATESET2.A[1]) * $START.revolute2.
↪phi + /*Real*/($STATESET2.A[2]) * $START.revolute1.phi fixed = true )  type: Real
```

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```
        $STATESET1.x:VARIABLE(start = /*Real*/($STATESET1.A[1]) * $START.revolute1.w␣
↪+ /*Real*/($STATESET1.A[2]) * $START.revolute2.w fixed = true )  type: Real"
```

Note how OpenModelica will inform the user about relevant and irrelevant start values for this model and for which variables a fixed default start value is assumed. The model has four joints but only one degree of freedom, so one of the joints *revolutePlanar* or *prismatic* must be initialized.

So, initializing *phi* and *w* of *revolutePlanar* will give a sensible start system.

```
model pistonInitialize
  extends piston(revolute1.phi.fixed = true, revolute1.phi.start = -1.221730476396031,
↪ revolute1.w.fixed = true, revolute1.w.start = 5);
equation
end pistonInitialize;
```

```
>>> setCommandLineOptions("-d=initialization");
>>> simulate(pistonInitialize, stopTime=2.0);
"Warning: Parameter body1.r_CM has no value, and is fixed during initialization␣
↪(fixed=true), using available start value (start={0, 0, 0}) as default value.
Warning: Parameter body2.r_CM has no value, and is fixed during initialization␣
↪(fixed=true), using available start value (start={0, 0, 0}) as default value."
```

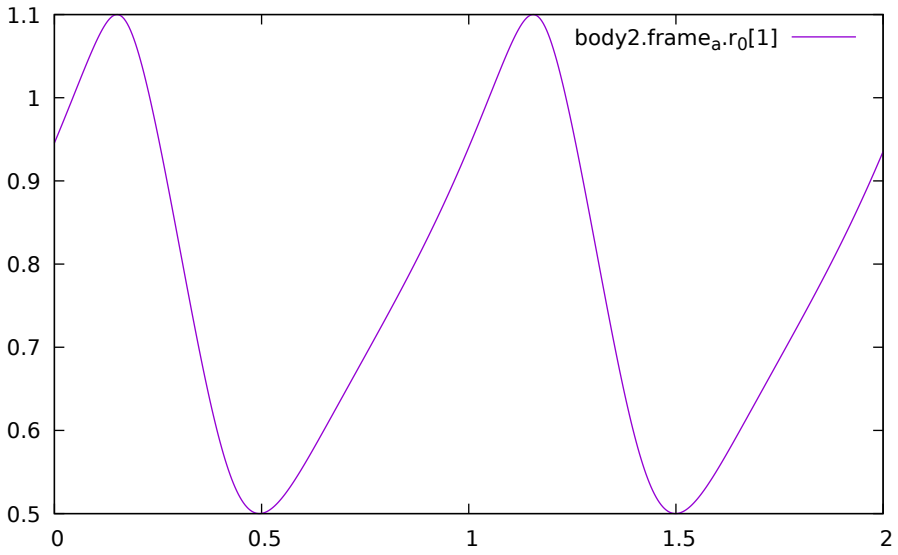



Figure 9.2: Vertical movement of mass body2.

### 9.3.2 Importing initial values from previous simulations

In many use cases it is useful to import initial values from previous simulations, possibly obtained with another Modelica tool, which are saved in a .mat file. There are two different options to do that.

#### Using previous simulation results as start values for the initial equations

The first option is to solve the initial equations specified by the Modelica model, using the previous simulation results as initial guesses for the iterative solvers, in case they are needed. This can be very helpful in case the initialization problem involves the solution of large nonlinear systems of equations by means of iterative algorithms, whose convergence is sensitive to the selected initial guess.

Importing a previously found solution allows the OpenModelica solver to pick very good initial guesses for the unknowns of the iterative solvers, thus achieving convergence with a few iterations. Since the initial equations

are solved in the process, the values of all variables and derivatives, as well as of all parameters with *fixed = false* attribute, are re-computed and fully consistent with the selected initial conditions, even in case the previously saved simulation results refer to a slightly different model configuration. Note that parameters with *fixed = true* will also get their values from the imported .mat file, so if you want to change them you need to edit the .mat file accordingly.

This option is activated by selecting the simulation result file name in the OMEdit *Simulation Setup | Simulation Flag | Equation System Initialization File* input field, or by setting the additional simulation flag *-iif=resultfile.mat*. By activating the checkbox *Save simulation flags inside the model i.e., __OpenModelica_simulationFlags annotation*, a custom annotation *__OpenModelica_simulationFlags(iif="filename.mat")* is added to the model, so this setting is saved with the model and is reused when loading the model again later on. It is also possible to specify at which point in time of the saved simulation results the initial values should be picked, by means of the *Simulation Setup | Simulation Flags | Equation System Initialization Time* input field, or by setting the simulation flag *-iit=initialTimeValue*.

### Using previous simulation results to directly initialize a simulation

The second option is to skip the solution of the initial equations entirely, directly starting the simulation with the imported start values. In this case, the initial equations of the model are ignored, and the initial values of all parameters and state variables are directly set to the values loaded from the .mat file. This option is useful to restart a simulation from the final state of a previous one, ignoring whatever initial conditions are declared in the Modelica model by either fixed = true attributes or initial equations.

Note that state variables and parameters will be directly initialized to the imported values, while algebraic variables will be recomputed with the regular simulation equations, on the basis of the imported initial state and parameter values. The values of algebraic variables in the imported file will only be used to initialize iteration variables, in case this computation involves nonlinear implicit equations and iterative solvers, otherwise they will be ignored.

To activate this second option, set *Simulation Setup | Simulation Flag | Initialization Method* to *none* in OMEdit, or set the simulation flag *-iim=none*. Also in this case, activating the checkbox *Save simulation flags inside model, i.e. __OpenModelica_simulationFlags annotation* saves this option in an *__OpenModelica_simulationFlags(iim=none)* annotation, so it is retained for future simulations of the same model.

### Beware of missing variables in the simulation result file

When importing simulation results to initialize a new simulation, bear in mind that, by default, protected and hidden variables are *not saved* to the .mat file, so they will be missing when importing the simulation results for initialization. This is particularly dangerous when the imported values are used directly, as unsaved protected or hidden variables will not be initialized and will retain their default zero value, which is likely to cause numerical problems such as division by zero when the simulation is started.

To avoid this problem, make sure you also save protected and hidden variables in the simulation result file, by setting the corresponding checkboxes in the *Simulation Setup | Output* tab of OMEdit, or by setting the simulation flags *-emit_protected* and *-ignoreHideResult*.

### Example of use

The following minimal working example demonstrates the use of the initial value import feature. You can create a new package *ImportInitialValues* in OMEdit, copy and paste its code from here, and then run the different models in it.

```
package ImportInitialValues "Test cases for importing initial values in OpenModelica"
  partial model Base "The mother of all models"
    Real v1, v2, x;
    parameter Real p1;
    parameter Real p2 = 2*p1;
    final Real p3 = 3*p1;
  end Base;

  model ResultFileGenerator "Dummy model for generating the initial.mat file"
    extends Base(p1 = 7, p2 = 10);
```

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```
  equation
    v1 = 2.8;
    v2 = 10;
    der(x) = 0;
  initial equation
    x = 4;
  annotation(
    experiment(StopTime = 1),
    __OpenModelica_simulationFlags(r = "../initial.mat"));
  end ResultFileGenerator;

  model M "Relies on Modelica code only for initialization"
    extends Base(
      v1(start = 14),
      p1 = 1, p2 = 1);
  equation
    (v1 - 3)*(v1 + 10)*(v1 - 15) = 0;
    v2 = time;
    der(x) = -x;
  initial equation
    x = 6;
  end M;

  model M2 "Imports parameters and initial guesses only, solve initial equations"
    extends M;
  annotation(__OpenModelica_simulationFlags(iif = "../initial.mat"));
  end M2;

  model M3 "import parameters, initial guesses and initial states, skip initial␣
↪equations"
    extends M;
  annotation(__OpenModelica_simulationFlags(iim = "none", iif = "../initial.mat"));
  end M3;
end ImportInitialValues;
```

Running the *ResultFileGenerator* model creates an *initial.mat* file with some initial values in the root OMEdit working directory: $p1 = 7$, $p2 = 10$, $p3 = 21$, $v1 = 2.8$, $v2 = 10$, $x = 4$, $der(x) = 0$. Note that the default directory when running simulations in OMEdit is a sub-directory named as the full model pathname, located in the working directory, so it is necessary to go up one directory to access the root working directory.

When running model *M*, the simulation process only relies on the initial and guess values provided by the Modelica source code. Regarding the parameter values, $p1 = 1$, $p2 = 1$, $p3 = 3*p1 = 3$; regarding *v1*, the implicit cubic equation is solved iteratively using the start value 14 as an initial guess, thus converging to the nearest solution $v1 = 15$. The other variable *v2* can be computed explicitly, so there is no need of any guess value for it. Finally, the initial value of the state variable is set to $x = 6$ by the initial equations.

When running model *M2*, the values of the *initial.mat* file are imported to provide values for non-final parameters and guess values for the initial equations, which are solved starting from there. Hence, the imported parameter values p1 = 7 and p2 = 10 override the model's binding equations, that would set both to 1; on the other hand, the final parameter p3 is computed based on the final binding equation to $p3 = p1*3 = 21$. Regarding *v1*, the iterative solver converges to the solution closest to the imported start value of 2.8, i.e. $v1 = 3$, while *v2* is computed explicitly, so it doesn't depend on the imported start value, which is ignored. The initial value of the state $x = 6$ is obtained by solving the initial equation, which is explicit and thus ignores the imported guess value $x = 4$.

Finally, when running model *M3*, parameters are handled like in the previous case, as well as the algebraic variables *v1* and *v2*. However, in this case the solution of the initial equations is skipped, so the state variable gets its initial value $x = 4$ straight from the imported *initial.mat* file.

### 9.3.3 Homotopy Method

For complex start conditions OpenModelica can have trouble finding a solution for the initialization problem with the default Newton method.

Modelica offers the homotopy operator[3] to formulate *actual* and *simplified* expression for equations, with homotopy parameter $\lambda$ going from 0 to 1:

$$actual \cdot \lambda + simplified \cdot (1 - \lambda).$$

OpenModelica has different solvers available for non-linear systems. Initializing with homotopy on the first try is default if a homotopy operator is used. It can be switched off with *noHomotopyOnFirstTry*. For a general overview see [SCO+11], [Sie12], for details on the implementation in OpenModelica see [OB13].

The homotopy methods distinguish between local and global methods meaning, if $\lambda$ affects the entire initialization system or only local strong connected components. In addition the homotopy methods can use equidistant $\lambda$ or and adaptive $\lambda$ in [0,1].

**Default order of methods tried to solve initialization system**

**If there is no homotopy in the model**

- Solve without homotopy method.

**If there is homotopy in the model or solving without homotopy failed**

- Try global homotopy approach with equidistant $\lambda$.

The default homotopy method will do three global equidistant steps from 0 to 1 to solve the initialization system.

Several compiler and simulation flags influence initialization with homotopy: *--homotopyApproach*, *-homAdaptBend*, *-homBacktraceStrategy*, *-homHEps*, *-homMaxLambdaSteps*, *-homMaxNewtonSteps*, *-homMaxTries*, *-homNegStartDir*, *-homotopyOnFirstTry*, *-homTauDecFac*, *-homTauDecFacPredictor*, *-homTauIncFac*, *-homTauIncThreshold*, *-homTauMax*, *-homTauMin*, *-homTauStart*, *-ils*.

## 9.4 Tearing

The size of linear and nonlinear equation systems can be substantially reduced by means of the Tearing method. Consider a system of $N$ equations. The Tearing method requires to pick $M < N$ variables $x_t$ as *tearing* or *iteration* variables, so that assuming their values are known, $N-M$ *torn* equations can be solved explicitly for the remaining $N - M$ *torn* variables, by sorting them appropriately. Then, the remaining M equations are put in *residual* form $f(x_t) = 0$, where the residuals can ultimately be computed by explicit computations as a function of the tearing variables $x_t$ only. The result is thus an equivalent implicit system of $M < N$ equations in the $M$ tearing variables, with an explicit procedure to compute the residual function $f(x_t)$. The Jacobian of that function, which is required by the Newton method, can then be obtained by either symbolic or numerical differentiation techniques.

The Tearing method has three main advantages:

- the size of the Jacobian matrix to be factorized in order to solve it is greatly reduced;
- for nonlinear systems solved by iterative methods like Newton-Raphson, it is only necessary to give initial guess values to the much smaller set of variables $x_t$; the initial guess values are set to the start attributes of the tearing variables;
- the method allows to solve mixed systems containing Real and discrete (Boolean or Integer) variables and equations by means of standard nonlinear equation solvers, as long as the discrete variables are selected as torn variables and the resulting residual equations have a continuous dependency on the Real tearing variables.

OpenModelica implements some heuristic algorithms to automatically choose the set of tearing variables. The tearing algorithm can be selected with the compiler flags: *--tearingMethod*, *--tearingHeuristic*. Since the tearing algorithms can be very time-consuming for large systems, they are automatically disabled for systems above a certain size, see *--maxSizeLinearTearing*, *--maxSizeNonlinearTearing*.

[3] Modelica Association, Modelica® - A Unified Object-Oriented Language for Systems Modeling Language Specification - Version 3.4, 2017 - Section 3.7.2.4

As of Modelica 3.6, there is no standardized way to influence the choice of tearing variables. OpenModelica provides a custom *__OpenModelica_tearingSelect* annotation that can be added to variable declarations to influence the choice of tearing variables:

```
Real x annotation(__OpenModelica_tearingSelect = TearingSelect.always);
Real y annotation(__OpenModelica_tearingSelect = TearingSelect.prefer);
Real z annotation(__OpenModelica_tearingSelect = TearingSelect.default);
Real v annotation(__OpenModelica_tearingSelect = TearingSelect.avoid);
Real w annotation(__OpenModelica_tearingSelect = TearingSelect.never);
```

This feature is currently experimental. There is discussion going on within the MAP-Lang group of the Modelica Association to standardize features for the selection of tearing variables and residual equations.

## 9.5 Algebraic Solvers

If the ODE system contains equations that need to be solved together, so called algebraic loops, OpenModelica can use a variety of different linear and non-linear methods to solve the equation system during simulation.

For the C runtime the linear solver can be set with *-ls* and the non-linear solver with *-nls*. There are dense and sparse solver available.

**Linear solvers**

- *default* : Lapack with totalpivot as fallback [ABB+99]
- *lapack* : Non-Sparse LU factorization using [ABB+99]
- *lis* : Iterative linear solver [Nis10]
- *klu* : Sparse LU factorization [Nat05]
- *umfpack* : Sparse unsymmetric multifrontal LU factorization [Dav04]
- *totalpivot* : Total pivoting LU factorization for underdetermined systems

**Non-linear solvers**

- *hybrid* : Modified Powell hybrid method from MINPACK [DJS96]
- *kinsol* : Combination of Newton-Krylov, Picard and fixed-point solver [T+98]
- *newton* : Newton-Raphson method [CK06]
- *mixed* : Homotopy with hybrid as fallback [Kel78] [BBOR15]
- *homotopy* : Damped Newton solver with fixed-point solver and Newton homotopy solver as fallbacks

In addition, there are further optional settings for the algebraic solvers available. A few of them are listed in the following:

General: *-nlsLS*

Newton: *-newton -newtonFTol -newtonMaxStepFactor -newtonXTol*

Sparse solver: *-nlssMinSize -nlssMaxDensity*

Enable logging: *-lv=LOG_LS -lv=LOG_LS_V -lv=LOG_NLS -lv=LOG_NLS_V*

### 9.5.1 References

CHAPTER

TEN

# AUTOMATIC PARALLELIZATION OF SIMULATIONS

OpenModelica can automatically parallelize the simulation of a model over the available CPU cores. The feature is enabled by building the model with the `--parmodauto` compiler flag:

```
setCommandLineOptions("--parmodauto");
loadModel(Modelica);
buildModel(Modelica.Fluid.Examples.BranchingDynamicPipes, fileNamePrefix="m");
```

With `--parmodauto` the compiler emits, alongside the usual simulation code, a description of the model's equation **task graph** (which equation depends on which). At run time the executable reads that description, groups the tasks into **clusters**, builds a task graph over the clusters and executes it in parallel with oneTBB.

How the tasks are grouped into clusters — the *clustering* — determines how well the work balances across the cores. The runtime ships several clustering strategies, and it can also **export** the task graph and clustering to JSON and **import** a clustering produced by an external tool. This makes it possible to develop and tune clustering/scheduling outside of the C++ runtime, for example with graph-visualization tools or with an optimizer, and then feed the result back into the simulation.

## 10.1 Run-time flags

The following simulation-executable flags control the clustering and the JSON export/import. They are passed to the generated executable (e.g. via `simulate(M, simflags="...")` or on the command line).

```
-parmodScheduler=flow|level          select the scheduler (default: flow)
-parmodClustering=NAME               select the clustering strategy
                                     (default, fixed_width_min_height, none)
-parmodClustersPerLevel=INT          max clusters per level for the default clustering

-parmodExportTaskGraph=FILE          export the final task graph + clustering as JSON
-parmodDumpStages=PREFIX             export one JSON snapshot before and after every
                                     clustering optimization (PREFIX.00.initial.json,
                                     PREFIX.01.<opt>.json, ...)
-parmodImportClustering=FILE         use the clustering from FILE instead of␣
↪computing one
```

Importing a clustering aborts the simulation (with an error) if the file references an unknown or duplicated equation, or if the requested clustering would form a cycle in the contracted task graph.

## 10.2 JSON format

Everything is keyed by the **stable equation index** (`eq`), which is independent of the internal graph ordering:

```
{
  "name": "ModelName",
  "num_threads": 8,
```

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```
  "tasks":        [ {"eq": 42, "level": 3, "cost": 2.0, "out_degree": 2} ],
  "dependencies": [ [11, 42] ],
  "clusters":     [ {"eqs": [42, 43], "lane": 1} ],
  "stage": 1, "stage_name": "cluster_merge_common"
}
```

- `level` is the dependency depth (level 1 runs first), `cost` is the runtime's per-task cost estimate, and `out_degree` is the task's number of successors.
- `lane` is the hardware lane (core) `0 .. num_threads-1` assigned by lane-based clustering, or `-1` when the active clustering does not assign lanes.
- `stage` / `stage_name` appear only in `-parmodDumpStages` snapshots.
- For **import**, only `{ "clusters": [ {"eqs": [...]}, ... ] }` is required; equations not listed become singleton clusters.

## 10.3 External tools

OpenModelica ships a small toolchain (installed under `share/omc/scripts/`) that consumes and produces this JSON. Each tool reads any export or `-parmodDumpStages` snapshot.

**`parmod_graph_to_graphml.py` *(Python, standard library only)***

Convert an export to GraphML for general graph tools (yEd, Gephi, NetworkX):

```
python3 parmod_graph_to_graphml.py taskgraph.json                # tasks,␣
↪colored by cluster
python3 parmod_graph_to_graphml.py --mode clusters taskgraph.json  # contracted␣
↪cluster graph
python3 parmod_graph_to_graphml.py --yed -o g.graphml taskgraph.json   # yEd,␣
↪pre-laid-out
```

Views (`--mode`): `tasks` (default), `clusters`, `lanes`, `both`.

**`parmod_graph_plot.jl` *(Julia, GraphPlot.jl)***

Render an export to SVG (default) or PNG, laid out left-to-right by level and colored by cluster:

```
julia parmod_graph_plot.jl taskgraph.json
julia parmod_graph_plot.jl --mode lanes --png taskgraph.json
```

Dependencies: `JSON`, `Graphs`, `GraphPlot`, `Colors`, `Compose` (and `Cairo`, `Fontconfig` for `--png`). Best for small/medium graphs; for very large graphs prefer the GraphML route.

**`parmod_optimize_clustering.jl` *(Julia, MetaheuristicsAlgorithms.jl)***

Optimize the clustering with a metaheuristic and write it back in the import format. The objective is the graph **height**: levels execute sequentially while the lanes within a level execute in parallel, so a level costs as much as its busiest lane and the height is the sum of those over all levels. Minimizing it balances each level's work across the `K` lanes (the *fixed-width / minimum height* goal). Clusters are keyed by `(level, lane)` so the result is always acyclic and safe to import.

```
julia parmod_optimize_clustering.jl taskgraph.json                  # GWO, K␣
↪= num_threads
julia parmod_optimize_clustering.jl --algorithm AEO --cores 8 --iters 500␣
↪taskgraph.json
julia parmod_optimize_clustering.jl --run --exe ./m taskgraph.json      #␣
↪optimize, then simulate
```

Options include `-a`/`--algorithm` (`GWO`, `WOA`, `AEO`, `SSA`, … — default `GWO`), `--pop`, `--iters`, `-k`/`--cores`, `--seed`, `-o`, and `--run`/`--exe`. It prints the serial and lower-bound reference heights, the op-

timized height, the speedup, and the improvement over the imported clustering. Install the dependency once with:

```
julia -e 'using Pkg; Pkg.add("JSON"); \
          Pkg.add(url="https://github.com/AbdelazimHussien/
↪MetaheuristicsAlgorithms.jl")'
```

**parmod_optimize_demo.sh** ***(Bash, end-to-end)***

Run the whole loop on a model and dump a GraphML/SVG of the clustering at every stage — both the optimizations performed inside the executable and the metaheuristic optimization performed in Julia — then report the differences:

```
MODELFILE=ParModelicaDemo.mo CORES=4 STOPTIME=1.0 \
  ./parmod_optimize_demo.sh ParModelicaDemo ./parmod_demo_out
./parmod_optimize_demo.sh --clean ./parmod_demo_out   # remove everything␣
↪regenerable
```

It builds the model with `--parmodauto`, exports the task graph and the per-stage clustering, renders them, runs `parmod_optimize_clustering.jl`, re-imports the optimized clustering, and finally compares the graph height (executable vs. optimized clustering), the simulation result (default vs. optimized clustering — these must match, since only the scheduling changes), and the wall-clock time of the two runs. `ParModelicaDemo.mo` is a small bundled model with a wide, shallow task graph that makes the clustering easy to see.

## 10.4 The optimization workflow

Putting it together, the clustering can be developed entirely outside the runtime and then used for the real simulation:

```
Modelica --omc --parmodauto-->                    executable
executable --parmodExportTaskGraph-->             taskgraph.json
taskgraph.json --parmod_optimize_clustering.jl--> optimized.json
optimized.json --parmodImportClustering-->        executable runs in parallel
```

Because the optimized clustering only changes how the equations are scheduled, the simulation results are identical to the default run; only the parallel execution differs.

CHAPTER

ELEVEN

# DEBUGGING

There are two main ways to debug Modelica code, the *transformations browser*, which shows the transformations OpenModelica performs on the equations. There is also a debugger for *debugging of algorithm sections and functions*.

## 11.1 The Equation-based Debugger

This section gives a short description how to get started using the equation-based debugger in OMEdit.

### 11.1.1 Enable Tracing Symbolic Transformations

This enables tracing symbolic transformations of equations. It is optional but strongly recommended in order to fully use the debugger. The compilation time overhead from having this tracing on is less than 1%, however, in addition to that, some time is needed for the system to write the xml file containing the transformation tracing information.

Enable -d=infoXmlOperations in Tools->Options->Simulation (see section *Simulation Options*) OR alternatively click on the checkbox *Generate operations in the info xml* in Tools->Options->Debugger (see section *Debugger Options*) which performs the same thing.

This adds all the transformations performed by OpenModelica on the equations and variables stored in the model_info.xml file. This is necessary for the debugger to be able to show the whole path from the source equation(s) to the position of the bug.

### 11.1.2 Load a Model to Debug

Load an interesting model. We will use the package Debugging.mo since it contains suitable, broken models to demonstrate common errors.

### 11.1.3 Simulate and Start the Debugger

Select and simulate the model as usual. For example, if using the Debugging package, select the model Debugging.Chattering.ChatteringEvents1. If there is an error, you will get a clickable link that starts the debugger. If the user interface is unresponsive or the running simulation uses too much processing power, click cancel simulation first.

### 11.1.4 Use the Transformation Debugger for Browsing

The debugger opens on the equation where the error was found. You can browse through the dependencies (variables that are defined by the equation, or the equation is dependent on), and similar for variables. The equations and variables form a bipartite graph that you can walk.

If the -d=infoXmlOperations was used or you clicked the "generate operations" button, the operations performed on the equations and variables can be viewed. In the example package, there are not a lot of operations because the models are small.

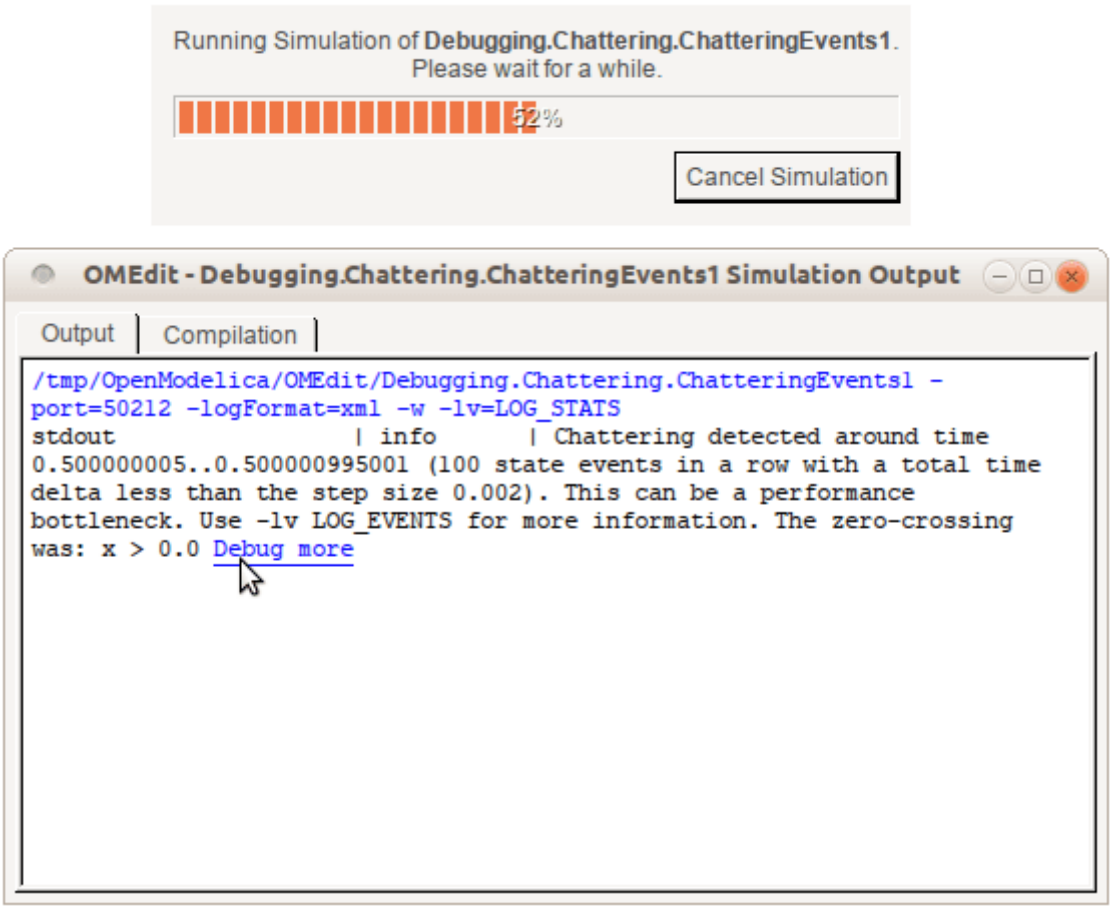



Figure 11.1: Simulating the model.

Try some larger models, e.g. in the MultiBody library or some other library, to see more operations with several transformation steps between different versions of the relevant equation(s). If you do not trigger any errors in a model, you can still open the debugger, using File->Open Transformations File (model_info.json).

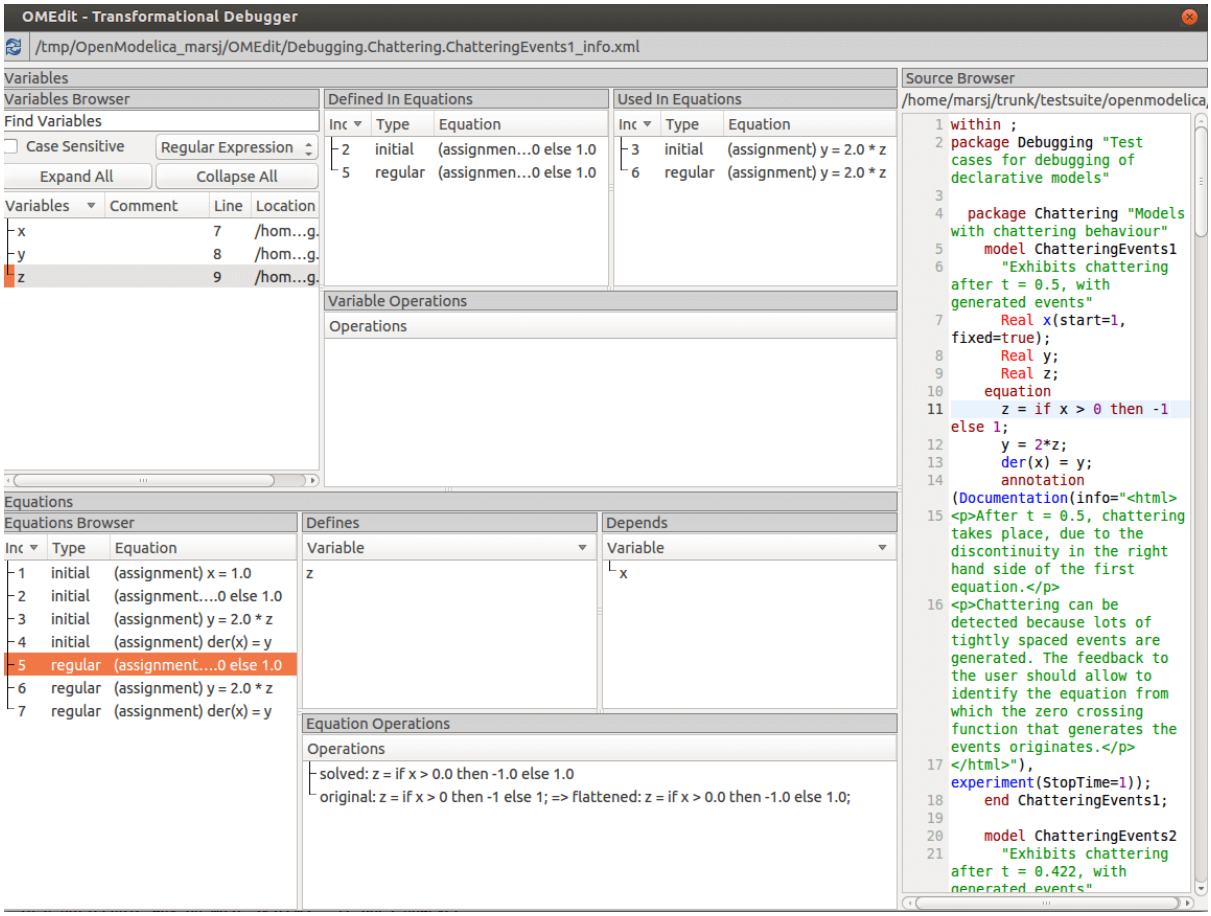



Figure 11.2: Transfomations Browser.

## 11.2 The Algorithmic Debugger

This section gives a short description how to get started using the algorithmic debugger in OMEdit. See section *Simulation Options* for further details of debugger options.

### 11.2.1 Adding Breakpoints

There are two ways to add the breakpoints,

- Click directly on the line number in Text View, a red circle is created indicating a breakpoint as shown in Figure 11.3.
- Open the Algorithmic Debugger window and add a breakpoint using the right click menu of Breakpoints Browser window.

### 11.2.2 Start the Algorithmic Debugger

You should add breakpoints before starting the debugger because sometimes the simulation finishes quickly and you won't get any chance to add the breakpoints.

There are four ways to start the debugger,

- Open the Simulation Setup and click on Launch Algorithmic Debugger before pressing Simulate.

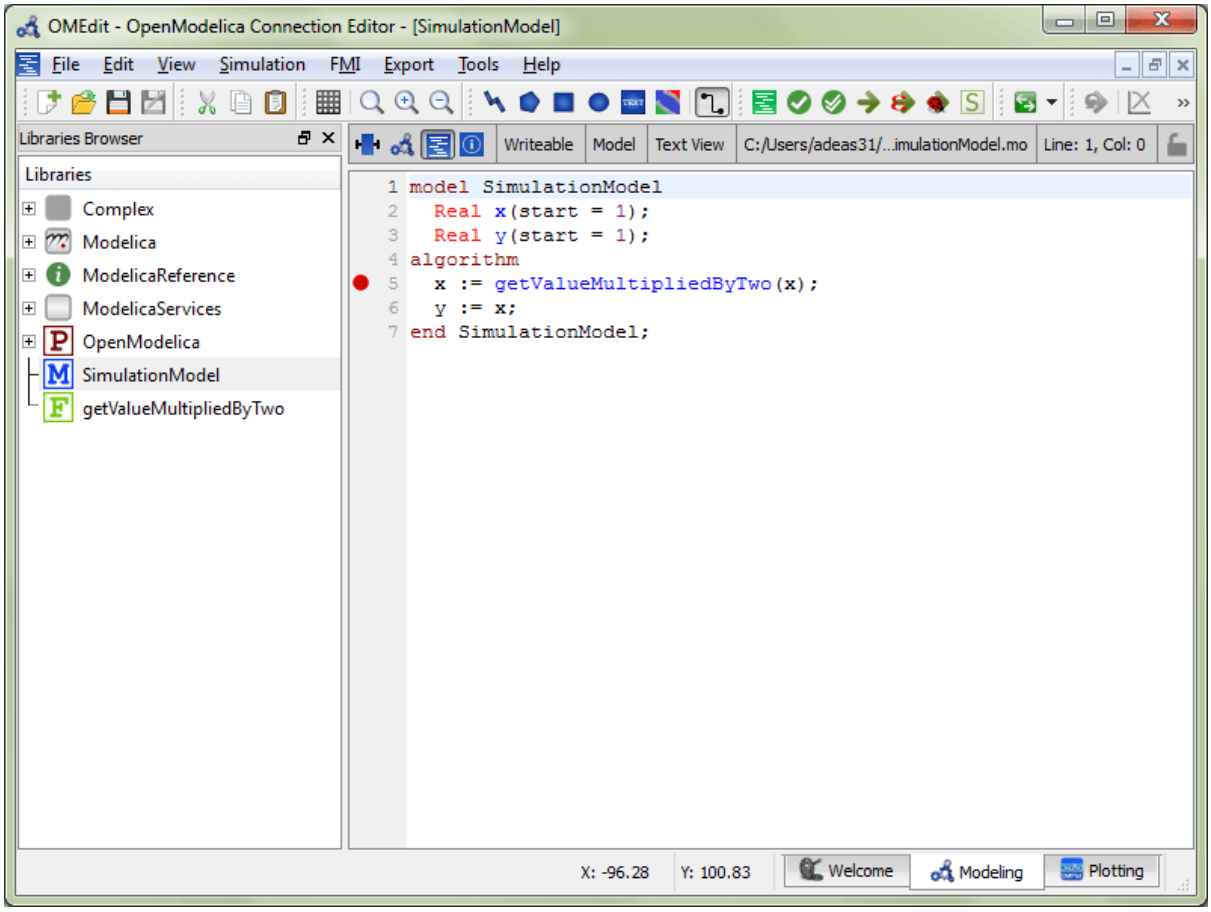



Figure 11.3: Adding breakpoint in Text View.

- Right click the model in Libraries Browser and select Simulate with Algorithmic Debugger.
- Open the Algorithmic Debugger window and from menu select Debug-> *Debug Configurations*.
- Open the Algorithmic Debugger window and from menu select Debug-> *Attach to Running Process*.

### 11.2.3 Debug Configurations

If you already have a simulation executable with debugging symbols outside of OMEdit then you can use the Debug->Debug Configurations option to load it.

The debugger also supports MetaModelica data structures so one can debug omc executable. Select omc executable as program and write the name of the mos script file in Arguments.

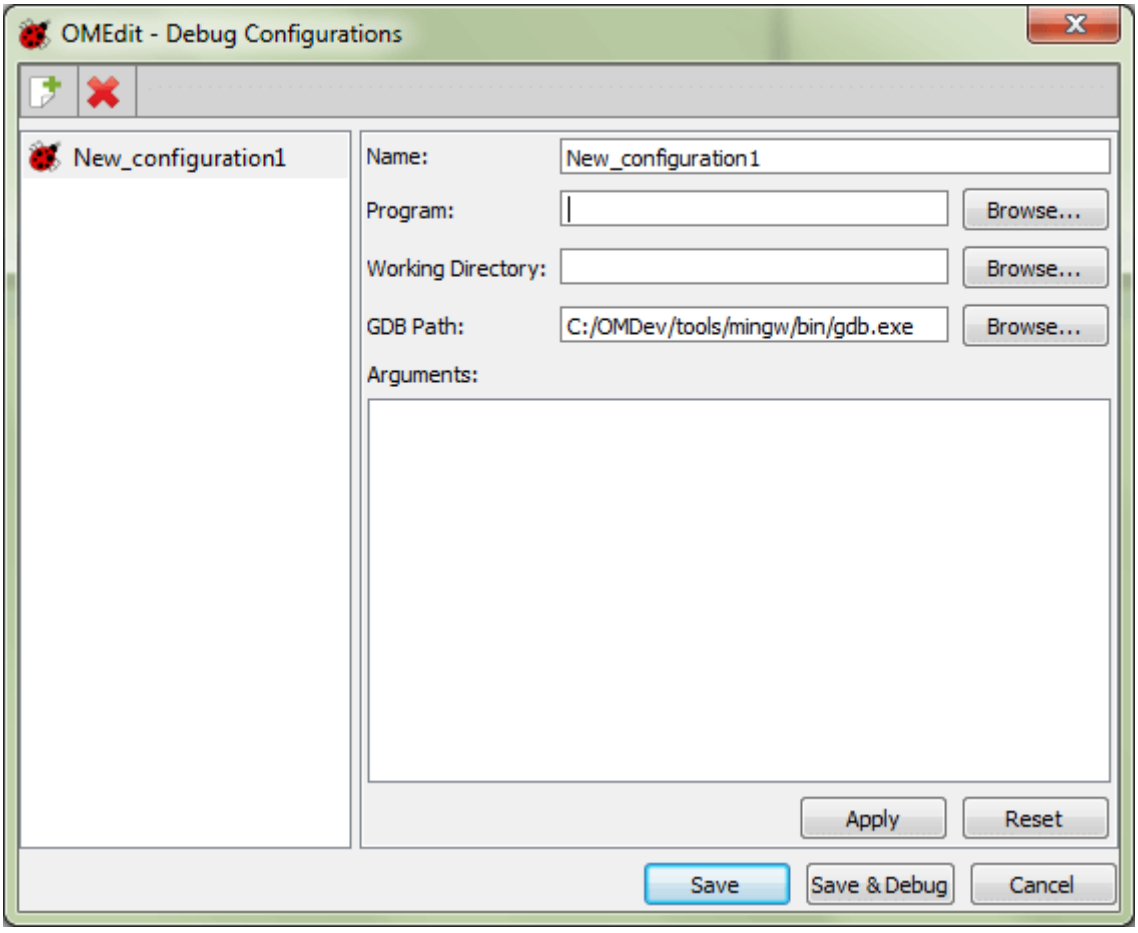



Figure 11.4: Debug Configurations.

### 11.2.4 Attach to Running Process

If you already have a running simulation executable with debugging symbols outside of OMEdit then you can use the Debug->Attach to Running Process option to attach the debugger with it. Figure 11.5 shows the Attach to Running Process dialog. The dialog shows the list of processes running on the machine. The user selects the program that he/she wish to debug. OMEdit debugger attaches to the process.

### 11.2.5 Using the Algorithmic Debugger Window

Figure 11.6 shows the Algorithmic Debugger window. The window contains the following browsers,

- *Stack Frames Browser* - shows the list of frames. It contains the program context buttons like resume, interrupt, exit, step over, step in, step return. It also contains a threads drop down which allows switching between different threads.

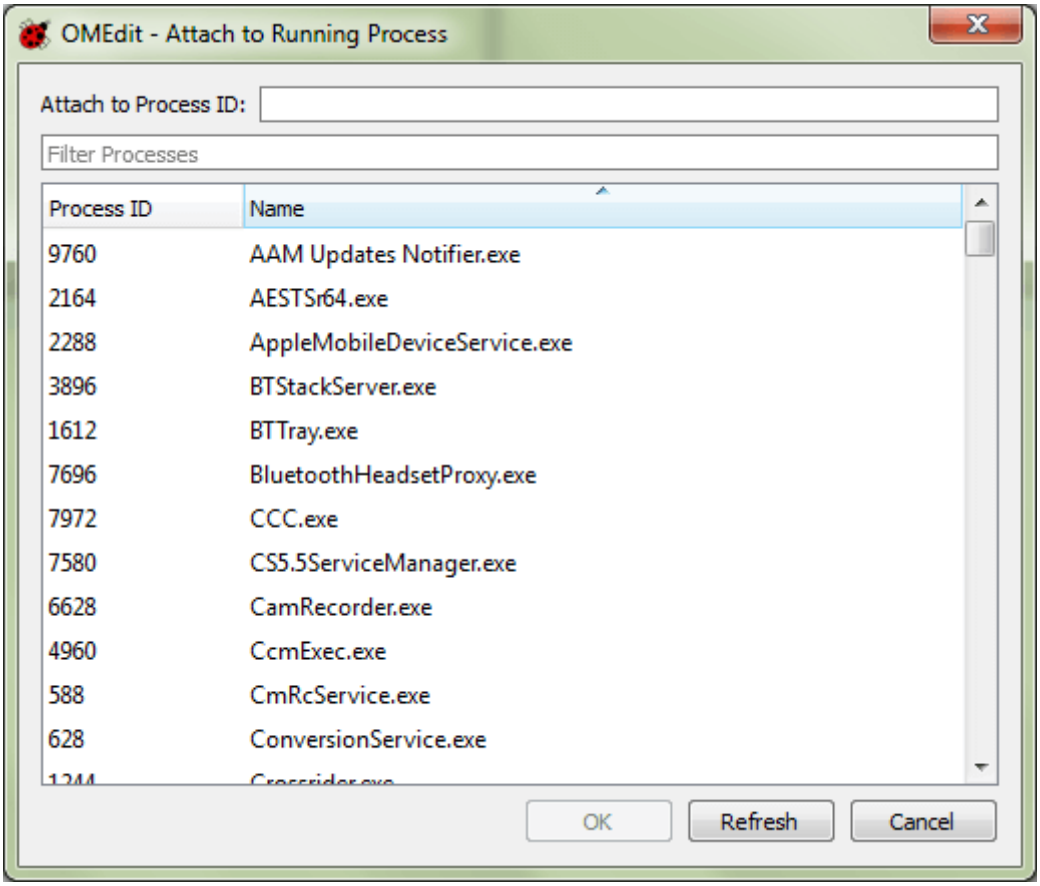



Figure 11.5: Attach to Running Process.

- *BreakPoints Browser* - shows the list of breakpoints. Allows adding/editing/removing breakpoints.
- *Locals Browser* - Shows the list of local variables with values. Select the variable and the value will be shown in the bottom right window. This is just for convenience because some variables might have long values.
- *Debugger CLI* - shows the commands sent to gdb and their responses. This is for advanced users who want to have more control of the debugger. It allows sending commands to gdb.
- *Output Browser* - shows the output of the debugged executable.

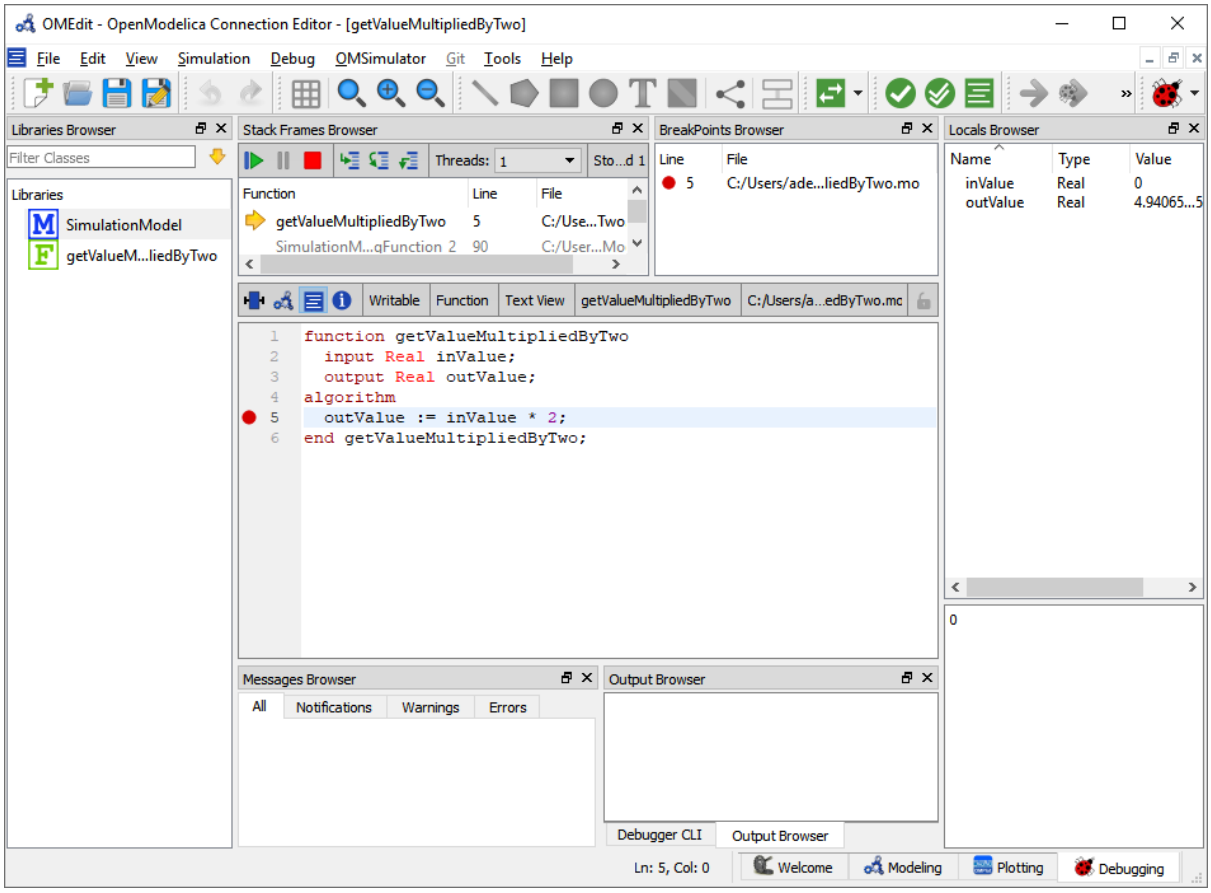



Figure 11.6: Algorithmic Debugger.

CHAPTER

TWELVE

# FLATTENING MODELS TO BASEMODELICA

## 12.1 BaseModelica

BaseModelica is an intermediate format to describe hybrid (continuous and discrete) systems with emphasis on defining the dynamic behavior of systems, rather than their structure. It is meant to become part of the Modelica standard, as a subset of the Modelica language that does not include object-oriented features such as lookup, instantiation, inheritance, connections, but rather gives a flat representation of a Modelica model which only contains variable declarations, function declarations, record declarations, equations, and initial equations.

The main aim of BaseModelica is to provide a much lower barrier of entry to the Modelica world, since writing a BaseModelica compiler or interpreter will be a much easier task than writing a full-fledged Modelica compiler.

BaseModelica is currently described by the MCP 0031 draft , and will eventually be incorporated in a future version of the Modelica Language Specification.

## 12.2 Converting Modelica models in BaseModelica with OpenModelica

The OpenModelica compiler front-end can flatten virtually 100% of Modelica models that are fully compliant with the Modelica Language Specification, converting them into a BaseModelica output. This provides a unique opportunity for organizations that want to enter the Modelica ecosystem, as they can delegate the heavy-lifting of flattening a Modelica model to the OpenModelica compiler (OMC), developing tools that only need to be able to parse and compile (or interpret) BaseModelica input.

Assume you have a package `MyPackage` contained in a file `MyPackage.mo` and you want to get the BaseModelica flattened code of model `MyPackage.Examples.MyModel` in the MyModel.mo file. From the command line, this is accomplished by typing

```
omc --BaseModelica -i=MyPackage.Examples.MyModel MyPackage.mo > MyModel.mo
```

If the package `MyPackage` is installed with the Package Manager, you can type

```
omc --BaseModelica -i=MyPackage.Examples.MyModel MyPackage > MyModel.mo
```

If you want to use OMEdit for that, you can load `MyPackage`, go to *Tools* | *Options* | *Simulation*, add `--BaseModelica` to the *Additional Translation Flags* input field, open `MyModel` and click on the Instantiate Model button, to get the BaseModelica flattened model in a separate window. Don't forget to remove `--BaseModelica` from the simulation options when you are done, otherwise regular simulations will be broken.

## 12.3 Array-preserving BaseModelica output

The OMC front-end can flatten models without scalarizing them, i.e., keeping arrays of variables together as first-class citizens and keeping array equations together via for loops. This feature is essential to manage models with large arrays efficiently.

From the command line, you can get array-preserving BaseModelica flat output by adding some extra debug flags to the previous command line, e.g.,

```
omc --BaseModelica -d=nonfScalarize,arrayConnect,combineSubscripts,
evaluateAllParameters,vectorizeBindings -i=MyPackage.Examples.MyModel MyPackage >
MyModel.mo
```

or by adding them to the Additional Translation Flags option in OMEdit.

Last, but not least, if you have a model with a large number of instances of the same class with the same modifier structure, the OMC front-end can automatically collect them into a single array, which can then be flattened efficiently without scalarization. To get that, replace the debug flags of the previous command line with

```
-d=nonfScalarize,mergeComponents,combineSubscripts,evaluateAllParameters,
vectorizeBindings
```

In this case, you also get a `MyModel_merged_table.json` file in the working directory, which lists the correspondences between the original scalar component names and the elements of the automatically created arrays.

CHAPTER

# THIRTEEN

# PORTING MODELICA LIBRARIES TO OPENMODELICA

One of the goals of OpenModelica is to provide a full, no-compromise implementation of the latest version of the Modelica Language Specification, released by the non-profit Modelica Association. This means that a main requirement for a Modelica library to work in OpenModelica is to be fully compliant to the Language Specification.

Libraries and models developed with other Modelica tools may contain some code which is not valid according to the current language specification, but still accepted by that tool, e.g. to support legacy code of their customers. In order to use those libraries and models in OpenModelica, one needs to make sure that such code is replaced by a valid one. Note that getting rid of invalid Modelica code does not make the library *only* usable in OpenModelica; to the contrary, doing that is the best guarantee that the library will be usable *both* with the original tool used for development *and* with OpenModelica, as well as with any other present or future Modelica tool that follows the standard strictly.

The first recommendation is to use any flag or option of the tool that was originally used to develop the library, that allows to check for strict compliance to the language specification. For example, Dymola features a translation option 'Pedantic mode for checking Modelica semantics' that issues an error if non-standard constructs are used.

For your convenience, here you can find a list of commonly reported issues.

## 13.1 Mapping of the library on the file system

Packages can be mapped onto individual *.mo* files or onto hierarchical directory structures on the file system, according to the rules set forth in Section 13.4. of the language specification. The file encoding must be UTF-8; the use of a BOM at the beginning of the file is deprecated and preferably avoided. If there are non-ASCII characters in the comments or in the documentation of your library, make sure that the file is encoded as UTF-8.

If a directory-based representation is chosen, each *.mo* file must start with a *within* clause, and each directory should contain a *package.order* file that lists all the classes and constants defined as separate files in that directory.

When using revision control systems such as Git, if the library is stored in a directory structure, it is recommended to include the top-level directory (that must have the same name as the top-level package) in the repository itself, to avoid problems in case the repository is cloned locally on a directory that doesn't have the right name.

The top-level directory name, or the single *.mo* file containing the entire package, should be named exactly as the package (e.g. *Modelica*), possibly followed by a space and by the version number (e.g. *Modelica 3.2.3*).

## 13.2 Modifiers for arrays

According to the rules set forth in Section 7.2.5 of the language specification, when instantiating arrays of components, modifier values should be arrays of the same size of the component array, unless the *each* prefix is introduced, in which case the scalar modifier values is applied to all the elements of the array. Thus, if *MyComponent* has a Real parameter *p*, these are all valid declarations

```
parameter Real q = {0, 1, 2};
MyComponent ma[3](p = {10, 20, 30});
MyComponent mb[3](p = q);
MyComponent mb[3](each p = 10);
```

while these are not

```
parameter Real r = 4;
MyComponent ma[3](p = r);
MyComponent mb[3](p = 20);
```

In most cases, the problem is solved by simply adding the *each* keyword where appropriate.

## 13.3 Access to conditional components

Up to Modelica 3.6, according to Section 4.4.5 of the language specification, "A component declared with a condition-attribute can only be modified and/or used in connections". This required to use the following, slightly convoluted patterns when dealing, e.g., with conditional input connectors, making use of internal auxiliary variables or connectors:

```
model M
  parameter Boolean activateIn1 = true;
  parameter Boolean activateIn2 = true;
  Modelica.Blocks.Interfaces.RealInput u1_in if activateIn1;
  Modelica.Blocks.Interfaces.RealInput u2_in = u2 if activateIn2 "binding equation␣
↪only holds if activateIn2 = true";
  Real u2 "internal variable corresponding to u2_in";
  Real y;
protected
  Modelica.Blocks.Interfaces.RealInput u1 "internal connector corresponding to u1_in";
equation
  y = u1 + u2;
  connect(u1_in, u1) "automatically disabled if u1_in is deactivated";
  if not activateIn1 then
    u1 = 0 "default value for protected connector value when u1_in is disabled";
  end if;
  if not activateIn2 then
    u2 = 0 "default value for u2 when u2_in is disabled";
  end if;
end M;
```

where conditional components 'u1_in' and 'u2_in' were only used in connect equations. Other Modelica tools accepted code that was more straightforward and easier to understand, but actually not compliant with this restriction, causing compatibility issues, e.g.:

```
model M
  parameter Boolean activateIn1 = true;
  parameter Boolean activateIn2 = true;
  Modelica.Blocks.Interfaces.RealInput u1_in if activateIn1;
  Modelica.Blocks.Interfaces.RealInput u2_in if activateIn2;
  Real u1;
  Real u2;
  Real y;
equation
  y = u1 + u2;
  if activateIn1 then
    u1 = u1_in;
  else
    u1 = 0 "default value for protected connector value when u1_in is disabled";
  end if;
  if activateIn2 then
    u2 = u2_in;
```

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```
  else
    u2 = 0 "default value for protected connector value when u2_in is disabled";
  end if;
end M;
```

Although this restriction makes identifying structurally inconsistent models easier, it requires to write code that can be pretty obscure when handling use cases that would be very straightforward to handle otherwise. Hence, this restriction will be removed in Modelica 3.7. In particular, the current draft of Modelica 3.7 explicitly states that if the Boolean expression activating the component is true, there are no restrictions on the use of such component. Since version 1.26.0, OpenModelica complies with these new relaxed rules.

## 13.4 Access to classes defined in partial packages

Consider the following example package

```
package TestPartialPackage
  partial package PartialPackage
    function f
      input Real x;
      output Real y;
    algorithm
      y := 2*x;
    end f;
  end PartialPackage;

  package RegularPackage
    extends PartialPackage;
    model A
      Real x = time;
    end A;
  end RegularPackage;

  model M1
    package P = PartialPackage;
    Real x = P.f(time);
  end M1;

  model M2
    extends M1(redeclare package P = RegularPackage);
  end M2;

  model M3
    encapsulated package LocalPackage
      import TestPartialPackage.PartialPackage;
      extends PartialPackage;
    end LocalPackage;
    package P = LocalPackage;
    Real x = P.f(time);
  end M3;
end TestPartialPackage;
```

Model *M1* references a class (a function, in this case) from a partial package. This is perfectly fine if one wants to write a generic model, which is then specialized by redeclaring the package to a non-partial one, as in *M2*. However, *M1* cannot be compiled for simulation, since, according to Section 5.3.2 of the language specification, the classes that are looked inside during lookup shall not be partial in a simulation model.

This problem can be fixed by accessing that class (the function *f*, in this case) from a non-final package that extends

the partial one, either by redeclaring the partial package to a non-partial one, as in *M2*, or by locally defining a non-partial package that extends from the partial one, as in *M3*. The latter option is of course viable only if the class being accessed is in itself not a partial or somehow incomplete one.

This issue is often encountered in models using *Modelica.Media*, that sometimes use some class definitions (e.g. unit types) from partial packages such as *Modelica.Media.Interfaces.PartialMedium*. The fix in most cases is just to use the same definition from the actual replaceable *Medium* package defined in the model, which will eventually be redeclared to a non-partial one in the simulation model.

## 13.5 Equality operator in algorithms

The following code is illegal, because it uses the equality '=' operator, which is reserved for equations, instead of the assignment operator ':=' inside an algorithm:

```
function f
  input Real x;
  input Real y = 0;
  output Real z;
algorithm
  z = x + y;
end f;
```

so, the OpenModelica parser does not accept it. The correct code is:

```
function f
  input Real x;
  input Real y = 0;
  output Real z;
algorithm
  z := x + y;
end f;
```

Some tools automatically and silently apply the correction to the code, please save it in its correct form to make it usable with OpenModelica.

Also note that binding *equations* with '=' sign are instead required for default values of function inputs.

## 13.6 Public non-input non-output variables in functions

According to Section 12.2 of the language specification, only input and output formal parameters are allowed in the function's public variable section. Hence, the following function declaration is not valid:

```
function f
  input Real x;
  output Real y;
  Real z;
algorithm
  z := 2;
  y := x+z;
end f;
```

and should be fixed by putting the variable *z* in the protected section:

```
function f
  input Real x;
  output Real y;
protected
  Real z;
```

(continues on next page)

(continued from previous page)

```
algorithm
  z := 2;
  y := x+z;
end f;
```

## 13.7 Subscripting of expressions

Some libraries use expression subscripting, e.g.

```
model M
  Real x[3];
  Real y[3];
  Real z;
equation
  z = (x.*y)[2];
  ...
end M;
```

This construct is already accepted by some Modelica tools, but is not yet included in the current Modelica Specification 3.6, so it is not supported in OpenModelica up to version 1.22.0. It has now been included in the draft for the 3.7 language specification, so it will be implemented in the future also by OpenModelica.

## 13.8 Incomplete specification of initial conditions

The simulation of Modelica models of dynamical systems requires the tool to determine a consistent initial solution for the simulation to start. To do so, the system equations are augmented by adding one initial condition for each continuous state variable (after index reduction) and one initial condition for each discrete state variable. Then, the augmented system is solved upon initialization.

These initial conditions can be formulated by adding a *start* = <*expression*> and a *fixed* = *true* attribute to those variables, e.g.

```
parameter Real x_start = 10;
parameter Real v_start = 2.5;
Real x(start = x_start, fixed = true);
discrete Real v(start = v_start, fixed = true);
Integer i(start = 2, fixed = true);
```

or by adding initial equations, e.g.:

```
  parameter Real x_start = 10;
  parameter Real v_start = 2.5;
  Real x;
  discrete Real v;
  Integer i;
  Real y(start = 3.5);
initial equation
  x = x_start;
  v = v_start;
  i = 2;
  der(y) = 0;
```

Note that in the latter case, the start attribute on *y* is not used directly to set the initial value of that variable, but only potentially used as initial guess for the solution of the initialization problem, that may require using an iterative nonlinear solver. Also note that sets of initial equations are often added to the models taken from reusable component libraries by selecting certain component parameters, such as *initOpt* or similar.

If the number of initial conditions matches the number of continuous and discrete states, then the initialization problem is well-defined. Although this is per se not a guarantee that all tools will be able to solve it and find the same solution, this is for sure a prerequisite for across-tool portability.

Conversely, if the number of initial conditions is less than the number of states, the tool has to add some initial equations, using some heuristics to change the fixed attribute of some variables from false to true. Consider for example the following model:

```
model M
  Real x;
  Real y(start = 1);
  Real z(start = 2);
equation
  der(x) = y + z;
  y = 2*x;
  z = 10*x + 1;
end M;
```

This model has one state variable $x$, no variables with *fixed* = *true* attributes and no initial equation, so there is one missing initial condition. One tool could choose to add the *fixed* = *true* attribute to the state variable $x$, fixing it to the default value of zero of its *start* attribute. Or, it could decide to give more priority to variables that have an explicitly modified *start* attribute, hence fix the initial value of $y$ to 1, or the initial value of $z$ to 2. Three completely different simulations would ensue.

The Modelica Language Specification, Section 8.6 does not prescribe or recommend any specific choice criterion in this case. Hence, different tools, or even different versions of the same tool, could add different initial conditions, leading to completely different simulations. In order to avoid any ambiguity and achieve good portability, it is thus recommended to make sure that the initial conditions of all simulation model are well-specified.

A model with not enough initial conditions causes the OMC to issue the following translation warning: "The initial conditions are not fully specified". By activating the Tools | Options | Simulation | Show additional information from the initialization process option, or the *-d=initialization* compiler flag, one can get an explicit list of the additional equations that OpenModelica automatically adds to get a fully specified initialization problem, which may be helpful to figure out which initial conditions are missing. In this case, we recommend to amend the source code of the model by adding suitable extra initial conditions, until that warning message no longer appears.

## 13.9 Modelica_LinearSystems2 Library

The Modelica_LinearSystem2 library was originally developed in Dymola with a plan of eventually making it part of the Modelica Standard Library (thus the underscore in the library name). The library is based on several functions, e.g. *readStringMatrix()*, *simulateModel()*, *linearizeModel()* that are built-in Dymola functions but are not part of the Modelica Standard Library.

In principle, these functions could be standardized and become part of the ModelicaServices library, which collects standardized interfaces to tool-specific functionality; then, OpenModelica could easily implement them based on its internal functionality. However, until this effort is undertaken, the Modelica_LinearSystem2 library cannot be considered as a full-fledged Modelica library, but only a Dymola-specific one.

If you are interested in using this library in OpenModelica and are willing to contribute to get it supported, please contact the development team, e.g. by opening an ticket on the issue tracker.

CHAPTER

FOURTEEN

# BACKWARDS COMPATIBILITY OF OPENMODELICA RELEASED VERSIONS

The development of OpenModelica is guided by two basic principles:

1. Follow the Modelica Language Specification (MLS) as strictly as possible.
2. Preserve backwards compatibility as much as possible.

The Open Source Modelica Consortium strongly believes in open standards, as enablers of strong and healthy eco-systems involving software tool developers and software tool users. Strict compliance with the MLS is the key factor to enable portability of models among different Modelica tools, which gives a huge added value to the Modelica community, compared to other communities of users of software using proprietary modelling languages. Compliance to the standard not only gives you the freedom to switch from one tool to another, avoiding vendor lock-in and protecting the value of your investment in modelling in the long term, but also allows you to use different tools simultaneously on the same Modelica code for different purposes, e.g., simulation, generation of FMUs, sensitivity analysis, parameter optimization, optimal control, etc. Hence, the development of OpenModelica development strives to implement the MLS standard as strictly as possible.

The Open Source Modelica Consortium also recognizes the value of the code developed by the users of OpenModelica. There is hardly anything more annoying than not being able to use legacy code with up-to-date versions of a software tool. Hence, the Consortium strives to keep newer versions of OpenModelica fully backwards compatible with older ones and is committed to releasing patch versions of the latest x.y.0 release of the software, in case regressions from previously released versions are reported on the OpenModelica issue tracker.

Given this commitment, we strongly recommend OpenModelica users to always use the latest released version of the software, to benefit from bug fixes, performance improvements and new added features. If you find any backwards-compatibility issue with new released versions, we strongly encourage you to report them on the issue tracker; chances are that it can get fixed in the nightly build in a short time, if possible.

Given the first stated principle, compliance to the MLS, there is one exception to the rule of keeping backwards compatibility: if we find that OpenModelica is not following the MSL for some reason, we try to fix it as soon as possible. This means that a model or library developed with older versions of OpenModelica may not work with more recently released version of the software *because the Modelica code was invalid according to the MLS*, but the older version of OpenModelica accepted it anyway. You can check ticket #10386 for one such example.

In these cases, one may be tempted to stick indefinitely to the latest version of OpenModelica that handled the invalid Modelica code successfully. Although you are of course free to do so, we do not recommend this policy because you are going to miss all the improvements to the OpenModelica software in the future. More importantly, if you then discover bugs that prevent you from using your Modelica code in new situations, we can't help you in any way, because you are locked to an old version for which we cannot provide maintenance support.

The ideal solution to handle these cases is to update the Modelica source code of the models to make it fully compliant with the MLS. This ensures maximum portability and long-term support of your Modelica code.

In case this is not possible for some reason, e.g. lack of time and resources, or the fact that the legacy code belongs to Modelica libraries you did not develop yourself, we provide a way to cope with non-standard Modelica code in newer version of OpenModelica: the --allowNonStandardModelica compiler flag allows to disable some Modelica compatibility checks and continue using your legacy code with newer versions of the compiler. This flag can be set in OMEdit in the *Tools* | *Options* | *Simulation* | *Additional Translation Flags*.

CHAPTER

FIFTEEN

# GENERATING GRAPH REPRESENTATIONS FOR MODELS

The system of equations after symbolic transformation is represented by a graph. OpenModelica can generate graph representations which can be displayed in the graph tool *yed* (http://www.yworks.com/products/yed). The graph generation is activated with the debug flag

+d=graphml

Two different graphml- files are generated in the working directory. *TaskGraph_model.graphml*, showing the strongly-connected components of the model and *BipartiteGraph_CompleteDAE_model.graphml* showing all variables and equations. When loading the graphs with *yEd*, all nodes are in one place. Please use the various layout algorithms to get a better overview.

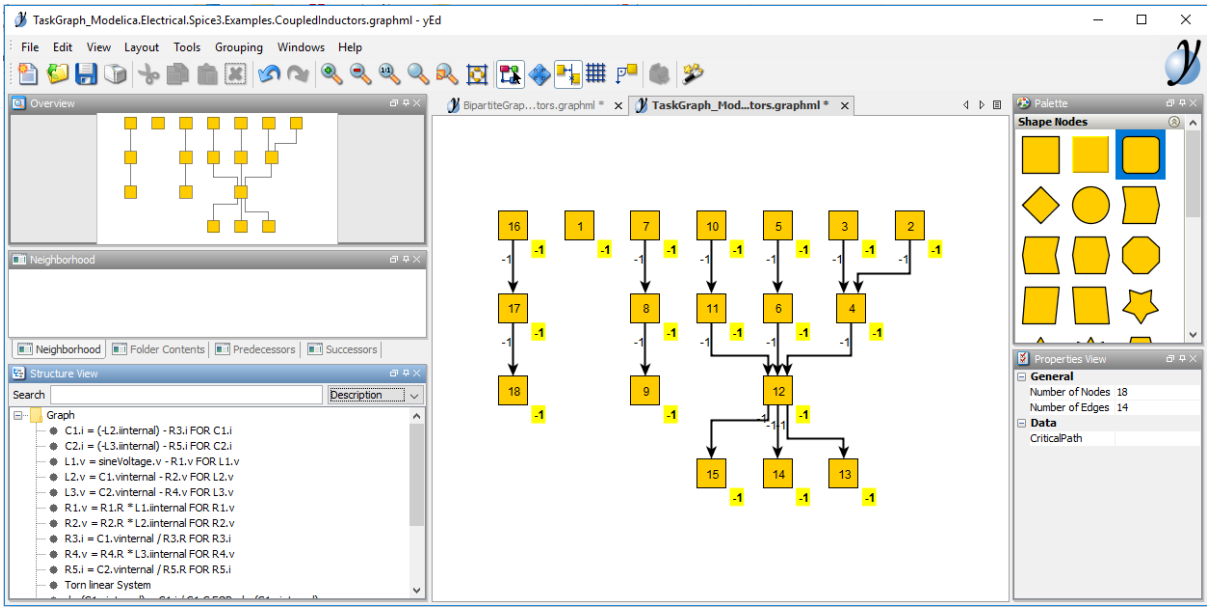



Figure 15.1: A task-graph representation of a model in yEd

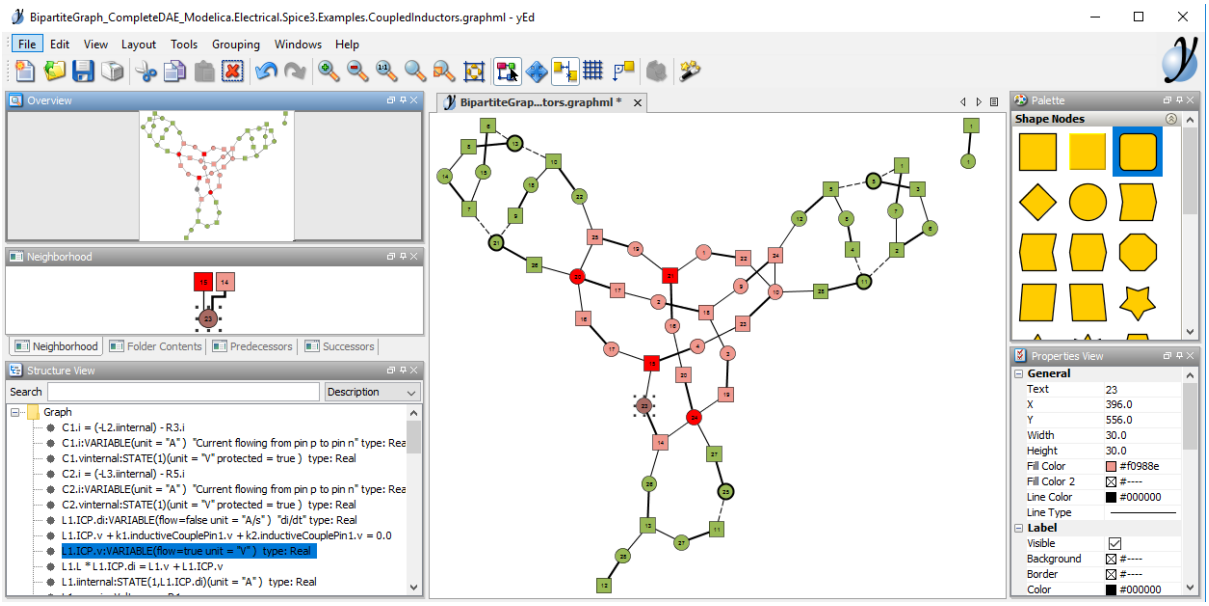



Figure 15.2: A biparite graph representation of a model in yEd

CHAPTER

SIXTEEN

# FUNCTIONAL MOCK-UP INTERFACE - FMI

The Functional Mock-up Interface (FMI) Standard for model exchange and co-simulation allows export, exchange and import of pre-compiled models between different tools. The FMI standard is Modelica independent, so import and export works both between different Modelica or non-Modelica tools.

See also *OMSimulator documentation*.

## 16.1 FMI Standards

Table 16.1: FMI standard versions

| Version | Support in OpenModelica |
|---|---|
| 1.0.1 | Deprecated |
| 2.0.5 | Supported |
| 3.0.2 | Experimental |

### 16.1.1 Layered Standards

Layered standards extend FMI 3.0 with optional, separately versioned specifications.

Table 16.2: FMI 3.0 layered standards

| Layered standard | Support in OpenModelica |
|---|---|
| FMI-LS-BUS | Not planned |
| FMI-LS-XCP | Not planned |
| FMI-LS-STRUCT | Planned |
| FMI-LS-REF | Planned |
| FMI-LS-DAE | Planned (demonstrator in progress). Export and import follow the `1.0.0-alpha.1` draft as of its commit `78313f4` (2026-09-02); the revision is also reported as a notification when an FMU is exported. |

### 16.1.2 Supported Capability Flags

The optional capabilities advertised in the `modelDescription.xml` of an exported FMU, per FMI version and interface type (Model Exchange, Co-Simulation and, for FMI 3.0, Scheduled Execution).

Table 16.3: Exported capability flags

| Capability | 2.0 ME | 2.0 CS | 3.0 ME | 3.0 CS | 3.0 SE |
|---|---|---|---|---|---|
| Get and set FMU state | yes | yes | yes | yes | yes |
| Serialize FMU state | no | no | yes | yes | yes |
| Directional derivatives | cond | exp | cond | cond | cond |
| Adjoint derivatives | — | — | wip | wip | wip |
| Per-element dependencies | — | — | no | no | no |
| Variable communication step size | — | yes | — | yes | — |
| Interpolate inputs | — | yes | — | — | — |
| Max output derivative order | — | 1 | — | 1 | — |
| Event mode | — | — | — | yes | — |
| Intermediate update | — | — | — | no | — |

Legend:

- `yes` / `no` — the capability flag is exported as `true` / `false`.
- `cond` — exported as `true` only when a symbolic directional-derivative Jacobian is available, i.e. not disabled via *-d=disableDirectionalDerivatives*.
- `exp` — only enabled with the experimental flag `-d=fmuExperimental` (`false` by default). In FMI 3.0 these state features are always enabled.
- `wip` — in active development; currently exported as `false`.
- `-` — not applicable to this interface type or FMI version.

## 16.2 FMI Export

To export a FMU use the OpenModelica command *buildModelFMU()* from the command line interface, OMShell, OMNotebook or MDT. The FMU export command is also integrated in OMEdit. Select *File* > *Export* > *FMU*. Or alternatively, right click a model to obtain the export command. The FMU package is generated in the current working directory of OMC or the directory set in *OMEdit* > *Options* > *FMI* > *Move FMU*. You can use the *cd()* command to see the current location. The location of the generated FMU is printed in the Messages Browser of OMEdit or on the command line.

You can set which version of FMI to export through OMEdit settings, see section *FMI Options*.

To export the bouncing ball example to an FMU, use the following commands:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
true
>>> buildModelFMU(BouncingBall)
"«DOCHOME»/BouncingBall.fmu"
```

**Note**

Notification: Model statistics after passing the front-end and creating the data structures used by the back-end:

* Number of equations: 6

* Number of variables: 6

Notification: Model statistics after passing the back-end for initialization:

* Number of independent subsystems: 3

* Number of states: 0 ()

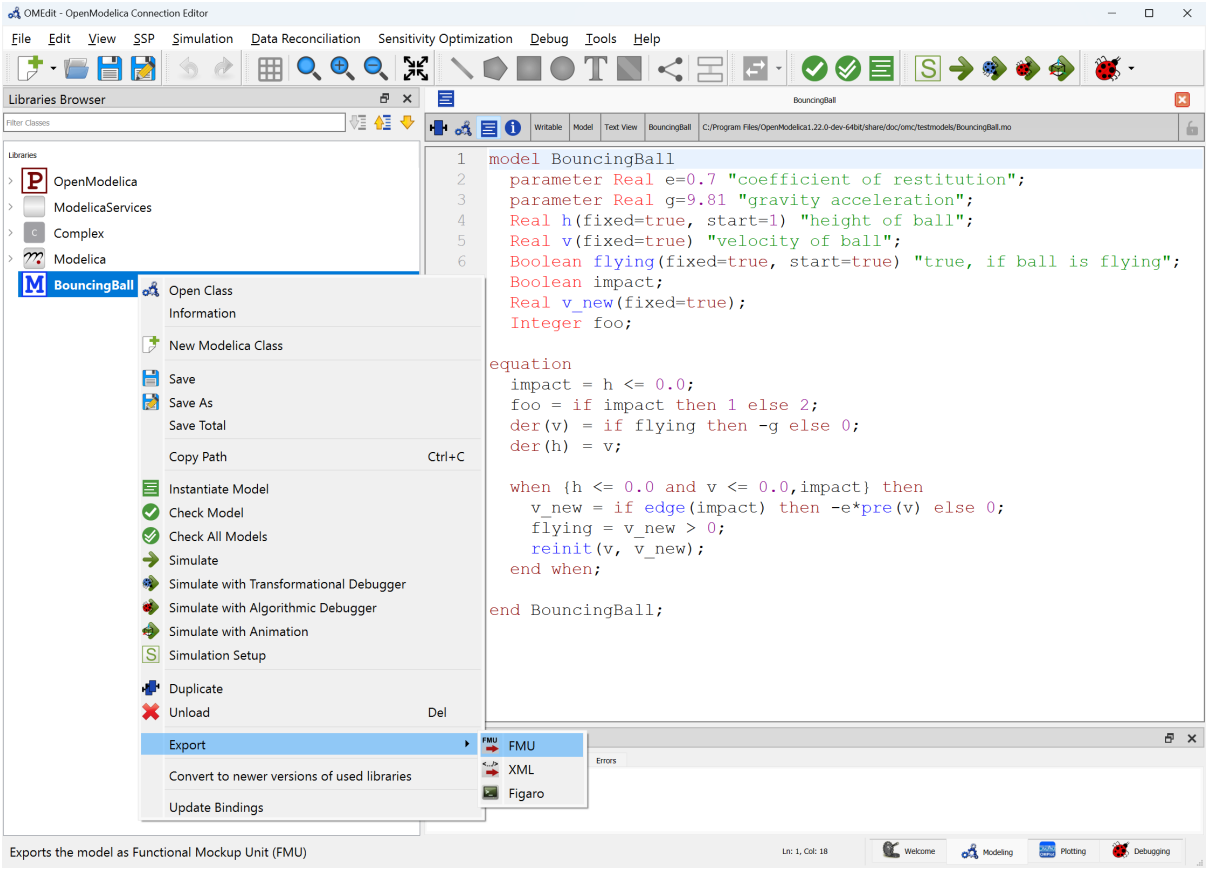



Figure 16.1: FMI Export.

```
* Number of discrete variables: 9 (v_new,$PRE.v_new,flying,$PRE.flying,foo,impact,$whenCondition1,$whenCondition2,$whenC
* Number of discrete states: 0 ()
* Number of clocked states: 0 ()
* Top-level inputs: 0
Notification: Strong component statistics for initialization (13):
* Single equations (assignments): 13
* Array equations: 0
* Algorithm blocks: 0
* Record equations: 0
* When equations: 0
* If-equations: 0
* Equation systems (not torn): 0
* Torn equation systems: 0
* Mixed (continuous/discrete) equation systems: 0
Notification: Model statistics after passing the back-end for simulation:
* Number of independent subsystems: 1
* Number of states: 2 (h,v)
* Number of discrete variables: 7 ($whenCondition3,$whenCondition2,$whenCondition1,flying,impact,v_new,foo)
```

```
* Number of discrete states: 2 (impact,v)
* Number of clocked states: 0 ()
* Top-level inputs: 0
Notification: Strong component statistics for simulation (9):
* Single equations (assignments): 7
* Array equations: 0
* Algorithm blocks: 0
* Record equations: 0
* When equations: 2
* If-equations: 0
* Equation systems (not torn): 0
* Torn equation systems: 0
* Mixed (continuous/discrete) equation systems: 0
Notification: Building FMU for platform 'static' (1/1).
Notification: Finished FMU for platform 'static' (1/1).
```

After the command execution is complete you will see that a file BouncingBall.fmu has been created. Its contents varies depending on the target platform. On the machine generating this documentation the contents in Listing 16.1 are generated (along with the C source code).

Listing 16.1: BouncingBall FMU contents

```
binaries/
binaries/linux64/
binaries/linux64/BouncingBall.so
documentation/
documentation/index.html
modelDescription.xml
```

A log file for FMU creation is also generated named ModelName_FMU.log. If there are some errors while creating the FMU, they will be shown in the command line window and logged in this log file as well.

By default an FMU that can be used for both Model Exchange and Co-Simulation is generated. We support FMI 1.0 (deprecated) and FMI 2.0 for Model Exchange and Co-Simulation FMUs, with experimental support for FMI 3.0 (see the version table above).

For the Co-Simulation FMU two integrator methods are available:

- Forward Euler [default]
- SUNDIALS CVODE (see[1])

Forward Euler uses root finding, which does an Euler step of `communicationStepSize` in `fmi2DoStep`. Events are checked for before and after the call to `fmi2GetDerivatives`.

If CVODE is chosen as integrator the FMU should also include runtime dependencies (*--fmuRuntimeDepends=modelica*) to copy all used dynamic libraries into the generated FMU to make it exchangeable.

To export a Co-Simulation FMU with CVODE for the bouncing ball example use the following commands:

[1] Sundials Webpage

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
true
>>> setCommandLineOptions("--fmiFlags=s:cvode")
true
>>> buildModelFMU(BouncingBall, version = "2.0", fmuType="cs")
"«DOCHOME»/BouncingBall.fmu"
```

**Note**

Notification: Model statistics after passing the front-end and creating the data structures used by the back-end:

* Number of equations: 6

* Number of variables: 6

Notification: Model statistics after passing the back-end for initialization:

* Number of independent subsystems: 3

* Number of states: 0 ()

* Number of discrete variables: 9 (v_new,$PRE.v_new,flying,$PRE.flying,foo,impact,$whenCondition1,$whenCondition2,$whenC

* Number of discrete states: 0 ()

* Number of clocked states: 0 ()

* Top-level inputs: 0

Notification: Strong component statistics for initialization (13):

* Single equations (assignments): 13

* Array equations: 0

* Algorithm blocks: 0

* Record equations: 0

* When equations: 0

* If-equations: 0

* Equation systems (not torn): 0

* Torn equation systems: 0

* Mixed (continuous/discrete) equation systems: 0

Notification: Model statistics after passing the back-end for simulation:

* Number of independent subsystems: 1

* Number of states: 2 (h,v)

* Number of discrete variables: 7 ($whenCondition3,$whenCondition2,$whenCondition1,flying,impact,v_new,foo)

* Number of discrete states: 2 (impact,v)

* Number of clocked states: 0 ()

* Top-level inputs: 0

Notification: Strong component statistics for simulation (9):

* Single equations (assignments): 7

* Array equations: 0

```
* Algorithm blocks: 0
* Record equations: 0
* When equations: 2
* If-equations: 0
* Equation systems (not torn): 0
* Torn equation systems: 0
* Mixed (continuous/discrete) equation systems: 0
Notification: Building FMU for platform 'static' (1/1).
Notification: Finished FMU for platform 'static' (1/1).
```

The FMU BouncingBall.fmu will have a new file BouncingBall_flags.json in its resources directory. By manually changing its content users can change the solver method without recompiling the FMU.

The BouncingBall_flags.json for this example is displayed in Listing 16.2.

Listing 16.2: BouncingBall FMI flags

```
{
  "s" : "cvode"
}
```

### 16.2.1 Compilation Process

OpenModelica exports source-code FMUs built with CMake. CMake version v3.21 or newer is recommended, minimum CMake version is v3.5.

The FMU contains a CMakeLists.txt file in the sources directory that can be used to re-compile the FMU for a different host and is also used to cross compile for different platforms.

The CMake compilation accepts the following settings:

- `BUILD_SHARED_LIBS`: Boolean value to switch between dynamic and statically linked binaries.
  - `ON` (default): Compile DLL/Shared Object binary object.
  - `OFF`: Compile static binary object.
- `FMI_INTERFACE_HEADER_FILES_DIRECTORY`: String value specifying path to FMI header files containing `fmi2Functions.h`, `fmi2FunctionTypes.h` and `fmi2TypesPlatforms.h`.
  - Defaults to a location inside the OpenModelica installation directory, which was used to create the FMU. They need to be version 2.0.4 from the FMI Standard.
- `RUNTIME_DEPENDENCIES_LEVEL`: String value to specify runtime dependencies set.
  - `none`: Adds no runtime dependencies to FMU. The FMU can't be used on a system if it doesn't provided all needed dependencies.
  - `modelica` (default): Add Modelica runtime dependencies to FMU, e.g. a external C library used from a Modelica function. Needs CMake version v3.21 or newer.
  - `all`: Add system and Modelica runtime dependencies. Needs CMake version v3.21 or newer.

  CMake install TARGETS RUNTIME_DEPENDENCIES is not supported when cross compiling. When cross compiling the FMU CMake project therefore falls back to installing the external libraries it linked against directly, which covers the Modelica libraries a model depends on but not the system libraries of the target platform.
- `NEED_CVODE`: Boolean value to integrate CVODE integrator into CoSimulation FMU.

  - `ON`: Link to SUNDIALS CVODE. If CVODE is not in a default location `CVODE_DIRECTORY` needs to be set. Its also recommended to use `RUNTIME_DEPENDENCIES_LEVEL=modelica` or higher to add SUNDIALS runtime dependencies into the FMU.
  - `OFF` (default): Don't link to SUNDIALS CVODE.
- `CVODE_DIRECTORY`: String value with location of libraries `sundials_cvode` and `sundials_nvecserial` with SUNDIALS version 5.4.0.
  - Defaults to a location inside the OpenModelica installation directory, which was used to create the FMU.

Then use CMake to configure, build and install the FMU. To repack the FMU after installation use custom target `create_fmu`.

For example to re-compile the FMU with cmake and runtime dependencies use:

```
$ unzip BouncingBall.fmu -d BouncingBall_FMU
$ cd BouncingBall_FMU/sources
$ cmake -S . -B build_cmake \
  -D RUNTIME_DEPENDENCIES_LEVEL=modelica \
  -D CMAKE_C_COMPILER=clang -D CMAKE_CXX_COMPILER=clang++
$ cmake --build build_cmake --target create_fmu --parallel
```

### 16.2.2 Platforms

The `platforms` setting specifies for what target system the FMU is compiled:

- Empty: Create a Source-Code-only FMU.
- `native`: Create a FMU compiled for the exporting system.
- `<cpu>-<vendor>-<os>` host triple: OpenModelica searches for programs in PATH matching pattern `<cpu>-<vendor>-<os>cc` to compile. E.g. `x86_64-linux-gnu` for a 64 bit Linux OS or `i686-w64-mingw32` for a 32 bit Windows OS using MINGW.
- `<cpu>-<vendor>-<os> docker run ghcr.io/openmodelica/crossbuild:v1.28.0` Host triple with Docker image provided by OpenModelica: OpenModelica will use Docker image ghcr.io/openmodelica/crossbuild:v1.28.0 to cross compile. The image provides compiler toolchain files to cross compile with CMake for the following host triples:
  - `i686-linux-gnu`
  - `x86_64-linux-gnu`
  - `aarch64-linux-gnu`
  - `arm-linux-gnueabi`
  - `arm-linux-gnueabihf`
  - `i686-w64-mingw32`
  - `x86_64-w64-mingw32`

  OpenModelica will add a matching `CMAKE_TOOLCHAIN_FILE` to the compilation process.

  If your model depends on external C libraries the library has to be available for the target platform, e.g. in `Resources/Library/win64` when compiling for `x86_64-w64-mingw32`. OpenModelica searches the `Resources/Library` sub directory matching the target platform and copies the library into the FMU next to the model binary. If no binary for the target platform is shipped with the Modelica library, providing a pre-compiled static library can be necessary.
- `<cpu>-<vendor>-<os> docker run <image>` Host triple with Docker image: OpenModelica will use the specified Docker image to cross compile for given host triple. Because privilege escalation is very easy to achieve with Docker OMEdit adds `--pull=never` to the Docker calls for the `multiarch/crossbuild` images. Only use this option if you understand the security risks associated with Docker images from

unknown sources. E.g. `x86_64-linux-gnu docker run --pull=never multiarch/crossbuild` to cross compile for a 64 bit Linux OS. Because system libraries can be different for different versions of the same operating system, it is advised to use *--fmuRuntimeDepends=all*.

### 16.2.3 Cross Compilation

Cross compilation can be done by using platform `<cpu>-<vendor>-<os> docker run ghcr.io/openmodelica/crossbuild:v1.28.0` or done manually. Both can be difficult at times.

To cross compile with CMake provide a toolchain file specifying the target system and where to find the compiler toolchain for the target system.

For example the Docker image ghcr.io/openmodelica/crossbuild:v1.28.0 provided by OpenModelica is based on Linux (Ubuntu 24.04 at the time of writing) and has toolchains installed to cross compile together with matching toolchain files.

#### Manual Cross Compilation

Let's have a look at example model `BouncingBall`:

First generate C sources for the FMU:

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")
True
>>> buildModelFMU(BouncingBall, platforms = {""})

"Notification: Model statistics after passing the front-end and creating the data␣
↪structures used by the back-end:
 * Number of equations: 6
 * Number of variables: 6
Notification: Model statistics after passing the back-end for initialization:
 * Number of independent subsystems: 3
 * Number of states: 0 ()
 * Number of discrete variables: 9 (v_new,$PRE.v_new,flying,$PRE.flying,foo,impact,
↪$whenCondition1,$whenCondition2,$whenCondition3)
 * Number of discrete states: 0 ()
 * Number of clocked states: 0 ()
 * Top-level inputs: 0
Notification: Strong component statistics for initialization (13):
 * Single equations (assignments): 13
 * Array equations: 0
 * Algorithm blocks: 0
 * Record equations: 0
 * When equations: 0
 * If-equations: 0
 * Equation systems (not torn): 0
 * Torn equation systems: 0
 * Mixed (continuous/discrete) equation systems: 0
Notification: Model statistics after passing the back-end for simulation:
 * Number of independent subsystems: 1
 * Number of states: 2 (h,v)
 * Number of discrete variables: 7 ($whenCondition3,$whenCondition2,$whenCondition1,
↪flying,impact,v_new,foo)
 * Number of discrete states: 2 (impact,v)
 * Number of clocked states: 0 ()
 * Top-level inputs: 0
Notification: Strong component statistics for simulation (9):
 * Single equations (assignments): 7
 * Array equations: 0
```

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```
 * Algorithm blocks: 0
 * Record equations: 0
 * When equations: 2
 * If-equations: 0
 * Equation systems (not torn): 0
 * Torn equation systems: 0
 * Mixed (continuous/discrete) equation systems: 0"
```

OpenModelica won't zip the FMU in this case. If you already have an existing FMU unzip it into some directory `<Model>.fmutmp`. Optionally delete existing binaries like `<Model>.fmutmp/binaries/linux64/`.

Then cross compile the sources with a suitable toolchain file.

```
# Optional: Work inside interactive Docker container
docker run --rm -it \
  -v $PWD:/fmu \
  -v $OPENMODELICAHOME/include/omc/FMI2:/fmiInclude \
  -w/fmu \
  ghcr.io/openmodelica/crossbuild:v1.28.0 bash

cd <Model>.fmutmp/sources
cmake -S . -B build \
  -DCMAKE_TOOLCHAIN_FILE=/opt/cmake/toolchain/x86_64-w64-mingw32.cmake \
  -DRUNTIME_DEPENDENCIES_LEVEL=none \
  -DFMI_INTERFACE_HEADER_FILES_DIRECTORY=/fmiInclude \
  -G "Unix Makefiles"
cmake --build build --parallel --target install
```

Now the FMU should contain `binaries/win64/BouncingBall.dll`. Compile additional binaries in the same way and when done zip the FMU by running

```
cmake --build build --parallel --target create_fmu
```

Now there should be a FMU with `win64` binaries `BouncingBall-fmu`.

## 16.3 FMI Import - SSP

If you want to simulate a single, stand-alone FMU, or possibly a connection of several FMUs, the recommended tool to do that is OMSimulator, see the *OMSimulator documentation* and *OMEdit* for further information.

### 16.3.1 FMI Import - Non-Standard Modelica Model

FMI Import allows to use an FMU, generated according to the FMI for Model Exchange 2.0 standard, as a component in a Modelica model. This can be useful if the FMU describes the behavior of a component or sub-system in a structured Modelica model, which is not easily turned into a pure FMI-based model that can be handled by OMSimulator.

FMI is a computational description of a dynamic model, while a Modelica model is a declarative description; this means that not all conceivable FMUs can be successfully imported as Modelica models. Also, the current implementation of FMU import in OpenModelica is still somewhat experimental and not guaranteed to work in all cases. However, if the FMU-ME you want to import was exported from a Modelica model and only represents continuous time dynamic behavior, it should work without problems when imported as a Modelica block.

Please also note that the current implementation of FMI Import in OpenModelica is based on a built-in wrapper that uses a *reinit()* statement in an algorithm section. This is not allowed by the Modelica Language Specification, so it is necessary to set the compiler to accept this non-standard construct by setting the *--allowNonStandardModelica=reinitInAlgorithms* compiler flag. In OMEdit, you can set this option by activating the *Enable FMU Import* checkbox in the *Tools* | *Options* | *Simulation* | *Translation Flags* tab. This will generate

a warning during compilation, as there is no guarantee that the imported model using this feature can be ported to other Modelica tools; if you want to use a model that contains imported FMUs in another Modelica tool, you should rely on the other tool's import feature to generate the Modelica blocks corresponding to the FMUs.

After setting the *--allowNonStandardModelica* flag, to import the FMU package use the OpenModelica command importFMU,

```
>>> list(OpenModelica.Scripting.importFMU, interfaceOnly=true);
```

The command could be used from command line interface, OMShell, OMNotebook or MDT. The importFMU command is also integrated with OMEdit through the *File* > *Import* > *FMU* dialog: the FMU package is extracted in the directory specified by workdir, or in the current directory of omc if not specified, see *Tools* > *Open Working Directory*.

The imported FMU is then loaded in the Libraries Browser and can be used as any other regular Modelica block.

CHAPTER

# SEVENTEEN

# OMSIMULATOR

Version: v1.17.0.postdev.alpha0-6199-gaef6678

## 17.1 Introduction

The OMSimulator project is a FMI-based co-simulation tool. It supports large-scale simulation and virtual prototyping using models from multiple sources utilizing the FMI standard. It is integrated into OpenModelica but also available stand-alone, i.e., without dependencies to Modelica specific models or technology. OMSimulator provides an industrial-strength open-source FMI-based modelling and simulation tool. Input/output ports of FMUs can be connected, ports can be grouped to buses, FMUs can be parameterized and composed, and composite models can be exported according to the SSP (System Structure and Parameterization) standard. Efficient FMI based simulation is provided for both model exchange and co-simulation. An external API is available for use from other tools and scripting languages such as *Python*.

## 17.2 OMSimulator

OMSimulator is a command line interface for the OMSimulatorLib library. It can be used to simulate Functional Mock-up Units (FMUs) and System Structure and Parameterization (SSP) files, as well as execute dedicated Python simulation scripts using the OMSimulator Python API.

### 17.2.1 OMSimulator Flags

A brief description of all command line flags can be displayed using

`OMSimulator --help`:

```
usage: OMSimulator [-h] [--validate] [--calibrate [ACTIVITY]]
                   [--calibrationOutput CALIBRATIONOUTPUT] [--uqFile UQFILE]
                   [--version]
                   [--addParametersToCSV | --no-addParametersToCSV]
                   [--algLoopSolver {fixedpoint,kinsol}] [--clearAllOptions]
                   [--CVODEMaxErrTestFails CVODEMAXERRTESTFAILS]
                   [--CVODEMaxNLSFailures CVODEMAXNLSFAILURES]
                   [--CVODEMaxNLSIterations CVODEMAXNLSITERATIONS]
                   [--CVODEMaxSteps CVODEMAXSTEPS]
                   [--deleteTempFiles | --no-deleteTempFiles]
                   [--directionalDerivatives | --no-directionalDerivatives]
                   [--dumpAlgLoops | --no-dumpAlgLoops]
                   [--emitEvents | --no-emitEvents]
                   [--ignoreInitialUnknowns | --no-ignoreInitialUnknowns]
                   [--initialStepSize INITIALSTEPSIZE]
                   [--inputExtrapolation | --no-inputExtrapolation]
                   [--intervals INTERVALS] [--logFile LOGFILE]
                   [--logLevel LOGLEVEL] [--master MASTER]
                   [--maxEventIteration MAXEVENTITERATION]
```

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```
                    [--maxLoopIteration MAXLOOPITERATION]
                    [--minimumStepSize MINIMUMSTEPSIZE] [--mode {cs,me}]
                    [--numProcs NUMPROCS] [--progressBar | --no-progressBar]
                    [--realTime | --no-realTime] [--resultFile RESULTFILE]
                    [--skipCSVHeader | --no-skipCSVHeader]
                    [--solver {euler,cvode}] [--solverStats | --no-solverStats]
                    [--startTime STARTTIME] [--stepSize STEPSIZE]
                    [--stopTime STOPTIME] [--stripRoot | --no-stripRoot]
                    [--suppressPath | --no-suppressPath] [--tempDir TEMPDIR]
                    [--timeout TIMEOUT] [--tolerance TOLERANCE]
                    [--wallTime | --no-wallTime] [--workingDir WORKINGDIR]
                    [--zeroNominal | --no-zeroNominal]
                    model

Command line entry point for OMSimulator. Allows running a model file
directly, e.g.: OMSimulator test.ssp OMSimulator model.fmu OMSimulator test.py
running a Python driver script without having to write a driver script. All
simulation settings (start/stop time, result file, tolerance, ...) are taken
from the model itself; use --resultFile/--startTime/--stopTime/--tolerance/
--stepSize to override them. For FMUs that export both model exchange and co-
simulation, use --mode to pick which one to run. Pass --stripRoot to drop the
"model.root" prefix from exported signal names. Files are validated against
their schema (FMI for .fmu, SSP for .ssp) before simulation; pass --validate
to only validate the file and skip simulation e.g.: OMSimulator --validate
test.ssp OMSimulator --validate model.fmu For an SSP with a UQ layered
standard file (see OMSimulator.calibration), pass --calibrate to fit the
parameters of a Calibration activity to its reference data instead of
simulating, e.g.: OMSimulator --calibrate cal_01 --calibrationOutput
calibrated.ssp test.ssp

positional arguments:
  model                 Path to a .ssp or .fmu file to simulate

options:
  -h, --help            show this help message and exit
  --validate            Only validate the file against its schema; do not
                        simulate
  --calibrate [ACTIVITY]
                        Fit the parameters of a Calibration activity of the UQ
                        file of the SSP to its reference data instead of
                        simulating; ACTIVITY is the activity id, needed if
                        there are several (.ssp only)
  --calibrationOutput CALIBRATIONOUTPUT
                        SSP file to write the calibrated model to (default:
                        the input name plus .calibrated.ssp)
  --uqFile UQFILE       Path of the UQ file inside the SSP (default: the one
                        referenced by ssc:MetaData of type
                        application/x-uncertainty-quantification)
  --version             show program's version number and exit
  --addParametersToCSV, --no-addParametersToCSV
                        Export parameters to a .csv file (default: false)
  --algLoopSolver {fixedpoint,kinsol}
                        Specifies the loop solver method used for algebraic
                        loops spanning multiple components (default: kinsol)
  --clearAllOptions     Reset all flags to their default values
  --CVODEMaxErrTestFails CVODEMAXERRTESTFAILS
```

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```
                      Maximum number of error test failures for CVODE
                      (default: 100)
--CVODEMaxNLSFailures CVODEMAXNLSFAILURES
                      Maximum number of nonlinear convergence failures for
                      CVODE (default: 100)
--CVODEMaxNLSIterations CVODEMAXNLSITERATIONS
                      Maximum number of nonlinear solver iterations for
                      CVODE (default: 5)
--CVODEMaxSteps CVODEMAXSTEPS
                      Maximum number of steps for CVODE (default: 1000)
--deleteTempFiles, --no-deleteTempFiles
                      Delete temporary files as soon as they are no longer
                      needed (default: true)
--directionalDerivatives, --no-directionalDerivatives
                      Use directional derivatives to calculate the Jacobian
                      for algebraic loops (default: true)
--dumpAlgLoops, --no-dumpAlgLoops
                      Dump information for algebraic loops (default: false)
--emitEvents, --no-emitEvents
                      Emit events during simulation (default: true)
--ignoreInitialUnknowns, --no-ignoreInitialUnknowns
                      Ignore initial unknowns from the modelDescription.xml
                      (default: false)
--initialStepSize INITIALSTEPSIZE
                      Specify the initial step size (default: 1e-06)
--inputExtrapolation, --no-inputExtrapolation
                      Enable input extrapolation using derivative
                      information (default: false)
--intervals INTERVALS
                      Specify the number of communication points (arg > 1)
                      (default: 500)
--logFile LOGFILE     Specify the log file (default: stdout)
--logLevel LOGLEVEL   Set the log level (0: default, 1: debug, 2:
                      debug+trace) (default: 0)
--master MASTER       Specify the master algorithm (ma) (default: ma)
--maxEventIteration MAXEVENTITERATION
                      Specify the maximum number of iterations for handling
                      a single event (default: 100)
--maxLoopIteration MAXLOOPITERATION
                      Specify the maximum number of iterations for solving
                      algebraic loops between system-level components.
                      Internal algebraic loops of components are not
                      affected. (default: 10)
--minimumStepSize MINIMUMSTEPSIZE
                      Specify the minimum step size (default: 1e-12)
--mode {cs,me}        Force 'cs' (co-simulation) or 'me' (model exchange)
                      for FMUs that export both kinds (.fmu only) (default:
                      co-simulation)
--numProcs NUMPROCS   Specify the maximum number of processors to use
                      (0=auto, 1=default) (default: 1)
--progressBar, --no-progressBar
                      Show a progress bar for the simulation progress in the
                      terminal (default: false)
--realTime, --no-realTime
                      Enable experimental feature for (soft) real-time co-
                      simulation (default: false)
```

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```
--resultFile RESULTFILE
                      Specify the name of the output result file (default:
                      the model name plus '_res.mat')
--skipCSVHeader, --no-skipCSVHeader
                      Skip the CSV delimiter row in the header of .csv
                      result files (default: true)
--solver {euler,cvode}
                      Set the ODE solver for model-exchange FMUs (.fmu,
                      mode=me only) (default: cvode)
--solverStats, --no-solverStats
                      Add solver stats to the result file, e.g., step size;
                      not supported for all solvers (default: false)
--startTime STARTTIME
                      Specify the start time (default: from the model)
--stepSize STEPSIZE   Specify the (maximum) step size (.fmu only) (default:
                      from the model)
--stopTime STOPTIME   Specify the stop time (default: from the model)
--stripRoot, --no-stripRoot
                      Remove the root system prefix from all exported
                      signals (default: false)
--suppressPath, --no-suppressPath
                      Suppress path information in info messages; especially
                      useful for testing (default: true)
--tempDir TEMPDIR     Specify the temporary directory (default: the working
                      directory)
--timeout TIMEOUT     Specify the maximum allowed time in seconds for
                      running a simulation (default: 0 (disabled))
--tolerance TOLERANCE
                      Specify the relative tolerance (default: from the
                      model)
--wallTime, --no-wallTime
                      Add wall time information to the result file (default:
                      false)
--workingDir WORKINGDIR
                      Specify the working directory (default: the current
                      directory)
--zeroNominal, --no-zeroNominal
                      Accept FMUs with invalid nominal values and replace
                      the invalid nominal values with 1.0 (default: false)
```

To use the `logLevel` flag with option debug (`--logLevel=1`) or debug+trace (`--logLevel=2`), OMSimulator needs to be built with debug configuration enabled. Refer to the OMSimulator README on GitHub for further instructions.

### 17.2.2 Examples

OMSimulator supports several ways of running simulations.

CHAPTER

EIGHTEEN

# RUNNING A PYTHON SCRIPT

A dedicated Python script can be passed directly to OMSimulator. The script can use the OMSimulator Python API to create and configure a simulation.

```
OMSimulator example.py
```

This is useful when the simulation setup is created programmatically or when a simulation needs additional Python logic.

CHAPTER

# NINETEEN

# RUNNING AN SSP FILE

An SSP file can be passed directly to OMSimulator. OMSimulator loads the system structure from the SSP file and executes the simulation.

```
OMSimulator example.ssp
```

CHAPTER

# TWENTY

# RUNNING AN FMU

An FMU can also be passed directly to OMSimulator.

```
OMSimulator example.fmu
```

This provides a simple way to simulate an FMU without creating an SSP system explicitly.

## 20.1 OMSimulatorLib

This library is the core of OMSimulator and provides a C interface that can easily be utilized to handle co-simulation scenarios.

The following is a list of the available C-API functions:

### 20.1.1 RunFile

Simulates a single FMU or SSP model.

```
oms_status_enu_t oms_RunFile(const char* filename);
```

### 20.1.2 activateVariant

This API provides support to activate a multi-variant modelling from an ssp file [(e.g). SystemStructure.ssd, VarA.ssd, VarB.ssd ] from a ssp file. By default when importing a ssp file the default variant will be "SystemStructure.ssd". The users can be able to switch between other variants by using this API and make changes to that particular variant and simulate them.

```
oms_status_enu_t oms_activateVariant(const char* crefA, const char* crefB);
```

### 20.1.3 addBus

Adds a bus to a given component.

```
oms_status_enu_t oms_addBus(const char* cref);
```

### 20.1.4 addConnection

Adds a new connection between connectors *A* and *B*. The connectors need to be specified as fully qualified component references, e.g., *"model.system.component.signal"*.

```
oms_status_enu_t oms_addConnection(const char* crefA, const char* crefB, bool␣
↪suppressUnitConversion);
```

The two arguments *crefA* and *crefB* get swapped automatically if necessary. The third argument suppressUnitConversion is optional and the default value is *false* which allows automatic unit conversion between connections, if set to *true* then automatic unit conversion will be disabled.

### 20.1.5 addConnector

Adds a connector to a given component.

```
oms_status_enu_t oms_addConnector(const char* cref, oms_causality_enu_t causality,␣
↪oms_signal_type_enu_t type);
```

### 20.1.6 addConnectorToBus

Adds a connector to a bus.

```
oms_status_enu_t oms_addConnectorToBus(const char* busCref, const char*␣
↪connectorCref);
```

### 20.1.7 addResources

Adds an external resources to an existing SSP. The external resources should be a ".ssv" or ".ssm" file

```
oms_status_enu_t oms_addResources(const char* cref_, const char* path)
```

### 20.1.8 addSignalsToResults

Add all variables that match the given regex to the result file.

```
oms_status_enu_t oms_addSignalsToResults(const char* cref, const char* regex);
```

The second argument, i.e. regex, is considered as a regular expression (C++11). *".*"* and *"(.)*"* can be used to hit all variables.

### 20.1.9 addSubModel

Adds a component to a system.

```
oms_status_enu_t oms_addSubModel(const char* cref, const char* fmuPath);
```

### 20.1.10 addSystem

Adds a (sub-)system to a model or system.

```
oms_status_enu_t oms_addSystem(const char* cref, oms_system_enu_t type);
```

### 20.1.11 compareSimulationResults

This function compares a given signal of two result files within absolute and relative tolerances.

```
int oms_compareSimulationResults(const char* filenameA, const char* filenameB, const␣
↪char* var, double relTol, double absTol);
```

The following table describes the input values:

| Input | Type | Description |
|---|---|---|
| filenameA | String | Name of first result file to compare. |
| filenameB | String | Name of second result file to compare. |
| var | String | Name of signal to compare. |
| relTol | Number | Relative tolerance. |
| absTol | Number | Absolute tolerance. |

The following table describes the return values:

| Type | Description |
|---|---|
| Integer | 1 if the signal is considered as equal, 0 otherwise |

### 20.1.12 copySystem

Copies a system.

```
oms_status_enu_t oms_copySystem(const char* source, const char* target);
```

### 20.1.13 delete

Deletes a connector, component, system, or model object.

```
oms_status_enu_t oms_delete(const char* cref);
```

### 20.1.14 deleteConnection

Deletes the connection between connectors *crefA* and *crefB*.

```
oms_status_enu_t oms_deleteConnection(const char* crefA, const char* crefB);
```

The two arguments *crefA* and *crefB* get swapped automatically if necessary.

### 20.1.15 deleteConnectorFromBus

Deletes a connector from a given bus.

```
oms_status_enu_t oms_deleteConnectorFromBus(const char* busCref, const char*␣
↪connectorCref);
```

### 20.1.16 deleteResources

Deletes the reference and resource file in a SSP. Deletion of ".ssv" and ".ssm" files are currently supported. The API can be used in two ways.

1) deleting only the reference file in ".ssd".
2) deleting both reference and resource files in ".ssp".

To delete only the reference file in ssd, the user should provide the full qualified cref of the ".ssv" file associated with a system or subsystem or component (e.g) "model.root:root1.ssv".

To delete both the reference and resource file in ssp, it is enough to provide only the model cref of the ".ssv" file (e.g) "model:root1.ssv".

When deleting only the references of a ".ssv" file, if a parameter mapping file ".ssm" is binded to a ".ssv" file then the ".ssm" file will also be deleted. It is not possible to delete the references of ".ssm" seperately as the ssm file is binded to a ssv file.

The filename of the reference or resource file is provided by the users using colon suffix at the end of cref. (e.g) ":root.ssv"

```
oms_status_enu_t oms_deleteResources(const char* cref);
```

### 20.1.17 doStep

Simulates a macro step of the given composite model. The step size will be determined by the master algorithm and is limited by the definied minimal and maximal step sizes.

```
oms_status_enu_t oms_doStep(const char* cref);
```

### 20.1.18 duplicateVariant

This API provides support to develop a multi-variant modelling in OMSimulator [(e.g). SystemStructure.ssd, VarA.ssd, VarB.ssd ]. When duplicating a variant, the new variant becomes the current variant and all the changes made by the users are applied to the new variants only, and all the ssv and ssm resources associated with the new variant will be given new name based on the variant name provided by the user. This allows the bundling of multiple variants of a system structure definition referencing a similar set of packaged resources as a single SSP. However there must still be one SSD file named SystemStructure.ssd at the root of the ZIP archive which will be considered as default variant.

```
oms_status_enu_t oms_duplicateVariant(const char* crefA, const char* crefB);
```

### 20.1.19 export

Exports a composite model to a SPP file.

```
oms_status_enu_t oms_export(const char* cref, const char* filename);
```

### 20.1.20 exportDependencyGraphs

Export the dependency graphs of a given model to dot files.

```
oms_status_enu_t oms_exportDependencyGraphs(const char* cref, const char*␣
↪initialization, const char* event, const char* simulation);
```

### 20.1.21 exportSSMTemplate

Exports all signals that have start values of one or multiple FMUs to a SSM file that are read from modelDescription.xml with a mapping entry. The mapping entry specifies a single mapping between a parameter in the source and a parameter of the system or component being parameterized. The mapping entry contains two attributes namely source and target. The source attribute will be empty and needs to be manually mapped by the users associated with the parameter name defined in the SSV file, the target contains the name of parameter in the system or component to be parameterized. The function can be called for a top level model or a certain FMU component. If called for a top level model, start values of all FMUs are exported to the SSM file. If called for a component, start values of just this FMU are exported to the SSM file.

```
oms_status_enu_t oms_exportSSMTemplate(const char* cref, const char* filename)
```

### 20.1.22 exportSSVTemplate

Exports all signals that have start values of one or multiple FMUs to a SSV file that are read from modelDescription.xml. The function can be called for a top level model or a certain FMU component. If called for a top level model, start values of all FMUs are exported to the SSV file. If called for a component, start values of just this FMU are exported to the SSV file.

```
oms_status_enu_t oms_exportSSVTemplate(const char* cref, const char* filename)
```

### 20.1.23 exportSnapshot

Lists the SSD representation of a given model, system, or component.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
oms_status_enu_t oms_exportSnapshot(const char* cref, char** contents);
```

### 20.1.24 freeMemory

Free the memory allocated by some other API. Pass the object for which memory is allocated.

```
void oms_freeMemory(void* obj);
```

### 20.1.25 getBoolean

Get boolean value of given signal.

```
oms_status_enu_t oms_getBoolean(const char* cref, bool* value);
```

### 20.1.26 getBus

Gets the bus object.

```
oms_status_enu_t oms_getBus(const char* cref, oms_busconnector_t** busConnector);
```

### 20.1.27 getComponentType

Gets the type of the given component.

```
oms_status_enu_t oms_getComponentType(const char* cref, oms_component_enu_t* type);
```

### 20.1.28 getConnections

Get list of all connections from a given component.

```
oms_status_enu_t oms_getConnections(const char* cref, oms_connection_t***␣
↪connections);
```

### 20.1.29 getConnector

Gets the connector object of the given connector cref.

```
oms_status_enu_t oms_getConnector(const char* cref, oms_connector_t** connector);
```

### 20.1.30 getDirectionalDerivative

This function computes the directional derivatives of an FMU.

```
oms_status_enu_t oms_getDirectionalDerivative(const char* cref, double* value);
```

### 20.1.31 getElement

Get element information of a given component reference.

```
oms_status_enu_t oms_getElement(const char* cref, oms_element_t** element);
```

### 20.1.32 getElements

Get list of all sub-components of a given component reference.

```
oms_status_enu_t oms_getElements(const char* cref, oms_element_t*** elements);
```

### 20.1.33 getFMUInfo

Returns FMU specific information.

```
oms_status_enu_t oms_getFMUInfo(const char* cref, const oms_fmu_info_t** fmuInfo);
```

### 20.1.34 getFixedStepSize

Gets the fixed step size. Can be used for the communication step size of co-simulation systems and also for the integrator step size in model exchange systems.

```
oms_status_enu_t oms_getFixedStepSize(const char* cref, double* stepSize);
```

### 20.1.35 getInteger

Get integer value of given signal.

```
oms_status_enu_t oms_getInteger(const char* cref, int* value);
```

### 20.1.36 getModelState

Gets the model state of the given model cref.

```
oms_status_enu_t oms_getModelState(const char* cref, oms_modelState_enu_t*␣
↪modelState);
```

### 20.1.37 getReal

Get real value.

```
oms_status_enu_t oms_getReal(const char* cref, double* value);
```

### 20.1.38 getResultFile

Gets the result filename and buffer size of the given model cref.

```
oms_status_enu_t oms_getResultFile(const char* cref, char** filename, int*␣
↪bufferSize);
```

### 20.1.39 getSolver

Gets the selected solver method of the given system.

```
oms_status_enu_t oms_getSolver(const char* cref, oms_solver_enu_t* solver);
```

### 20.1.40 getStartTime

Get the start time from the model.

```
oms_status_enu_t oms_getStartTime(const char* cref, double* startTime);
```

### 20.1.41 getStopTime

Get the stop time from the model.

```
oms_status_enu_t oms_getStopTime(const char* cref, double* stopTime);
```

### 20.1.42 getString

Get string value.

Memory is allocated for *value*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
oms_status_enu_t oms_getString(const char* cref, char** value);
```

### 20.1.43 getSubModelPath

Returns the path of a given component.

```
oms_status_enu_t oms_getSubModelPath(const char* cref, char** path);
```

### 20.1.44 getSystemType

Gets the type of the given system.

```
oms_status_enu_t oms_getSystemType(const char* cref, oms_system_enu_t* type);
```

### 20.1.45 getTime

Get the current simulation time from the model.

```
oms_status_enu_t oms_getTime(const char* cref, double* time);
```

### 20.1.46 getTolerance

Gets the tolerance of a given system or component.

```
oms_status_enu_t oms_getTolerance(const char* cref, double* relativeTolerance);
```

### 20.1.47 getVariableStepSize

Gets the step size parameters.

```
oms_status_enu_t oms_getVariableStepSize(const char* cref, double* initialStepSize,␣
↪double* minimumStepSize, double* maximumStepSize);
```

### 20.1.48 getVersion

Returns the library's version string.

```
const char* oms_getVersion();
```

### 20.1.49 importFile

Imports a composite model from a SSP file.

```
oms_status_enu_t oms_importFile(const char* filename, char** cref);
```

### 20.1.50 importSnapshot

Loads a snapshot to restore a previous model state. The model must be in virgin model state, which means it must not be instantiated.

```
oms_status_enu_t oms_importSnapshot(const char* cref, const char* snapshot, char**␣
↪newCref);
```

### 20.1.51 initialize

Initializes a composite model.

```
oms_status_enu_t oms_initialize(const char* cref);
```

### 20.1.52 instantiate

Instantiates a given composite model.

```
oms_status_enu_t oms_instantiate(const char* cref);
```

### 20.1.53 list

Lists the SSD representation of a given model, system, or component.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
oms_status_enu_t oms_list(const char* cref, char** contents);
```

### 20.1.54 listUnconnectedConnectors

Lists all unconnected connectors of a given system.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
oms_status_enu_t oms_listUnconnectedConnectors(const char* cref, char** contents);
```

### 20.1.55 listVariants

This API shows the number of variants available [(e.g). SystemStructure.ssd, VarA.ssd, VarB.ssd ] from a ssp file.

```
oms_status_enu_t oms_listVariants(const char* cref);
```

### 20.1.56 loadSnapshot

Loads a snapshot to restore a previous model state. The model must be in virgin model state, which means it must not be instantiated.

```
oms_status_enu_t oms_loadSnapshot(const char* cref, const char* snapshot, char**␣
↪newCref);
```

### 20.1.57 newModel

Creates a new and yet empty composite model.

```
oms_status_enu_t oms_newModel(const char* cref);
```

### 20.1.58 newResources

Adds a new empty resources to the SSP. The resource file is a ".ssv" file where the parameter values set by the users using "oms_setReal()", "oms_setInteger()" and "oms_setReal()" are writtern to the file. Currently only ".ssv" files can be created.

The filename of the resource file is provided by the users using colon suffix at the end of cref. (e.g) ":root.ssv"

```
oms_status_enu_t oms_newResources(const char* cref)
```

### 20.1.59 referenceResources

Switches the references of ".ssv" and ".ssm" in a SSP file. Referencing of ".ssv" and ".ssm" files are currently supported. The API can be used in two ways.

1) Referencing only the ".ssv" file.

2) Referencing both the ".ssv" along with the ".ssm" file.

This API should be used in combination with "oms_deleteResources".To switch with a new reference, the old reference must be deleted first using "oms_deleteResources" and then reference with new resources.

When deleting only the references of a ".ssv" file, if a parameter mapping file ".ssm" is binded to a ".ssv" file, then the reference of ".ssm" file will also be deleted. It is not possible to delete the references of ".ssm" seperately as the ssm file is binded to a ssv file. Hence it is not possible to switch the reference of ".ssm" file alone. So inorder to switch the reference of ".ssm" file, the users need to bind the reference of ".ssm" file along with the ".ssv".

The filename of the reference or resource file is provided by the users using colon suffix at the end of cref (e.g) ":root.ssv", and the ".ssm" file is optional and is provided by the user as the second argument to the API.

```
oms_status_enu_t oms_referenceResources(const char* cref, const char* ssmFile);
```

### 20.1.60 removeSignalsFromResults

Removes all variables that match the given regex to the result file.

```
oms_status_enu_t oms_removeSignalsFromResults(const char* cref, const char* regex);
```

The second argument, i.e. regex, is considered as a regular expression (C++11). *".*"* and *"(.)*"* can be used to hit all variables.

### 20.1.61 rename

Renames a model, system, or component.

```
oms_status_enu_t oms_rename(const char* cref, const char* newCref);
```

### 20.1.62 replaceSubModel

Replaces an existing fmu component, with a new component provided by the user, When replacing the fmu checks are made in all ssp concepts like in ssd, ssv and ssm, so that connections and parameter settings are not lost. It is possible that the namings of inputs and parameters match, but the start values might have been changed, in such cases new start values will be applied in ssd, ssv and ssm. In case if the Types of inputs and outputs and parameters differed, then the variables are updated according to the new changes and the connections will be removed with warning messages to user. In case when replacing a fmu, if the fmu contains parameter mapping associated with the ssv file, then only the ssm file entries are updated and the start values in the ssv files will not be changed.

```
oms_status_enu_t oms_replaceSubModel(const char* cref, const char* fmuPath);
```

### 20.1.63 reset

Reset the composite model after a simulation run.

The FMUs go into the same state as after instantiation.

```
oms_status_enu_t oms_reset(const char* cref);
```

### 20.1.64 setActivationRatio

Experimental feature for setting the activation ratio of FMUs for experimenting with multi-rate master algorithms.

```
oms_status_enu_t experimental_setActivationRatio(const char* cref, int k);
```

### 20.1.65 setBoolean

Sets the value of a given boolean signal.

```
oms_status_enu_t oms_setBoolean(const char* cref, bool value);
```

### 20.1.66 setBusGeometry

```
oms_status_enu_t oms_setBusGeometry(const char* bus, const ssd_connector_geometry_t*␣
↪geometry);
```

### 20.1.67 setCommandLineOption

Sets special flags.

```
oms_status_enu_t oms_setCommandLineOption(const char* cmd);
```

### 20.1.68 setConnectionGeometry

```
oms_status_enu_t oms_setConnectionGeometry(const char* crefA, const char* crefB,␣
↪const ssd_connection_geometry_t* geometry);
```

### 20.1.69 setConnectorGeometry

Set geometry information to a given connector.

```
oms_status_enu_t oms_setConnectorGeometry(const char* cref, const ssd_connector_
↪geometry_t* geometry);
```

### 20.1.70 setElementGeometry

Set geometry information to a given component.

```
oms_status_enu_t oms_setElementGeometry(const char* cref, const ssd_element_geometry_
↪t* geometry);
```

### 20.1.71 setFixedStepSize

Sets the fixed step size. Can be used for the communication step size of co-simulation systems and also for the integrator step size in model exchange systems.

```
oms_status_enu_t oms_setFixedStepSize(const char* cref, double stepSize);
```

### 20.1.72 setInteger

Sets the value of a given integer signal.

```
oms_status_enu_t oms_setInteger(const char* cref, int value);
```

### 20.1.73 setLogFile

Redirects logging output to file or std streams. The warning/error counters are reset.

filename="" to redirect to std streams and proper filename to redirect to file.

```
oms_status_enu_t oms_setLogFile(const char* filename);
```

### 20.1.74 setLoggingCallback

Sets a callback function for the logging system.

```
void oms_setLoggingCallback(void (*cb)(oms_message_type_enu_t type, const char*␣
↪message));
```

### 20.1.75 setLoggingInterval

Set the logging interval of the simulation.

```
oms_status_enu_t oms_setLoggingInterval(const char* cref, double loggingInterval);
```

### 20.1.76 setLoggingLevel

Enables/Disables debug logging (logDebug and logTrace).

0 default, 1 default+debug, 2 default+debug+trace

```
void oms_setLoggingLevel(int logLevel);
```

### 20.1.77 setMaxLogFileSize

Sets maximum log file size in MB. If the file exceeds this limit, the logging will continue on stdout.

```
void oms_setMaxLogFileSize(const unsigned long size);
```

### 20.1.78 setReal

Sets the value of a given real signal.

```
oms_status_enu_t oms_setReal(const char* cref, double value);
```

This function can be called in different model states:

- Before instantiation: *setReal* can be used to set start values or to define initial unknowns (e.g. parameters, states). The values are not immediately applied to the simulation unit, since it isn't actually instantiated.
- After instantiation and before initialization: Same as before instantiation, but the values are applied immediately to the simulation unit.
- After initialization: Can be used to force external inputs, which might cause discrete changes of continuous signals.

### 20.1.79 setRealInputDerivative

Sets the first order derivative of a real input signal.

This can only be used for CS-FMU real input signals.

```
oms_status_enu_t oms_setRealInputDerivative(const char* cref, double value);
```

### 20.1.80 setResultFile

Set the result file of the simulation.

```
oms_status_enu_t oms_setResultFile(const char* cref, const char* filename, int␣
↪bufferSize);
```

The creation of a result file is omitted if the filename is an empty string.

### 20.1.81 setSolver

Sets the solver method for the given system.

```
oms_status_enu_t oms_setSolver(const char* cref, oms_solver_enu_t solver);
```

### 20.1.82 setStartTime

Set the start time of the simulation.

```
oms_status_enu_t oms_setStartTime(const char* cref, double startTime);
```

### 20.1.83 setStopTime

Set the stop time of the simulation.

```
oms_status_enu_t oms_setStopTime(const char* cref, double stopTime);
```

### 20.1.84 setString

Sets the value of a given string signal.

```
oms_status_enu_t oms_setString(const char* cref, const char* value);
```

### 20.1.85 setTempDirectory

Set new temp directory.

```
oms_status_enu_t oms_setTempDirectory(const char* newTempDir);
```

### 20.1.86 setTolerance

Sets the tolerance for a given model or system.

```
oms_status_enu_t oms_setTolerance(const char* cref, double relativeTolerance);
```

Default values are *1e-4* for both relative and absolute tolerances.

A tolerance specified for a model is automatically applied to its root system, i.e. both calls do exactly the same:

```
oms_setTolerance("model", relativeTolerance);
oms_setTolerance("model.root", relativeTolerance);
```

Component, e.g. FMUs, pick up the tolerances from there system. That means it is not possible to define different tolerances for FMUs in the same system right now.

In a strongly coupled system (*oms_system_sc*), the relative tolerance is used for CVODE and the absolute tolerance is used to solve algebraic loops.

In a weakly coupled system (*oms_system_wc*), both the relative and absolute tolerances are used for the adaptive step master algorithms and the absolute tolerance is used to solve algebraic loops.

### 20.1.87 setUnit

Sets the unit of a given signal.

```
oms_status_enu_t oms_setUnit(const char* cref, const char* value);
```

### 20.1.88 setVariableStepSize

Sets the step size parameters for methods with stepsize control.

```
oms_status_enu_t oms_getVariableStepSize(const char* cref, double* initialStepSize,␣
↪double* minimumStepSize, double* maximumStepSize);
```

### 20.1.89 setWorkingDirectory

Set a new working directory.

```
oms_status_enu_t oms_setWorkingDirectory(const char* newWorkingDir);
```

### 20.1.90 simulate

Simulates a composite model.

```
oms_status_enu_t oms_simulate(const char* cref);
```

### 20.1.91 simulate_realtime

Experimental feature for (soft) real-time simulation.

```
oms_status_enu_t experimental_simulate_realtime(const char* ident);
```

### 20.1.92 stepUntil

Simulates a composite model until a given time value.

```
oms_status_enu_t oms_stepUntil(const char* cref, double stopTime);
```

### 20.1.93 terminate

Terminates a given composite model.

```
oms_status_enu_t oms_terminate(const char* cref);
```

## 20.2 OMSimulatorPython3

This section documents the new **oms3 Python API**, designed to improve modularity and reduce overhead, while providing tighter integration with Python. The updated architecture separates the simulation core from the SSP (System Structure and Parameterization) standards, offering greater flexibility, interoperability and efficient model management.

### 20.2.1 Core Capabilities

The **oms3 Python API** provides an extensive set of commands for building, configuring, and validating SSP models. The following table summarizes the main functionalities provided by the package.

| Category | Functionality |
|---|---|
| **Model Management** | • Create new SSP models<br>• Create, activate, and duplicate variants<br>• Add or delete resources, components, systems, connectors<br>• Create nested systems<br>• Set parameters and solvers<br>• Swap SSV references |
| **Connectivity** | • Add components and connectors<br>• Define and manage connections |
| **SSP Standards** | • Import and export SSP models<br>• Create SSV and SSM descriptions<br>• Export SSV and SSM templates<br>• Validate SSP, SSV, and SSM |
| **FMU Integration** | • Import and validate FMUs as components |
| **Utilities** | • Error handling, logging, and debugging support |

### 20.2.2 Command Line Interface

In addition to the Python API, the **oms3 Python** package installs a `OMSimulator` command line entry point that can run a `.ssp` or `.fmu` or `.py` file directly, without having to write a driver script:

```
OMSimulator model.ssp
OMSimulator model.fmu
```

All simulation settings (start/stop time, tolerance, ...) are taken from the model itself; use the flags below to override them. Both file types are validated against their schema (FMI for `.fmu`, SSP for `.ssp`) before simulation.

The full list of command line arguments can also be printed at any time with:

```
OMSimulator --help
```

The table below summarizes the most commonly used flags. For a complete list, refer to *OMSimulator Flags*.

Table 20.1: OMSimulator command line flags

| Flag | Value | Description |
|---|---|---|
| `--resultFile` | `FILE` | Override the result file name. |
| `--startTime` | `TIME` | Override the simulation start time. |
| `--stopTime` | `TIME` | Override the simulation stop time. |
| `--tolerance` | `TOL` | Override the solver tolerance (`.fmu` only). |
| `--stepSize` | `SIZE` | Override the (maximum) simulation step size (`.fmu` only). |
| `--mode` | `cs` \| `me` | Force co-simulation or model exchange for FMUs that export both kinds (`.fmu` only). |
| `--solver` | `euler` \| `cvode` | Set the ODE solver for model-exchange FMUs (`.fmu`, requires `--mode me`). |
| `--stripRoot` | — | Remove the root system prefix from exported signal names (applies to both `.fmu` and `.ssp`). |
| `--validate` | `.fmu` \| `.ssp` | Only validate the file against its schema; do not simulate. |
| `--calibrate` | `[ACTIVITY]` | Fit the parameters of a Calibration activity instead of simulating (`.ssp` only), see *Parameter Calibration*. |
| `--calibrationOut` | `FILE` | SSP file the calibrated model is written to. |
| `--uqFile` | `PATH` | UQ file inside the SSP, if the SSP does not reference it. |

#### Examples

```
# Simulate an FMU using its own declared defaults
OMSimulator model.fmu

# Force model-exchange mode with the Euler solver and a custom step size
OMSimulator model.fmu --mode me --solver euler --stepSize 1e-3

# Only validate an FMU or SSP against its schema, without simulating
OMSimulator model.fmu --validate
OMSimulator model.ssp --validate

# Override the stop time and result file of an SSP
OMSimulator model.ssp --stopTime 10 --resultFile out.mat

# Drop the "model.root" prefix from exported signal names (.fmu or .ssp)
OMSimulator model.fmu --stripRoot
OMSimulator model.ssp --stripRoot

# Calibrate the parameters of activity cal_01 against its reference data
OMSimulator model.ssp --calibrate cal_01 --calibrationOutput calibrated.ssp
```

### 20.2.3 Parameter Calibration

The `OMSimulator.calibration` module fits parameters of an SSP model to reference data. The problem is described by a `Calibration` activity of the OpenSCALING UQ layered standard, in a UQ file inside the SSP that the SSD references with an `ssc:MetaData` element of type `application/x-uncertainty-quantification`:

- `CalibrationTargets`: the parameters to fit, with initial value and bounds
- `ObservedVariables`: the simulated variables compared to the reference data
- `ReferenceData`: a CSV file; the first column is the time
- `ParameterSet`: further parameter values to set
- `SimulationSetting`: stop time and tolerance

The fit is a bounded nonlinear least squares problem solved with `scipy.optimize.least_squares`, so it needs numpy and scipy (`pip install OMSimulator[calibration]`). Each evaluation resets the model, sets the parameters, initializes it and steps through the time points of the reference data, so the FMUs are instantiated only once.

The standard does not yet define how observed variables map to the reference data, their weights, the calibration time window or optimizer options. These are read from an optional `KeyValues` element of type `org.openmodelica.omsimulator.calibration` in the `SimulationSetting`:

Table 20.2: Calibration options

| Key | Description |
|---|---|
| `startTime`, `stopTime` | Calibration time window (default: the reference data up to the `stopTime` of the `SimulationSetting`). |
| `dataName:<variable>` | Reference data column of an observed variable (default: the column named like the variable, optionally followed by `\|unit`). |
| `weight:<variable>` | Residual weight of an observed variable (default: 1). |
| `scaling` | `none` (default), `range` or `std`: divide the residuals of each observed variable by the range or standard deviation of its reference data. |
| `relativeTolerance` | Optimizer tolerance on cost, step and gradient (default: 1e-8). |
| `maxEvaluations` | Maximum number of model evaluations. |
| `diffStep` | Relative finite difference step for the Jacobian. |

The calibrated values are written to `<activity>_calibrated.ssv` next to the UQ file and the `ResultSet` of the activity gets one `ErrorMetric` of type `RMSE` per observed variable, referring to that parameter set.

```
from OMSimulator.calibration import calibrateSSP

result = calibrateSSP("model.ssp", "cal_01", output="calibrated.ssp")
print(result.parameters, result.rmse)
```

`CalibrationProblem.fromXML` and `Calibration` run the same fit on an already instantiated model, e.g., to set further values before calibrating.

### 20.2.4 Quick start Example

The following example demonstrates how to

- Create a new SSP model
- Add FMU components as resources
- Establish connections between components
- Export the model to an SSP file
- Re-import the exported SSP file
- Instantiate the model, set parameter values, and run a simulation

```
from OMSimulator import SSP, CRef, Settings
Settings.suppressPath = True

# This example creates a new SSP file with an FMU instantiated as a component.
# It then exports the SSP file and re-imports and set run time value on the␣
↪instantiated model and the simulates the model.

model = SSP()
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
↪Add.fmu')
model.addResource('../resources/Modelica.Blocks.Math.Gain.fmu', new_name='resources/
↪Gain.fmu')

component1 = model.addComponent(CRef('default', 'Add1'), 'resources/Add.fmu')
component3 = model.addComponent(CRef('default', 'Gain1'), 'resources/Gain.fmu')


model.addConnection(CRef('default', 'Gain1', 'y'), CRef('default', 'Add1', 'u1'))

#model.list()
model.export('SimpleSimulation5.ssp')
## import the exported SSP file
model2 = SSP('SimpleSimulation5.ssp')

instantiated_model = model2.instantiate()
instantiated_model.setResultFile("SimpleSimulation5_res.mat")
instantiated_model.setValue(CRef('default', 'Gain1', 'k'), 2.0)
instantiated_model.setValue(CRef('default', 'Gain1', 'u'), 6.0)

print(f"info: After instantiation:")
print(f"info:    default.Gain1.k: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'k'))}", flush=True)
print(f"info:    default.Gain1.u: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'u'))}", flush=True)
```

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```
print(f"info:    default.Gain1.y: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'y'))}", flush=True)
print(f"info:    default.Add1.u1: {instantiated_model.getValue(CRef('default', 'Add1',
↪ 'u1'))}", flush=True)

instantiated_model.initialize()
instantiated_model.simulate()
print(f"info: After simulation:")
print(f"info:    default.Gain1.k: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'k'))}", flush=True)
print(f"info:    default.Gain1.u: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'u'))}", flush=True)
print(f"info:    default.Gain1.y: {instantiated_model.getValue(CRef('default', 'Gain1
↪', 'y'))}", flush=True)
print(f"info:    default.Add1.u1: {instantiated_model.getValue(CRef('default', 'Add1',
↪ 'u1'))}", flush=True)

instantiated_model.terminate()
instantiated_model.delete()
```

### 20.2.5 SSP

The `ssp` module provides a high-level interface for creating, importing, and managing SSP (System Structure and Parameterization) models. SSP models are used to describe complex system architectures by connecting multiple components and defining their parameters, enabling seamless simulation and co-simulation workflows.

```
from OMSimulator import SSP, Settings
Settings.suppressPath = True

# Create a new, empty SSP model instance
model = SSP()

# Create a new, empty SSP model with a custom model name and root system name
model = SSP(model_name="model", system_name="root")

# Load an existing SSP model from a file
model = SSP("PIController.ssp")

# list the ssp components
model.list()
```

`model_name` and `system_name` are optional. `model_name` defaults to `"default"` and `system_name` defaults to `model_name`. The model name is the first element of every component reference, so a model created with `model_name="model"` is addressed as `CRef('model', 'Add1')`. Both arguments are ignored when an existing SSP file is loaded, because the names are then read from the file.

Once created or loaded, an SSP model instance allows you to:

- Add and configure components.
- Connect signals between components.
- Define parameters and experiment settings.
- Export the model for simulation or further analysis.

### 20.2.6 SSD

The **SSV** class provides a high-level interface for importing, and managing SSD (System Structure Description) models which are unpacked from SSP files. We can use the SSD class to load an SSD file, inspect its structure, and manipulate its elements programmatically.

```
from OMSimulator import SSD, Settings
Settings.suppressPath = True
ssd = SSD.importFromFile('../resources/LOC/SystemStructure.ssd')
ssd.list()
```

### 20.2.7 SSV

The **SSV** class provides an interface for creating and managing *System Structure Parameter Values* (SSV) files. These files are used to define parameter values, units, and variability information for components within an SSP model.

**Typical use cases include:**

- Defining scalar variables and their default values
- Assigning units and data types to parameters
- Storing both numeric and string-based parameter values
- Exporting parameter sets to *.ssv* files for reuse across simulations

**Key Methods**

- `setValue(name, value, unit=None)` Assigns a parameter value. Optionally, a unit can be specified.
- `export(filename)` Writes the defined parameters to an external *.ssv* file.

**Example**

```
from OMSimulator import SSV, Settings

Settings.suppressPath = True

# Create a new SSV file and define parameters
ssv1 = SSV()
ssv1.setValue("k1", 2.0, "m")
ssv1.setValue("k2", 3.0)
ssv1.setValue("k3", 3)
ssv1.setValue("k4", False)
ssv1.setValue("param3", "hello")

# Export to file
ssv1.export("myfile1.ssv")
```

### 20.2.8 SSM

The **SSM** class provides an interface for creating and managing *System Structure and Mapping* (SSM) files. These files define how parameters declared in an SSV file are mapped to component parameters within an SSP model. This enables separation of parameter definitions from their usage, improving reusability and modularity.

**Typical use cases include:**

- Linking global parameter definitions (from SSV files) to component parameters in an SSP model.
- Supporting multiple parameter mappings for the same input across different components.
- Creating flexible configurations by swapping or updating parameter mappings without modifying the model structure.

**Key Methods**

- `mapParameter(source, target)` Creates a mapping between a parameter defined in an SSV file (`source`) and a component parameter or input signal (`target`).
- `export(filename)` Writes the defined parameter mappings to an external *.ssm* file.

**Example**

```
from OMSimulator import SSV, SSM, Settings

Settings.suppressPath = True

# Define parameters in SSV
ssv1 = SSV()
ssv1.setValue("Input1", 2.0)
ssv1.setValue("param1", 3.0)
ssv1.setValue("param2", 3)
ssv1.export("mapping1.ssv")

# Create parameter mappings in SSM
ssm1 = SSM()
ssm1.mapParameter("Input1", "Add1.u1")
ssm1.mapParameter("Input1", "u2")
ssm1.mapParameter("Input1", "u3")
ssm1.mapParameter("param1", "k1")
ssm1.mapParameter("param2", "k2")
ssm1.export("mapping2.ssm")
```

### 20.2.9 FMU

The **FMU** class provides an interface for loading and inspecting *Functional Mock-up Units (FMUs)*.This class allows users to access key metadata, states, and variables of an FMU directly from Python, enabling integration, validation and simulation.

**Typical use cases include:**

- Loading an FMU into memory for inspection or simulation.
- Accessing FMU metadata such as name, GUID, and FMI version.
- Iterating through state variables and retrieving their properties.
- Using variable metadata (signal type, causality, variability, value references) for analysis or parameter mapping.
- set default experiment settings such as start time, stop time, step size, and tolerance.
- set parameters and inputs before simulation.

**Syntax**

fmu = FMU(fmuPath: str, instanceName: str = "")

**Arguments**

- *fmuPath*: Path to the FMU file.
- *instanceName*: Optional name for the FMU instance. If not provided, it defaults to the model name of the FMU. The instance name is used in the result file as prefix for the variable names.

**Example**

```
from OMSimulator import FMU

# Load FMU
```

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```
fmu = FMU('../resources/Modelica.Electrical.Analog.Examples.CauerLowPassAnalog.fmu')

# Print metadata
print("name:", fmu.modelName)
print("guid:", fmu.guid)
print("fmi version:", fmu.fmiVersion)

# Inspect state variables
print("States:")
for var in sorted(fmu.states, key=lambda x: x.name):
    print({
        'name': var.name,
        'signal_type': var.signal_type.name,
        'valueReference': var.valueReference,
        'variability': var.variability,
        'causality': var.causality.name
    })
## instantiate the FMU
fmu.instantiate()
## set result file
fmu.setResultFile('CauerLowPass_res.mat')
## set parameter and input values
fmu.setValue('R1', 1000.0)
fmu.setValue('C1.u', 1e-6)
## initialize the FMU
fmu.initialize()
## simulate the FMU
fmu.simulate()
fmu.terminate()
fmu.delete()
```

### 20.2.10 Component

The **Component** class provides a flexible interface for defining modular building blocks in an SSP model. It supports **architectural modeling**, allowing components to represent actual FMUs or "dummy fmus" with expected connectors and parameter values. This makes it possible to design and validate system architectures before all FMUs are available.

**Key Features:**

- **Flexible instantiation** — create a component from an FMU or as a dummy placeholder.
- **Connector support** — define inputs, outputs, and parameters with explicit causality and signal type.
- **Parameter management** — assign values to parameters or inputs directly within the component.
- **SSV integration** — link components to SSV files to define and manage parameter sets externally.
- **System integration** — add the component to SSP models for hierarchical or flat system architectures.

```
from OMSimulator import CRef, Connector, Causality, SignalType, SSV
from OMSimulator.component import Component

# Create a dummy component
component = Component(CRef('add'), 'dummy.fmu')

# Add connectors
component.addConnector(Connector('input', Causality.input, SignalType.Real))
component.addConnector(Connector('output', Causality.output, SignalType.Real))
```

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```
component.addConnector(Connector('parameter', Causality.parameter, SignalType.Real))

# Set parameter values
component.setValue('parameter', 1.0)
component.setValue('input', 2.0)

# Create an SSV file for parameter initialization
ssv = SSV()
ssv.setValue('parameter', 1.0)
ssv.setValue('input', 2.0)
ssv.export('dummy.ssv')

# Link SSV file to component
component.addSSVReference('dummy.ssv')

# List component details
component.list()
```

### 20.2.11 addSystem

The **addSystem** method creates a new system within an SSP model. Systems serve as containers for components and connectors, and can be organized hierarchically to support **nested-system architectures**. This enables modular, scalable, and reusable system designs.

**Key Features:**

- **System instantiation** — create new systems within the SSP model.
- **Hierarchical modeling** — use structured `CRef` paths to create nested systems (e.g., a subsystem inside another subsystem).
- **Organization** — group related components, connectors, and resources within a defined subsystem for clarity and reusability.
- **Scalability** — build complex system hierarchies with multiple levels.

**Syntax**

```
addSystem(cref)
```

**Parameters:**

- `cref` (*CRef*): The system reference, specifying the hierarchical path and system name within the SSP model.

**Example**

```
from OMSimulator import SSP, CRef

model = SSP()

# Create systems
model.addSystem(CRef('default', 'sub-system'))
model.addSystem(CRef('default', 'sub-system2'))

# Create a nested subsystem inside 'sub-system2'
model.addSystem(CRef('default', 'sub-system2', 'sub-sub-system'))
```

### 20.2.12 addConnector

The **addConnector** API is used to define external interfaces for systems and components within an SSP model. A connector specifies the signal type and causality (e.g., input, output, or parameter) of a variable, allowing subsystems and components to communicate through well-defined ports.

**Connectors can be added at different hierarchy levels:**

- **Top-level system connectors**, which expose inputs, outputs, and parameters of the entire SSP model.
- **Subsystem connectors**, which define interaction points within nested systems and enable modular system design.

**Syntax:**

```
addConnector(Connector(name, causality, signal_type))
```

**Parameters:**

- `name` (*str*): Name of the connector.
- `causality` (*Causality*): Role of the connector (`input`, `output`, or `parameter`).
- `signal_type` (*SignalType*): Type of signal (e.g., `Real`, `Integer`,``Boolean``, `String`).

**Example:**

```
from OMSimulator import SSP, CRef, Connector, Causality, SignalType

model = SSP()
# Add a top-level system connector
model.activeVariant.system.addConnector(Connector('input1', Causality.input,␣
↪SignalType.Real))
# Add a connector to a subsystem
model.addSystem(CRef('default', 'sub-system'))
model.activeVariant.system.elements[CRef('sub-system')].addConnector(Connector('output
↪', Causality.output, SignalType.Real))
```

### 20.2.13 addConnection

The **addConnection** API is used to link the output of one component to the input of another within an SSP model. Connections define the signal flow between components, ensuring that data is transmitted correctly during simulation.

**Connections are defined using source and target references:**

- **Source**: Specifies the output variable of a component.
- **Target**: Specifies the input variable of another component.

**Syntax:**

```
addConnection(source: CRef, target: CRef)
```

**Parameters:**

- `source` (*CRef*): Reference to the output variable of the source component.
- `target` (*CRef*): Reference to the input variable of the target component.

**Example:**

```
from OMSimulator import SSP, CRef, Settings

model = SSP()
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
```

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```
↪Add.fmu')
model.addResource('../resources/Modelica.Blocks.Math.Gain.fmu', new_name='resources/
↪Gain.fmu')

model.addComponent(CRef('default', 'Add1'), 'resources/Add.fmu')
model.addComponent(CRef('default', 'Gain1'), 'resources/Gain.fmu')
## add a connection from Gain1.y to Add1.u1
model.addConnection(CRef('default', 'Gain1', 'y'), CRef('default', 'Add1', 'u1'))
## list the components in the model and connections
model.list()
```

### 20.2.14 addResource

The **addResource** method allows you to add external files, such as FMUs, SSV, SSM, SRMD etc.. to an SSP model's resource directory. This ensures that all required model files are bundled with the SSP package and can be referenced consistently during simulation.

**Key Features:**

- **File management** — copy or rename external FMUs and resources into the SSP project structure only once and use the instances multiple times in the model.
- **Integration with components** — added resources can then be used to instantiate components within the SSP model.

**Syntax**

```
addResource(source_path, new_name=None)
```

**Parameters:**

- `source_path` (*str*): Path to the external resource file (e.g., FMU)
- `new_name` (*str, optional*): New name for the resource within the SSP project structure. If not provided, the original filename is used.

**Example**

```
from OMSimulator import SSP, CRef, Settings

# Add an FMU to the SSP model's resources folder
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
↪Add.fmu')
model.addResource('../resources/Modelica.Blocks.Math.Gain.fmu', new_name='resources/
↪Gain.fmu')
```

### 20.2.15 addComponent

The **addComponent** method allows you to instantiate a component within an SSP model. Components can be FMUs or dummy placeholders, enabling flexible system architecture design and simulation.

**Key Features:**

- **Component instantiation** — create components based on FMU resources or dummy placeholders.
- **Hierarchical modeling** — components can be placed in nested systems using a structured *CRef* path.
- **Flexible integration** — components can later be connected via connectors, linked to SSV files, or assigned custom solver settings.
- **Supports multiple components** — multiple instances of the same FMU can be added with unique identifiers.

**Syntax**

```
addComponent(cref, resource_path)
```

**Parameters:**

- `cref` (*CRef*): The component reference, specifying the hierarchical path and component name within the SSP model.
- `resource_path` (*str*): Path to the FMU or model resource that the component should instantiate.

**Returns:**

- The newly created **Component** object.

**Example**

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

model = SSP()

# Add resources to the SSP model
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
↪Add.fmu')
model.addResource('../resources/Modelica.Blocks.Math.Gain.fmu', new_name='resources/
↪Gain.fmu')

# Instantiate components
component1 = model.addComponent(CRef('default', 'Add1'), 'resources/Add.fmu')
# instantiate multiple instances of the same FMU
component2 = model.addComponent(CRef('default', 'Add2'), 'resources/Add.fmu')
component3 = model.addComponent(CRef('default', 'Gain1'), 'resources/Gain.fmu')
component4 = model.addComponent(CRef('default', 'Gain2'), 'resources/Gain.fmu')
# list the components in the model
model.list()
```

### 20.2.16 addSSVReference

The **addSSVReference** API is used to associate an SSV (System Structure Parameterer and values) file with a specific component in an SSP model. This allows parameter values defined in the SSV file to be applied directly to the component, enabling flexible configuration and reuse of parameter sets.

The API also supports an optional third argument for specifying a **parameter mapping file** (.ssm), which defines how the variables in the SSV file map to the parameters of the component.

**Syntax:**

```
addSSVReference(cref, ssv_path: str, ssm_path: str = None)
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system or component to which the SSV file should be applied.
- `ssv_path` (*str*): Path to the SSV file relative to the SSP model resources.
- `ssm_path` (*str, optional*): Path to a parameter mapping file (.ssm) that defines how SSV variables correspond to component parameters.

**Example:**

```
from OMSimulator import SSP, CRef, Settings, SSV, SSM, Connector, Causality,␣
↪SignalType

Settings.suppressPath = True

# This example creates a new SSP file with an FMU instantiated as a component and
# set parameter values to ssv file and map some parameters to ssm file

model = SSP()
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
↪Add.fmu')
component1 = model.addComponent(CRef('default', 'Add1'), 'resources/Add.fmu')
component2 = model.addComponent(CRef('default', 'Add2'), 'resources/Add.fmu')

## create a ssv file
ssv1 = SSV()
ssv1.setValue("connector_param", 2.0)
ssv1.setValue("connector_input", 3.0)
ssv1.export("myfile3.ssv")

## create a ssm file
ssm = SSM()
ssm.mapParameter("connector_param", "u1")
ssm.mapParameter("connector_input", "u2")
ssm.export("myfile4.ssm")


 ## Add  SSV resource to the model
 model.addResource("myfile3.ssv", "resources/myfile3.ssv")
 ## Add ssm resources to the model
 model.addResource("myfile3.ssv", "resources/myfile4.ssm")

 # Reference the SSV to a specific component
 model.addSSVReference(CRef('default', 'Add1'), 'resources/myfile3.ssv')

 # With an optional SSM mapping file
 model.addSSVReference(CRef('default', 'Add2'), 'resources/myfile4.ssv', 'resources/
↪myfile4.ssm')
```

### 20.2.17 removeSSVReference

Removes the reference to a given SSV (System Structure parameter and values) file from a specific component or subsystem within the SSP model.This method is useful when a component or subsystem should no longer be associated with a parameter set defined in an SSV file.

**Notes:**

- The SSV file itself remains in the `resources/` folder of the SSP.
- Only the *reference* from the specified component is removed.
- If a parameter mapping file (.ssm) is associated with the SSV, it is also removed.
- If the component had multiple SSV references, only the matching one is cleared.

**Syntax:**

```
removeSSVReference(cref, ssv_path)
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system or component to which the SSV file should be applied.
- `ssv_path` (*str*): Path to the SSV file relative to the SSP model resources.

**Example usage**:

```
# Load an existing SSP model
model = SSP("swapSSV1.ssp")

# Remove SSV reference from top-level component Add1
model.removeSSVReference(CRef("default", "Add1"), "resources/swap1.ssv")

# Remove SSV reference from Add3 inside the subsystem
model.removeSSVReference(CRef("default", "sub-system", "Add3"), "resources/
↪swap1.ssv")
# List the model details to verify removal
model.list()
```

### 20.2.18 swapSSVReference

Swaps the reference to an existing SSV (System Structure parameter and values) file with a new one for a specific component or subsystem within the SSP model.

This method is essentially a combination of `removeSSVReference` and `addSSVReference`. It ensures that the old SSV reference is removed and replaced with the new SSV reference in a single step, reducing the risk of leaving the system without any SSV mapping during the transition.

**Notes:**

- The old SSV file remains in the `resources/` folder of the SSP model.
- Only the *reference* is swapped — no SSV files are deleted.
- If a parameter mapping file (.ssm) is associated with the old SSV, it will also be swapped accordingly.
- This method is equivalent to calling:

```
model.removeSSVReference(cref, old_ssv)
model.addSSVReference(cref, new_ssv)
```

**Syntax:**

```
swapSSVReference(cref, old_ssv, new_ssv)
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system, or component where the SSV file should be swapped.
- `old_ssv` (*str*): Path to the currently referenced SSV file relative to the SSP model resources.
- `new_ssv` (*str*): Path to the new SSV file relative to the SSP model resources.

**Example usage**:

```
# Load an existing SSP model
model = SSP("swapSSV3.ssp")

# Swap SSV reference from default system (swap5.ssv → swap6.ssv)
model.swapSSVReference(CRef("default"), "resources/swap5.ssv", "resources/
↪swap6.ssv")

# Swap SSV reference from sub-system (swap6.ssv → swap5.ssv)
model.swapSSVReference(CRef("default", "sub-system"), "resources/swap6.ssv",
```

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```
↪ "resources/swap5.ssv")

print("After swapping swap6.ssv to default and swap5.ssv to sub-system")
print("=================================================================")
model.list()
```

### 20.2.19 listSSVReference

Retrieves the list of SSV (System Structure parameter and values) files currently referenced by a system, sub-system, or component within the SSP model.

**Notes:**

- Only the references are listed — the method does not open or parse the SSV files.
- If no SSV file is associated with the given scope, an empty list is returned.
- The returned paths are relative to the `resources/` directory of the SSP archive.

**Syntax:**

```
listSSVReference(cref) -> list[dict]
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system, or component for which SSV references should be listed.

**Returns:**

- (*list[dict]*): A list of dict referenced by the given system, sub-system, or component.
  - Each dict contains:
    - `ssv` (*str*): Path to the referenced SSV file relative to the SSP model resources.
    - `ssm` (*str | None*): Path to the associated SSM file if one exists; otherwise, `None`.

**Example usage**:

```
model = SSP("listSSVReference1.ssp")
model.list()

print("List of SSV references")
print("======================")
print(f"Top level system SSV resources    : {model.listSSVReference(CRef('default'))}
↪")
print(f"Top level sub-system SSV resources: {model.listSSVReference(CRef('default',
↪'sub-system'))}")
print(f"Component Add1 SSV resources      : {model.listSSVReference(CRef('default',
↪'Add1'))}")
print(f"Component Add2 SSV resources      : {model.listSSVReference(CRef('default',
↪'Add2'))}")
print(f"Component Add3 SSV resources      : {model.listSSVReference(CRef('default',
↪'sub-system', 'Add3'))}")
```

### 20.2.20 exportSSVTemplate

Exports a template SSV (System Structure Parameter Values) file for a given system, sub-system, or component within the SSP model.

The generated SSV template contains all parameters that can be configured for the referenced scope (system or component), but without assigned values. This is useful for creating new parameter sets, preparing configuration files, or documenting the available tunable parameters in a model.

**Notes:**

- The exported SSV file contains parameter definitions but not their actual values.
- **The scope of the export depends on the provided *CRef***
  - Root system → exports all parameters for the entire SSP.
  - Sub-system → exports parameters for that sub-system and its components.
  - Component → exports only the parameters of the selected component.
- The output file is always written to the specified path; existing files will be overwritten.

**Syntax:**

```
exportSSVTemplate(cref, ssv_path)
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system, or component for which the SSV template should be generated.
- `ssv_path` (*str*): Path where the exported SSV template will be saved.

**Example usage**:

```
from OMSimulator import SSP, CRef

# Load an existing SSP model
model = SSP("exportSSVTemplate1.ssp")

# Export template for the entire SSP
model.exportSSVTemplate(CRef("default"), "exportSSVTemplate1.ssv")

# Export template for a sub-system
model.exportSSVTemplate(CRef("default", "sub-system"), "exportSSVTemplate2.
↪ssv")

# Export template for a single component (Add1)
model.exportSSVTemplate(CRef("default", "Add1"), "exportSSVTemplate3.ssv")

# Export template for another component (Add2)
model.exportSSVTemplate(CRef("default", "Add2"), "exportSSVTemplate4.ssv")
```

**Example usage with fmu component:**

```
from OMSimulator import FMU
fmu = FMU('../resources/Modelica.Blocks.Math.Add.fmu')
## export the start values in fmu to ssv template
fmu.exportSSVTemplate('startValuesSSVTemplate.ssv')
```

### 20.2.21 exportSSVTemplate

Exports a template SSM (System Structure Parameter mapping) file for a given system, sub-system, or component within the SSP model.

The generated SSM template contains all parameters that can be configured for the referenced scope (system or component), with source and target variables. The source attribute in ssm template will be empty and should be set by user to map to the desired variable in the SSV file. This is useful for creating new parameter mapping files, preparing configuration files.

**Notes:**

- The exported SSM file contains source and target definitions but source attribute will be empty.
- **The scope of the export depends on the provided *CRef***
  - Root system → exports all parameters for the entire SSP.
  - Sub-system → exports parameters for that sub-system and its components.
  - Component → exports only the parameters of the selected component.
- The output file is always written to the specified path; existing files will be overwritten.

**Syntax:**

```
exportSSMTemplate(cref, ssm_path)
```

**Parameters:**

- `cref` (*CRef*): Reference to a system, sub-system, or component for which the SSV template should be generated.
- `ssm_path` (*str*): Path where the exported SSV template will be saved.

**Example usage**:

```
from OMSimulator import SSP, CRef

# Load an existing SSP model
model = SSP("exportSSMTemplate1.ssp")

# Export template for the entire SSP
model.exportSSMTemplate(CRef("default"), "exportSSMTemplate1.ssm")

# Export template for a sub-system
model.exportSSMTemplate(CRef("default", "sub-system"), "exportSSMTemplate2.
↪ssm")

# Export template for a single component (Add1)
model.exportSSMTemplate(CRef("default", "Add1"), "exportSSMTemplate3.ssm")

# Export template for another component (Add2)
model.exportSSMTemplate(CRef("default", "Add2"), "exportSSMTemplate4.ssm")
```

**Example usage with fmu component**:

```
from OMSimulator import FMU
fmu = FMU('../resources/Modelica.Blocks.Math.Add.fmu')
## export the start values in fmu to ssv template
fmu.exportSSMTemplate('startValuesSSVTemplate.ssm')
```

### 20.2.22 setValue

Assigns a numerical value to a parameter of a component within the SSP model.

This method is used to directly set start values or parameter values of model variables defined in an FMU component. The values are stored in the SSP model and will be applied when the model is simulated or exported.

**Notes:**

- The parameter must exist in the referenced FMU/component or a top level system connectors; otherwise, an error will be raised.

- Values are stored at the SSP level and exported together with the model structure.
- Supported data types are numerical (`float`, `int`, `str`, `bool`).
- Special FMI-3.0 data types like `Float64`, `Float32`, `Int8`, `Int16`, `Int32`, `Int64`, `UInt8`, `UInt16`, `UInt32`, `UInt64` are handled via special classes in OMSimulator like `Float64`, `Int32`, etc. These classes can be imported from OMSimulator and used to set parameter values with specific fmi3 data types.
- Parameters can be set before or after instantation.

**Syntax:**

```
setValue(cref, value)
```

**Parameters:**

- `cref` (*CRef*): Reference to the parameter variable within a component. The `CRef` must specify the system, component, and parameter name (e.g., `CRef("default", "Add1", "k1")`).
- `value` (*float | int | str | bool | Float64 | Float32 | Int8 | Int16 | Int32 | Int64 | UInt8 | UInt16 | UInt32 | UInt64*): The value to assign to the parameter.

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Create a new SSP model
model = SSP()

# Add FMU resource
model.addResource("../resources/Modelica.Blocks.Math.Add.fmu", new_name="Add.fmu")

# Add two components
model.addComponent(CRef("default", "Add1"), "Add.fmu")
model.addComponent(CRef("default", "Add2"), "Add.fmu")

# Set parameter values for Add1
model.setValue(CRef("default", "Add1", "k1"), 2.0)
model.setValue(CRef("default", "Add1", "k2"), 3.0)

# Set parameter values for Add2
model.setValue(CRef("default", "Add2", "k1"), 100.0)
model.setValue(CRef("default", "Add2", "k2"), 300.0)

# Display model details
model.list()

# Export the SSP with parameter values applied
model.export("setValue2.ssp")
```

**Example of setting FMI-3.0 specific data types:**

```
from OMSimulator import SSP, CRef, Settings, Float64, Int32, UInt16, Float32, Int8,␣
↪Int16, Int64, UInt8, UInt32, UInt64

model = SSP()
model.addResource("../resources/Feedthrough3.fmu", new_name="resources/Feedthrough3.
↪fmu")
```

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```
model.addComponent(CRef("default", "Feedthrough1"), "resources/Feedthrough3.fmu")

model.setValue(CRef("default", "Feedthrough1", "Float64_continuous_input"), Float64(3.
↪5))
model.setValue(CRef("default", "Feedthrough1", "Int64_input"), Int64(7))
model.setValue(CRef("default", "Feedthrough1", "Float32_continuous_input"), Float32(1.
↪5))
model.setValue(CRef("default", "Feedthrough1", "Int8_input"), Int8(3))
model.setValue(CRef("default", "Feedthrough1", "Boolean_input"), True)

model.setValue(CRef("default", "Feedthrough1", "Float32_discrete_input"), Float32(2.
↪5))
model.setValue(CRef("default", "Feedthrough1", "Enumeration_input"), 2)

model.setValue(CRef("default", "Feedthrough1", "Int16_input"), Int16(1000))
model.setValue(CRef("default", "Feedthrough1", "UInt16_input"), UInt16(2000))
model.setValue(CRef("default", "Feedthrough1", "UInt32_input"), UInt32(3000))
model.setValue(CRef("default", "Feedthrough1", "UInt64_input"), UInt64(4000))
```

### 20.2.23 getValue

Retrieves the current value of a parameter or variable from a system, sub-system, or component within the SSP model.

This method is typically used to query parameter values that have been set using `setValue`, or to inspect default values provided by FMUs or the SSP model. It can be applied both before and after simulation, depending on whether the SSP has been instantiated and executed.

**Notes:**

- If called before instantiation, it will return the value stored in the SSP model (either default or set explicitly by the user).
- If called after instantation, it return the updated value depending on the FMU state.
- Works for system-level, sub-system, and component parameters.
- Returns a Python type corresponding to the variable type (`float` for Real, `int` for Integer, `bool` for Boolean, etc.).

**Syntax:**

```
getValue(cref) -> value
```

**Parameters:**

- `cref` (*CRef*): Reference to the parameter or variable whose value should be retrieved. For example, `CRef("default", "Add1", "k1")` refers to parameter `k1` of component `Add1`.

**Returns:**

- (*float* | *int* | *bool* | *str*): The current value of the requested parameter or variable.

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Load an existing SSP model
model = SSP("setValue2.ssp")
```

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```
# Retrieve values from top-level system parameter
print(f"info:    default.param1 : {model.getValue(CRef('default', 'param1'))}",␣
↪flush=True)

# Retrieve values from FMU components
print(f"info:    Add1.k1 : {model.getValue(CRef('default', 'Add1', 'k1'))}",␣
↪flush=True)
print(f"info:    Add2.k2 : {model.getValue(CRef('default', 'Add2', 'k2'))}",␣
↪flush=True)
```

### 20.2.24 mapParameter

Creates a parameter mapping between a connector and one or more parameters within the SSP model.

**Notes:**

- Parameter mapping enables hierarchical parameterization of systems and sub-systems.
- A single connector can be mapped to multiple parameters (fan-out mapping).
- Mappings can be stored inline or in the associated SSM (System Structure Mapping) file.

**Syntax:**

```
mapParameter(cref, connector, parameter)
```

**Parameters:**

- `cref` (*CRef*): Reference to the system, sub-system, or component where the mapping is applied. Typically, this is the root system (e.g., `CRef("default")`).
- `connector` (*str*): Name of the connector providing the source value.
- `parameter` (*str*): Name of the target parameter or input to be mapped to the connector.

**Example usage**:

```
from OMSimulator import SSP, CRef, Connector, Causality, SignalType

# Create a new SSP model
model = SSP()

# Add top-level system connectors
model.activeVariant.system.addConnector(Connector("param1", Causality.parameter,␣
↪SignalType.Real))
model.activeVariant.system.addConnector(Connector("param2", Causality.parameter,␣
↪SignalType.Real))
model.activeVariant.system.addConnector(Connector("param3", Causality.parameter,␣
↪SignalType.Real))
model.activeVariant.system.addConnector(Connector("input1", Causality.input,␣
↪SignalType.Real))
model.activeVariant.system.addConnector(Connector("input2", Causality.input,␣
↪SignalType.Real))

# Assign values to virtual connectors
model.setValue(CRef("default", "connector_param"), 2.0)
model.setValue(CRef("default", "connector_input"), 3.0)

# Map top-level parameters
model.mapParameter(CRef("default"), "connector_param", "param1")
model.mapParameter(CRef("default"), "connector_param", "param2")
```

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```
model.mapParameter(CRef("default"), "connector_param", "param3")

# Map inputs
model.mapParameter(CRef("default"), "connector_input", "input1")
model.mapParameter(CRef("default"), "connector_input", "input2")
```

### 20.2.25 duplicate and activate Variant

Creates a copy of an existing variant (SSD file) within an SSP model and assigns it a new name.

A variant in SSP represents a specific configuration of a system (stored as an SSD file). By duplicating a variant, users can create an alternative configuration without modifying the original one. This is particularly useful for scenario testing, parameter studies, or creating multiple versions of a system with different inputs, parameters, or components.

**Notes:**

- The duplicate is a *deep copy* of the variant — all systems, components, and parameter values are copied.
- The duplicate can be modified independently of the original (e.g., by adding components, changing parameter values).
- Duplicated variants must be explicitly added back to the model using `model.add(variant)`.
- The active variant of a model can be switched using `model.activeVariantName = "VariantName"`.

**Syntax:**

```
variant_copy = model.variants['Variant-Name'].duplicate(new_name)
```

**Parameters:**

- `new_name` (*str*): Name for the duplicated variant.

**Returns:**

- (*SSD*): A new `SSD` object representing the duplicated variant.

**Example usage**:

```
from OMSimulator import SSD, SSP, Settings, CRef

Settings.suppressPath = True

# Create a new SSP model with a default variant
model = SSP(temp_dir="./tmp-duplicateVariant2/")
model.addResource("../resources/Modelica.Blocks.Math.Add.fmu")
model.addComponent(CRef("default", "Add1"), "resources/Modelica.Blocks.Math.Add.fmu")

# Set parameter values in default variant
model.setValue(CRef("default", "Add1", "u1"), 10.0)
model.setValue(CRef("default", "Add1", "u2"), 20.0)
model.setValue(CRef("default", "Add1", "k1"), 30.0)

# Duplicate the default variant as "Variant-B"
variantB = model.variants["default"].duplicate("Variant-B")
model.add(variantB)

# Modify parameter values in Variant-B
```

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```
variantB.setValue(CRef("default", "Add1", "u1"), 100.0)
variantB.setValue(CRef("default", "Add1", "u2"), 200.0)

# Export SSP with both variants
model.export("duplicateVariant2.ssp")

# Load the model again and duplicate Variant-B as Variant-C
model2 = SSP("duplicateVariant2.ssp")
variantC = model2.variants["Variant-B"].duplicate("Variant-C")
model2.add(variantC)

# Modify Variant-C independently
variantC.setValue(CRef("default", "Add1", "u1"), -100.0)
variantC.addComponent(CRef("default", "Add2"), "resources/Modelica.Blocks.Math.Add.fmu
↪")

# Switch active variant to Variant-C
model2.activeVariantName = "Variant-C"

# Add new component only to Variant-C
model2.addComponent(CRef("default", "Add3"), "resources/Modelica.Blocks.Math.Add.fmu")
variantC.setValue(CRef("default", "Add3", "u1"), -200.0)
variantC.setValue(CRef("default", "Add3", "k1"), -30.0)

# Print the structure of the model
model2.list()
```

### 20.2.26 getVariant

Get the list of available variants for a given system or sub-system within the SSP model.

**Syntax:**

```
getVariant(cref : None | str) -> SSD | None
```

**Parameters:**

- `cref` : variant name (e.g) SystemStructure, VarA, VarB, if None is given then it will return the current active variant.

**Example usage**:

```
from OMSimulator import SSP, CRef

# Load an existing SSP model
model = SSP("exportSSMTemplate1.ssp")
## get list of available variants
model.getAllVariantNames()
## get current active variant
varA = model.getVariant("varA")
```

### 20.2.27 listResource

Lists all resource files stored in the `resources/` folder of the SSP model.

This method is useful for inspecting the files available in the model, including FMUs, SSV parameter files, SSM mapping files, and other artifacts. It provides a quick overview of which resources are packaged inside the SSP archive.

**Syntax:**

```
listResource() -> list[str]
```

**Returns:**

- (*list[str]*): A list of resource file paths contained in the SSP model.

**Example usage**:

```
model = SSP("deleteResources1.ssp")
model.list()

print("list of Resources in SSP:")
print("=========================")
print(model.listResource())
```

### 20.2.28 deleteResource

Removes a resource file from the `resources/` folder of the SSP model.

This method deletes the specified resource file from the model archive and updates the SSP structure accordingly. It is useful for cleaning up unused parameter sets, mapping files, or FMUs.

**Notes:**

- The file is physically removed from the SSP archive — it cannot be recovered unless re-added.
- If the resource is still referenced by components, connectors, or mappings, those references will become invalid and may cause errors.
- Can be used for any type of resource (e.g., FMU, SSV, SSM, or custom files).

**Syntax:**

```
deleteResource(resource_path)
```

**Parameters:**

- `resource_path` (*str*): Path to the resource file to be deleted, relative to the SSP `resources/` directory.

**Example usage**:

```
model = SSP("deleteResources1.ssp")
model.list()

# Delete a parameter set file
model.deleteResource("resources/delete3.ssv")
print("After deleting delete3.ssv:")
model.list()

# Delete another SSV file
model.deleteResource("resources/delete4.ssv")
print("After deleting delete4.ssv:")
model.list()

# Delete an FMU resource
model.deleteResource("resources/Add.fmu")
print("After deleting resources/Add.fmu:")
model.list()
```

### 20.2.29 delete

Deletes a connector, component, or subsystem from the SSP model.

This method removes the specified element from the model hierarchy. It can be used to: - Remove individual connectors (parameters or inputs/outputs) from a system or component. - Remove components from a subsystem or top-level system. - Remove entire subsystems, including all their child components and connectors.

**Notes:**

- Deleting a connector removes it from the system/component, but does not affect other connectors or components.
- Deleting a component removes all its connectors and any associated parameter values.
- Deleting a subsystem removes the subsystem and all nested components and connectors.
- Any SSV/SSM references pointing to deleted elements may become invalid.
- The operation modifies the active variant; other variants are unaffected unless explicitly modified.

**Syntax:**

```
delete(cref)
```

**Parameters:**

- **`cref` (*CRef*): Reference to the element to delete. Can point to a connector, component, or subsystem. Examples:**
  - Connector: `CRef("default", "param1")`
  - Component: `CRef("default", "Add1")`
  - Subsystem: `CRef("default", "sub-system")`

**Example usage**:

```
from OMSimulator import SSP, CRef

# Load an existing SSP model
model2 = SSP("deleteConnector1.ssp")

# Delete individual connectors
model2.delete(CRef("default", "param1"))
model2.delete(CRef("default", "sub-system", "input"))
model2.delete(CRef("default", "sub-system", "Add2", "u1"))
model2.delete(CRef("default", "Add1", "u1"))

print("## After deleting connectors:")
model2.list()

# Delete an entire component
model2.delete(CRef("default", "sub-system", "Add2"))
print("## After deleting component Add2 from sub-system:")
model2.list()
# Delete an entire sub-system
model2.delete(CRef('default', 'sub-system'))
print("## After deleting sub-system:")
model2.list()
# Delete the entire system
model2.delete(CRef('default'))
print("## After deleting full system:")
model2.list()
```

### 20.2.30 instantiate

Instantiates an SSP model for simulation by creating an internal runtime representation. After instantiation, users can modify parameter values on the instantiated model and specify the simulation result file before running the simulation.

**Notes:**

- All start values from SSV files and inline SSP `setValue` calls are applied initially.
- Values set via `setValue` on the instantiated model override the initial values.
- The instantiated model is independent of the SSP file on disk
- After instantiation, simulation methods such as `initialize()`, `simulate()`, `terminate()`, and `delete()` can be used.
- The instantiated model should be deleted using `delete()` to free resources after simulation.
- `setResultFile()` should be called before simulation to define the output file for logged results.

**Syntax:**

```
instantiated_model = model.instantiate() -> InstantiatedSSP
```

**Returns:**

- (*InstantiatedSSP*): A runtime object representing the SSP model, ready for simulation.

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

# import SSP
model2 = SSP("SimpleSimulation2.ssp")
model2.list()

# Instantiate the model for simulation
instantiated_model = model2.instantiate()  # Start values from SSV and inline␣
↪setValue are applied

# Set result file
instantiated_model.setResultFile("SimpleSimulation6_res.mat")

# Override parameter values at runtime
instantiated_model.setValue(CRef("default", "Gain1", "k"), 2.0)
instantiated_model.setValue(CRef("default", "Gain1", "u"), 6.0)
```

### 20.2.31 setResultFile

Specifies the file where simulation results of an instantiated SSP model will be stored.

**Notes:**

- The file path can be relative or absolute.
- Supported formats depend on the simulator backend (commonly .mat or .csv files).
- Must be called before *simulate()* to ensure proper logging of results.

**Syntax:**

```
setResultFile(file_path)
```

**Parameters:**

- `file_path` (*str*): Path to the simulation result file.

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Load SSP and instantiate model
model = SSP("SimpleSimulation2.ssp")
instantiated_model = model.instantiate()

# Specify the result file
instantiated_model.setResultFile("SimpleSimulation6_res.mat")
```

### 20.2.32 initialize

Initializes an instantiated SSP model and prepares it for simulation.

**Notes:**

- Must be called **after** *instantiate()* and **before** *simulate()*.
- Applies all parameter and connector start values at runtime.
- Performs consistency checks on component connections and initial conditions.
- Initializes all FMU components and sets the model to a "ready-to-simulate" state.
- Does not perform the actual simulation; only prepares the model for it.

**Syntax:**

```
initialize()
```

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Load SSP and instantiate model
model = SSP("SimpleSimulation2.ssp")
instantiated_model = model.instantiate()

# Apply result file and runtime parameters
instantiated_model.setResultFile("SimpleSimulation6_res.mat")
instantiated_model.setValue(CRef("default", "Gain1", "k"), 2.0)
instantiated_model.setValue(CRef("default", "Gain1", "u"), 6.0)

# Initialize the model before simulation
instantiated_model.initialize()
```

### 20.2.33 Solver

OMSimulator supports different solver methods depending on the FMI kind of the components in the system. Solvers are configured by name in the Simulation Setup dialog and assigned to individual FMU components.

### Available Solvers

#### Co-Simulation (CS) Solvers

Co-simulation solvers act as masters that drive the co-simulation protocol. They are used for FMUs that implement the co-simulation interface (CS FMUs).

| Method | Description |
|---|---|
| `oms_ma` | **Master Algorithm** — fixed-step co-simulation master. The step size is controlled by the `fixedStepSize` setting. |
| `oms_mav` | **Master Algorithm with Variable Step** — variable-step co-simulation master. Uses `initialStepSize`, `minimumStepSize`, and `maximumStepSize` to control the step size, and `relativeTolerance` for error control. |
| `oms_mav2` | **Master Algorithm with Variable Step (v2)** — an improved variable-step co-simulation master with enhanced error estimation. Supports the same settings as `oms_mav`. |

#### Model-Exchange (ME) Solvers

Model-exchange solvers are ODE integrators used for FMUs that implement the model-exchange interface (ME FMUs). They integrate the continuous-time equations provided by the FMU.

| Method | Description |
|---|---|
| `cvode` | **CVODE** — variable-step, variable-order ODE solver from the SUNDIALS suite. Suitable for stiff and non-stiff systems. Supports `initialStepSize`, `minimumStepSize`, `maximumStepSize`, and `relativeTolerance`. |
| `euler` | **Explicit Euler** — simple fixed-step explicit Euler integrator. Suitable for non-stiff systems. Controlled by `fixedStepSize`. |

### Solver Settings

The following settings can be configured for each named solver:

| Setting | Applies to | Description |
|---|---|---|
| `relativeTolerance` | `oms_mav`, `oms_mav2`, `cvode` | Relative error tolerance used for step-size control. |
| `fixedStepSize` | `oms_ma`, `euler` | The fixed communication / integration step size. |
| `initialStepSize` | `oms_mav`, `oms_mav2`, `cvode` | The initial step size at the start of simulation. |
| `minimumStepSize` | `oms_mav`, `oms_mav2`, `cvode` | The minimum allowed step size. |
| `maximumStepSize` | `oms_mav`, `oms_mav2`, `cvode` | The maximum allowed step size. |

### Solver Assignment

Each FMU component in a system can be assigned one named solver configuration. The available solvers are filtered based on the FMI kind of the component:

- **CS FMUs** — only co-simulation solvers (`oms_ma`, `oms_mav`, `oms_mav2`) are available.
- **ME FMUs** — only model-exchange solvers (`cvode`, `euler`) are available.
- **me+cs FMUs** — all solvers are available.

If no solver is assigned to a component, the system default `oms_ma` is applied.

**Example**

The following example creates two named solver configurations — one using the fixed-step Euler method and one using the variable-step CVODE solver — and assigns them to individual components.

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

model = SSP()

# Add FMU resources
model.addResource('../resources/Modelica.Blocks.Math.Add.fmu', new_name='resources/
↪Add.fmu')
model.addResource('../resources/Modelica.Blocks.Math.Gain.fmu', new_name='resources/
↪Gain.fmu')

# Instantiate components
model.addComponent(CRef('default', 'Add1'), 'resources/Add.fmu')
model.addComponent(CRef('default', 'Add2'), 'resources/Add.fmu')
model.addComponent(CRef('default', 'Gain1'), 'resources/Gain.fmu')
model.addComponent(CRef('default', 'Gain2'), 'resources/Gain.fmu')

# Define solver configurations
solver1 = {'name': 'solver1', 'method': 'euler', 'fixedStepSize': 1e-3}
model.newSolver(solver1)

solver2 = {'name': 'solver2', 'method': 'cvode', 'relativeTolerance': 1e-4,
           'initialStepSize': 1e-6, 'minimumStepSize': 1e-12, 'maximumStepSize': 0.
↪001}
model.newSolver(solver2)

# Assign solvers to components
model.setSolver(CRef('default', 'Add1'), 'solver1')
model.setSolver(CRef('default', 'Add2'), 'solver2')
model.setSolver(CRef('default', 'Gain1'), 'solver1')
model.setSolver(CRef('default', 'Gain2'), 'solver2')
```

### 20.2.34 simulate

Runs the simulation of an instantiated SSP model.

**Notes:**

- Must be called **after** *initialize()*.
- Simulation uses start values from SSV files and any parameters overridden via *setValue*.
- Logged results are saved in the format defined by `setResultFile()` (commonly .mat).
- Simulation is performed on the active variant of the SSP model.

**Syntax:**

```
simulate()
```

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Load SSP and instantiate model
```

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```
model = SSP("SimpleSimulation2.ssp")
instantiated_model = model.instantiate()

# Apply result file and runtime parameters
instantiated_model.setResultFile("SimpleSimulation6_res.mat")
instantiated_model.setValue(CRef("default", "Gain1", "k"), 2.0)
instantiated_model.setValue(CRef("default", "Gain1", "u"), 6.0)

# Initialize before simulation
instantiated_model.initialize()

# Run the simulation
instantiated_model.simulate()
```

### 20.2.35 terminate and delete

Terminates the simulation of an instantiated SSP model.It releases internal simulation resources, closes loggers, and ensures that the model state is marked as terminated.

**Syntax:**

```
terminate()
delete()
```

**Example usage**:

```
from OMSimulator import SSP, CRef, Settings

Settings.suppressPath = True

# Load SSP and instantiate model
model = SSP("SimpleSimulation2.ssp")
instantiated_model = model.instantiate()

# Apply result file and runtime parameters
instantiated_model.setResultFile("SimpleSimulation6_res.mat")
instantiated_model.setValue(CRef("default", "Gain1", "k"), 2.0)
instantiated_model.setValue(CRef("default", "Gain1", "u"), 6.0)

# Initialize and run simulation
instantiated_model.initialize()
instantiated_model.simulate()

# Terminate the simulation
instantiated_model.terminate()
# Clean up resources
instantiated_model.delete()
```

## 20.3 OpenModelicaScripting

This is a shared library that provides a OpenModelica Scripting interface for the OMSimulatorLib library.

### 20.3.1 Examples

```
loadOMSimulator();
oms_setTempDirectory("./temp/");
oms_newModel("model");
oms_addSystem("model.root", OpenModelica.Scripting.oms_system.oms_system_sc);

// instantiate FMUs
oms_addSubModel("model.root.system1", "FMUs/System1.fmu");
oms_addSubModel("model.root.system2", "FMUs/System2.fmu");

// add connections
oms_addConnection("model.root.system1.y", "model.root.system2.u");
oms_addConnection("model.root.system2.y", "model.root.system1.u");

// simulation settings
oms_setResultFile("model", "results.mat");
oms_setStopTime("model", 0.1);
oms_setFixedStepSize("model.root", 1e-4);

oms_instantiate("model");
oms_setReal("model.root.system1.x_start", 2.5);

oms_initialize("model");
oms_simulate("model");
oms_terminate("model");
oms_delete("model");
unloadOMSimulator();
```

### 20.3.2 OpenModelica Scripting Commands

### 20.3.3 addBus

Adds a bus to a given component.

```
status := oms_addBus(cref);
```

### 20.3.4 addConnection

Adds a new connection between connectors *A* and *B*. The connectors need to be specified as fully qualified component references, e.g., *"model.system.component.signal"*.

```
status := oms_addConnection(crefA, crefB, suppressUnitConversion);
```

The two arguments *crefA* and *crefB* get swapped automatically if necessary. The third argument suppressUnitConversion is optional and the default value is *false* which allows automatic unit conversion between connections, if set to *true* then automatic unit conversion will be disabled.

### 20.3.5 addConnector

Adds a connector to a given component.

```
status := oms_addConnector(cref, causality, type);

The second argument "causality", should be any of the following,

"OpenModelica.Scripting.oms_causality.oms_causality_input"
"OpenModelica.Scripting.oms_causality.oms_causality_output"
```

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```
"OpenModelica.Scripting.oms_causality.oms_causality_parameter"
"OpenModelica.Scripting.oms_causality.oms_causality_bidir"
"OpenModelica.Scripting.oms_causality.oms_causality_undefined"

The third argument type, should be any of the following,

"OpenModelica.Scripting.oms_signal_type.oms_signal_type_real"
"OpenModelica.Scripting.oms_signal_type.oms_signal_type_integer"
"OpenModelica.Scripting.oms_signal_type.oms_signal_type_boolean"
"OpenModelica.Scripting.oms_signal_type.oms_signal_type_string"
"OpenModelica.Scripting.oms_signal_type.oms_signal_type_enum"
"OpenModelica.Scripting.oms_signal_type.oms_signal_type_bus"
```

### 20.3.6 addConnectorToBus

Adds a connector to a bus.

```
status := oms_addConnectorToBus(busCref, connectorCref);
```

### 20.3.7 addSignalsToResults

Add all variables that match the given regex to the result file.

```
status := oms_addSignalsToResults(cref, regex);
```

The second argument, i.e. regex, is considered as a regular expression (C++11). *".*"* and *"(.)*"* can be used to hit all variables.

### 20.3.8 addSubModel

Adds a component to a system.

```
status := oms_addSubModel(cref, fmuPath);
```

### 20.3.9 addSystem

Adds a (sub-)system to a model or system.

```
status := oms_addSystem(cref, type);

The second argument type, should be any of the following,

"OpenModelica.Scripting.oms_system.oms_system_none"
"OpenModelica.Scripting.oms_system.oms_system_wc"
"OpenModelica.Scripting.oms_system.oms_system_sc"
```

### 20.3.10 compareSimulationResults

This function compares a given signal of two result files within absolute and relative tolerances.

```
status := oms_compareSimulationResults(filenameA, filenameB, var, relTol, absTol);
```

The following table describes the input values:

| Input | Type | Description |
|---|---|---|
| filenameA | String | Name of first result file to compare. |
| filenameB | String | Name of second result file to compare. |
| var | String | Name of signal to compare. |
| relTol | Number | Relative tolerance. |
| absTol | Number | Absolute tolerance. |

The following table describes the return values:

| Type | Description |
|---|---|
| Integer | 1 if the signal is considered as equal, 0 otherwise |

### 20.3.11 copySystem

Copies a system.

```
status := oms_copySystem(source, target);
```

### 20.3.12 delete

Deletes a connector, component, system, or model object.

```
status := oms_delete(cref);
```

### 20.3.13 deleteConnection

Deletes the connection between connectors *crefA* and *crefB*.

```
status := oms_deleteConnection(crefA, crefB);
```

The two arguments *crefA* and *crefB* get swapped automatically if necessary.

### 20.3.14 deleteConnectorFromBus

Deletes a connector from a given bus.

```
status := oms_deleteConnectorFromBus(busCref, connectorCref);
```

### 20.3.15 export

Exports a composite model to a SPP file.

```
status := oms_export(cref, filename);
```

### 20.3.16 exportDependencyGraphs

Export the dependency graphs of a given model to dot files.

```
status := oms_exportDependencyGraphs(cref, initialization, event, simulation);
```

### 20.3.17 exportSnapshot

Lists the SSD representation of a given model, system, or component.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
(contents, status) := oms_exportSnapshot(cref);
```

### 20.3.18 freeMemory

Free the memory allocated by some other API. Pass the object for which memory is allocated.

This function is not needed for OpenModelicaScripting Interface

### 20.3.19 getBoolean

Get boolean value of given signal.

```
(value, status) := oms_getBoolean(cref);
```

### 20.3.20 getFixedStepSize

Gets the fixed step size. Can be used for the communication step size of co-simulation systems and also for the integrator step size in model exchange systems.

```
(stepSize, status) := oms_getFixedStepSize(cref);
```

### 20.3.21 getInteger

Get integer value of given signal.

```
(value, status) := oms_getInteger(cref);
```

### 20.3.22 getModelState

Gets the model state of the given model cref.

```
(modelState, status) := oms_getModelState(cref);
```

### 20.3.23 getReal

Get real value.

```
(value, status) := oms_getReal(cref);
```

### 20.3.24 getSolver

Gets the selected solver method of the given system.

```
(solver, status) := oms_getSolver(cref);
```

### 20.3.25 getStartTime

Get the start time from the model.

```
(startTime, status) := oms_getStartTime(cref);
```

### 20.3.26 getStopTime

Get the stop time from the model.

```
(stopTime, status) := oms_getStopTime(cref);
```

### 20.3.27 getSubModelPath

Returns the path of a given component.

```
(path, status) := oms_getSubModelPath(cref);
```

### 20.3.28 getSystemType

Gets the type of the given system.

```
(type, status) := oms_getSystemType(cref);
```

### 20.3.29 getTime

Get the current simulation time from the model.

```
(time, status) := oms_getTime(cref);
```

### 20.3.30 getTolerance

Gets the tolerance of a given system or component.

```
(relativeTolerance, status) := oms_getTolerance(cref);
```

### 20.3.31 getVariableStepSize

Gets the step size parameters.

```
(initialStepSize, minimumStepSize, maximumStepSize, status) := oms_
↪getVariableStepSize(cref);
```

### 20.3.32 getVersion

Returns the library's version string.

```
version := oms_getVersion();
```

### 20.3.33 importFile

Imports a composite model from a SSP file.

```
(cref, status) := oms_importFile(filename);
```

### 20.3.34 importSnapshot

Loads a snapshot to restore a previous model state. The model must be in virgin model state, which means it must not be instantiated.

```
status := oms_importSnapshot(cref, snapshot);
```

### 20.3.35 initialize

Initializes a composite model.

```
status := oms_initialize(cref);
```

### 20.3.36 instantiate

Instantiates a given composite model.

```
status := oms_instantiate(cref);
```

### 20.3.37 list

Lists the SSD representation of a given model, system, or component.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
(contents, status) := oms_list(cref);
```

### 20.3.38 listUnconnectedConnectors

Lists all unconnected connectors of a given system.

Memory is allocated for *contents*. The caller is responsible to free it using the C-API. The Lua and Python bindings take care of the memory and the caller doesn't need to call free.

```
(contents, status) := oms_listUnconnectedConnectors(cref);
```

### 20.3.39 loadSnapshot

Loads a snapshot to restore a previous model state. The model must be in virgin model state, which means it must not be instantiated.

```
status := oms_loadSnapshot(cref, snapshot);
```

### 20.3.40 newModel

Creates a new and yet empty composite model.

```
status := oms_newModel(cref);
```

### 20.3.41 removeSignalsFromResults

Removes all variables that match the given regex to the result file.

```
status := oms_removeSignalsFromResults(cref, regex);
```

The second argument, i.e. regex, is considered as a regular expression (C++11). *".*"* and *"(.)*"* can be used to hit all variables.

### 20.3.42 rename

Renames a model, system, or component.

```
status := oms_rename(cref, newCref);
```

### 20.3.43 reset

Reset the composite model after a simulation run.

The FMUs go into the same state as after instantiation.

```
status := oms_reset(cref);
```

### 20.3.44 setBoolean

Sets the value of a given boolean signal.

```
status := oms_setBoolean(cref, value);
```

### 20.3.45 setCommandLineOption

Sets special flags.

```
status := oms_setCommandLineOption(cmd);
```

### 20.3.46 setFixedStepSize

Sets the fixed step size. Can be used for the communication step size of co-simulation systems and also for the integrator step size in model exchange systems.

```
status := oms_setFixedStepSize(cref, stepSize);
```

### 20.3.47 setInteger

Sets the value of a given integer signal.

```
status := oms_setInteger(cref, value);
```

### 20.3.48 setLogFile

Redirects logging output to file or std streams. The warning/error counters are reset.

filename="" to redirect to std streams and proper filename to redirect to file.

```
status := oms_setLogFile(filename);
```

### 20.3.49 setLoggingInterval

Set the logging interval of the simulation.

```
status := oms_setLoggingInterval(cref, loggingInterval);
```

### 20.3.50 setLoggingLevel

Enables/Disables debug logging (logDebug and logTrace).

0 default, 1 default+debug, 2 default+debug+trace

```
oms_setLoggingLevel(logLevel);
```

### 20.3.51 setReal

Sets the value of a given real signal.

```
status := oms_setReal(cref, value);
```

This function can be called in different model states:

- Before instantiation: *setReal* can be used to set start values or to define initial unknowns (e.g. parameters, states). The values are not immediately applied to the simulation unit, since it isn't actually instantiated.
- After instantiation and before initialization: Same as before instantiation, but the values are applied immediately to the simulation unit.
- After initialization: Can be used to force external inputs, which might cause discrete changes of continuous signals.

### 20.3.52 setRealInputDerivative

Sets the first order derivative of a real input signal.

This can only be used for CS-FMU real input signals.

```
status := oms_setRealInputDerivative(cref, value);
```

### 20.3.53 setResultFile

Set the result file of the simulation.

```
status := oms_setResultFile(cref, filename);
status := oms_setResultFile(cref, filename, bufferSize);
```

The creation of a result file is omitted if the filename is an empty string.

### 20.3.54 setSolver

Sets the solver method for the given system.

```
status := oms_setSolver(cref, solver);

The second argument "solver" should be any of the following,

"OpenModelica.Scripting.oms_solver.oms_solver_none"
"OpenModelica.Scripting.oms_solver.oms_solver_sc_min"
"OpenModelica.Scripting.oms_solver.oms_solver_sc_explicit_euler"
"OpenModelica.Scripting.oms_solver.oms_solver_sc_cvode"
"OpenModelica.Scripting.oms_solver.oms_solver_sc_max"
"OpenModelica.Scripting.oms_solver.oms_solver_wc_min"
"OpenModelica.Scripting.oms_solver.oms_solver_wc_ma"
"OpenModelica.Scripting.oms_solver.oms_solver_wc_mav"
"OpenModelica.Scripting.oms_solver.oms_solver_wc_mav2"
"OpenModelica.Scripting.oms_solver.oms_solver_wc_max"
```

### 20.3.55 setStartTime

Set the start time of the simulation.

```
status := oms_setStartTime(cref, startTime);
```

### 20.3.56 setStopTime

Set the stop time of the simulation.

```
status := oms_setStopTime(cref, stopTime);
```

### 20.3.57 setTempDirectory

Set new temp directory.

```
status := oms_setTempDirectory(newTempDir);
```

### 20.3.58 setTolerance

Sets the tolerance for a given model or system.

```
status := oms_setTolerance(const char* cref, double relativeTolerance);
```

Default values are *1e-4* for both relative and absolute tolerances.

A tolerance specified for a model is automatically applied to its root system, i.e. both calls do exactly the same:

```
oms_setTolerance("model", relativeTolerance);
oms_setTolerance("model.root", relativeTolerance);
```

Component, e.g. FMUs, pick up the tolerances from there system. That means it is not possible to define different tolerances for FMUs in the same system right now.

In a strongly coupled system (*oms_system_sc*), the relative tolerance is used for CVODE and the absolute tolerance is used to solve algebraic loops.

In a weakly coupled system (*oms_system_wc*), both the relative and absolute tolerances are used for the adaptive step master algorithms and the absolute tolerance is used to solve algebraic loops.

### 20.3.59 setVariableStepSize

Sets the step size parameters for methods with stepsize control.

```
status := oms_getVariableStepSize(cref, initialStepSize, minimumStepSize,␣
↪maximumStepSize);
```

### 20.3.60 setWorkingDirectory

Set a new working directory.

```
status := oms_setWorkingDirectory(newWorkingDir);
```

### 20.3.61 simulate

Simulates a composite model.

```
status := oms_simulate(cref);
```

### 20.3.62 stepUntil

Simulates a composite model until a given time value.

```
status := oms_stepUntil(cref, stopTime);
```

### 20.3.63 terminate

Terminates a given composite model.

```
status := oms_terminate(cref);
```

## 20.4 OMEdit

OMSimulator provides a graphical modelling environment through OMEdit, the OpenModelica Connection Editor. This feature requires a full OpenModelica installation that includes OMSimulator.

Composite models are imported and exported in the System Structure Description (SSD) format, which is part of the System Structure and Parameterization (SSP) standard.

See also FMI documentation and SSP documentation.

### 20.4.1 Architecture

OMEdit communicates with OMSimulator through a Python-based ZMQ server:

- **OMSimulatorGuiServer.py** — handles all GUI-driven requests (model management, element queries, solver settings, connections, etc.)
- **OMSimulatorSimulationServer.py** — handles simulation execution and result streaming

The GUI server is started automatically when the first SSP model is opened or created. A notification in the Messages Browser confirms the server is running, including the script path and ZMQ endpoint.

### 20.4.2 New SSP Model

A new and empty SSP model can be created from `File -> New -> SSP` menu item.

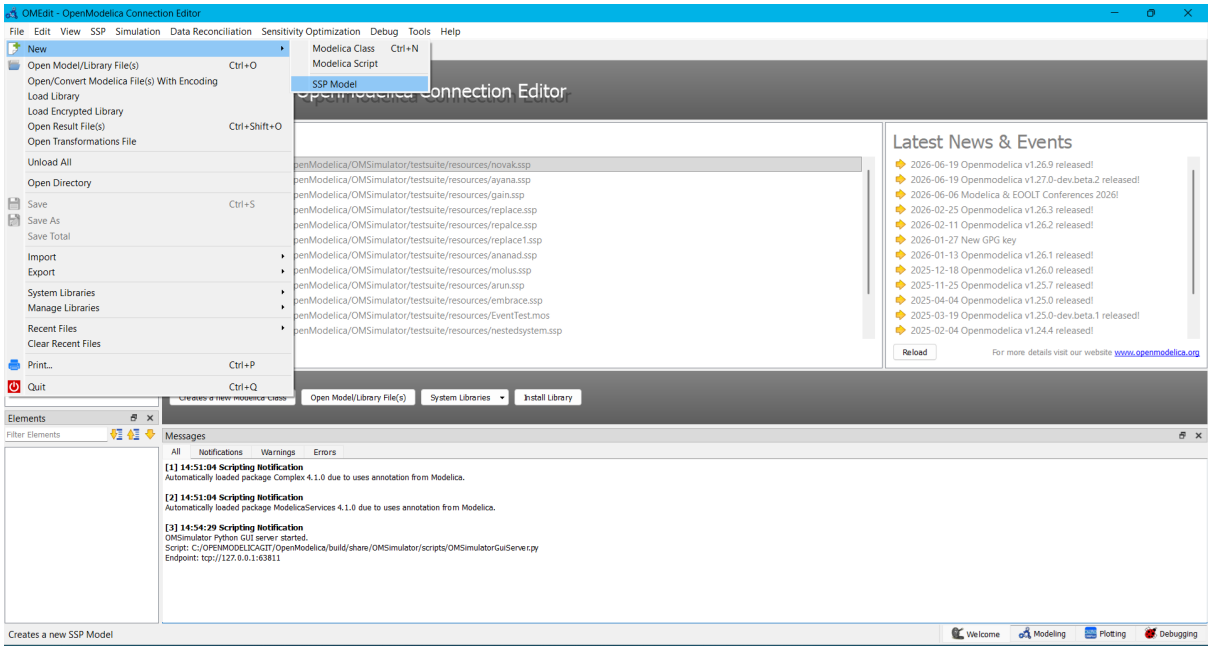



Figure 20.1: OMEdit: New SSP Model

A dialog opens to enter the model name and the name of the root system.

### 20.4.3 Open SSP Model

An existing SSP file (`.ssp`) can be opened from `File -> Open Model/Library`. If a model with the same name is already loaded, an error is reported and the file is not loaded again.

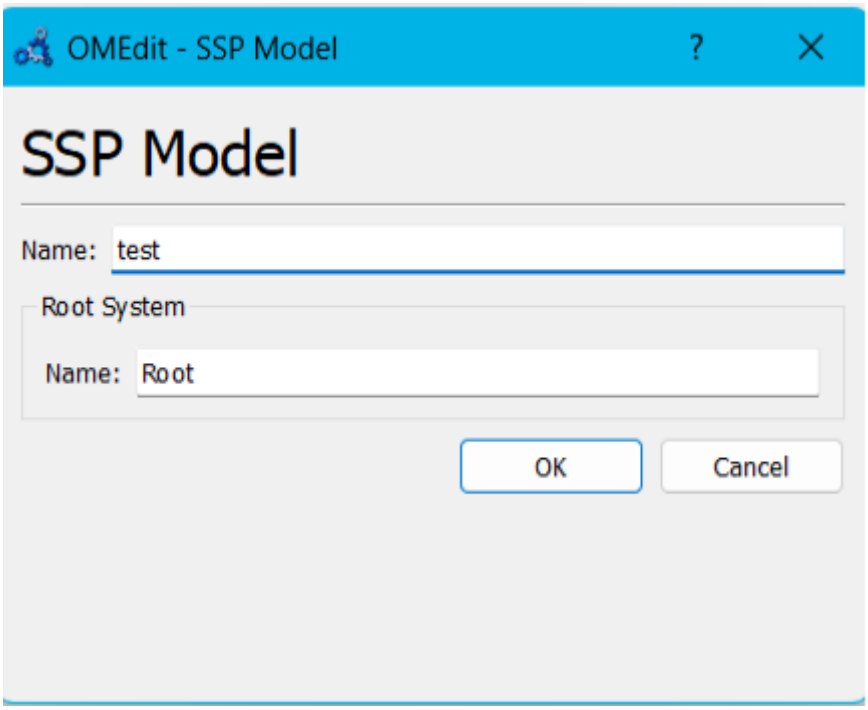



Figure 20.2: OMEdit: New SSP Model Dialog

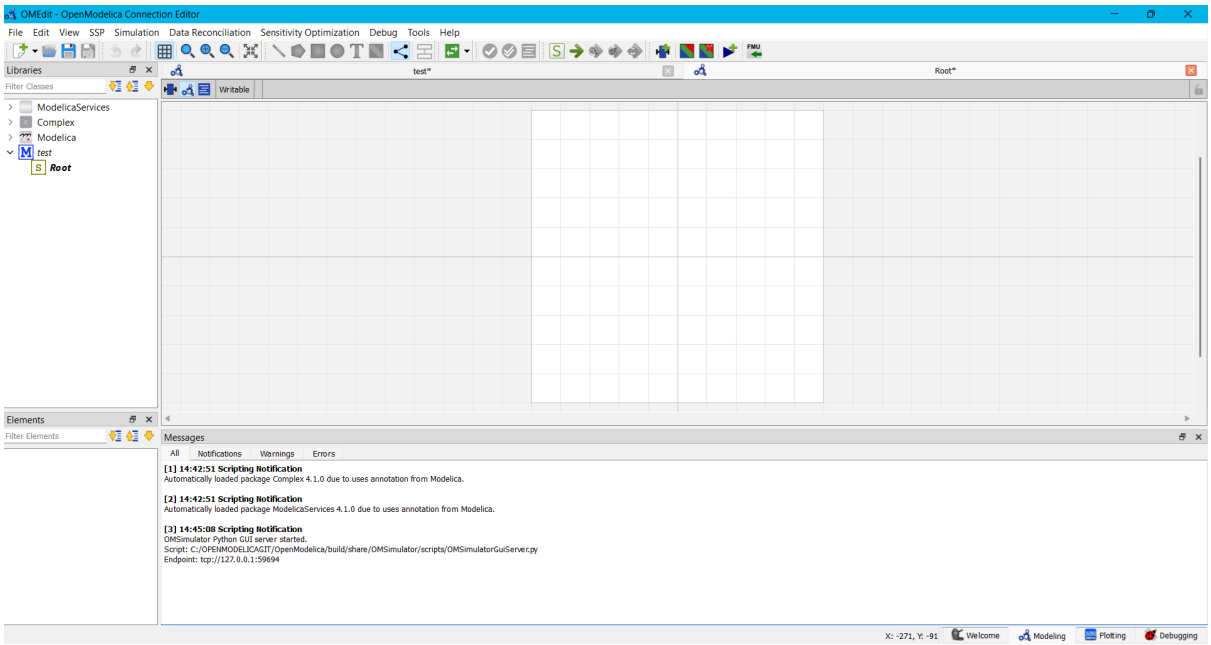



Figure 20.3: OMEdit: Newly created empty root system of SSP model

### 20.4.4 Add System and Sub-Systems

A root system is always created together with the model. Additional subsystems can be added inside the root system via `SSP -> Add System`.

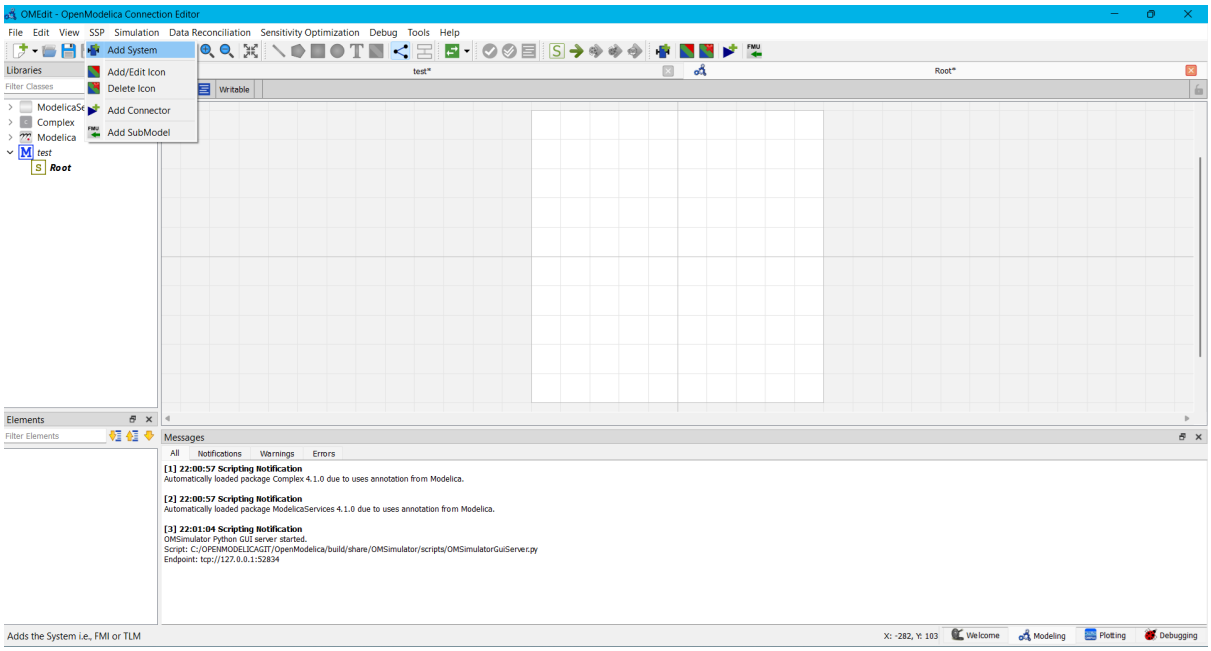



Figure 20.4: OMEdit: Add System

A dialog opens to enter the name of the new system.

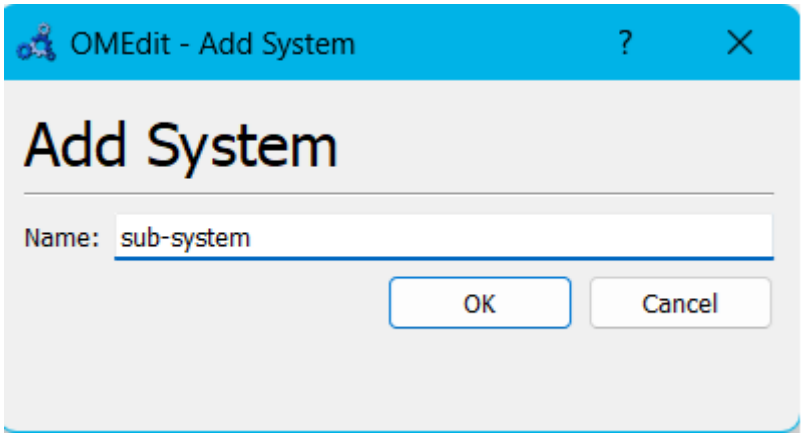



Figure 20.5: OMEdit: Add System Dialog

### 20.4.5 Add SubModel

A sub-model is typically an FMU, but it can also be a result file (CSV). To add a sub-model, select the target system in the Libraries Browser and choose `SSP -> Add SubModel`.

A file browser opens to select an FMU (`.fmu`) or result file (`.csv`). A dialog then opens to set the name for the new sub-model.

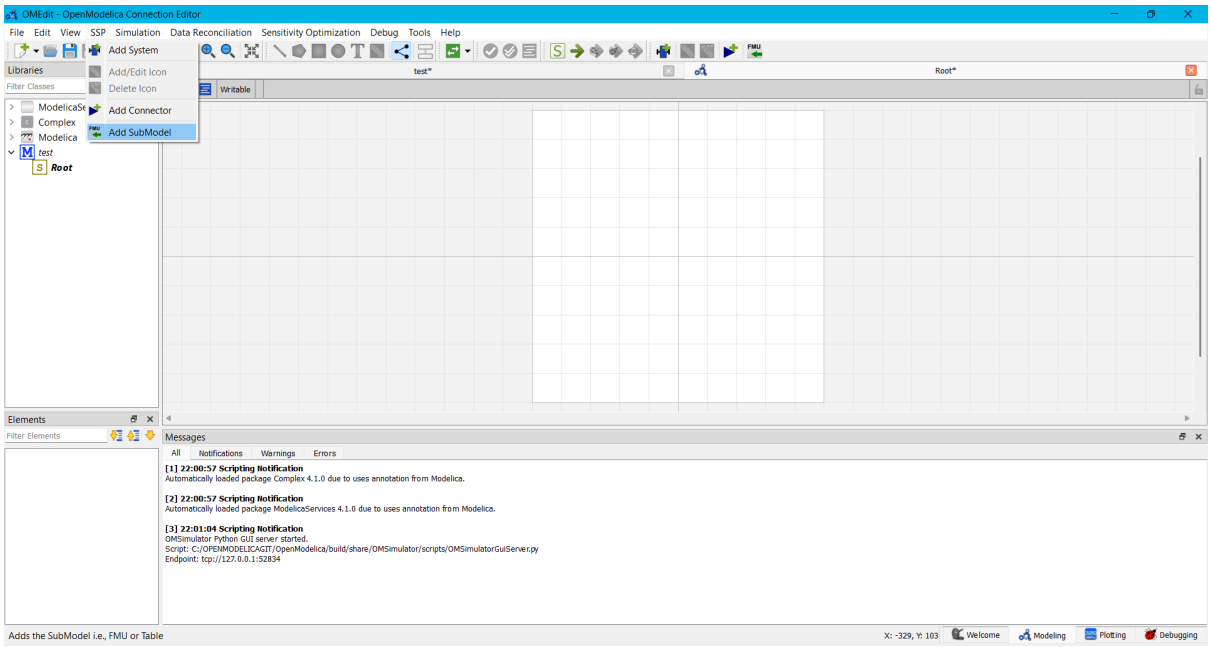



Figure 20.6: OMEdit: Add SubModel

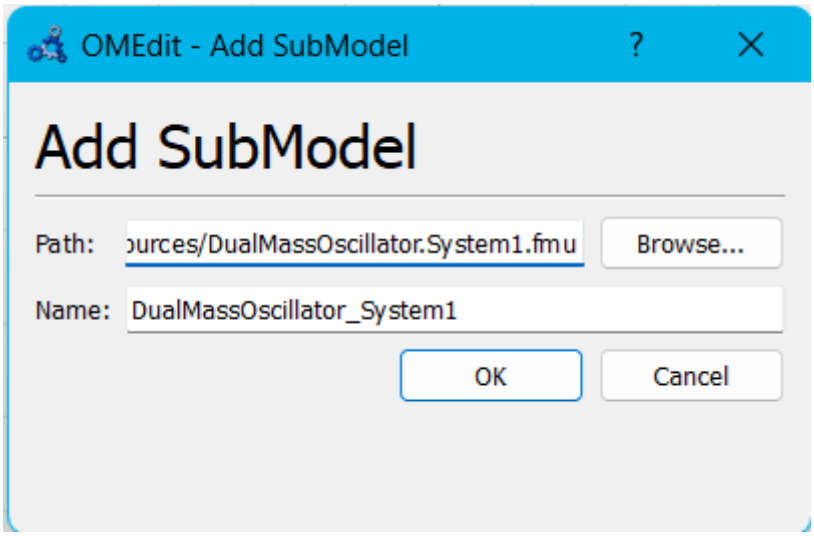



Figure 20.7: OMEdit: Add SubModel Dialog

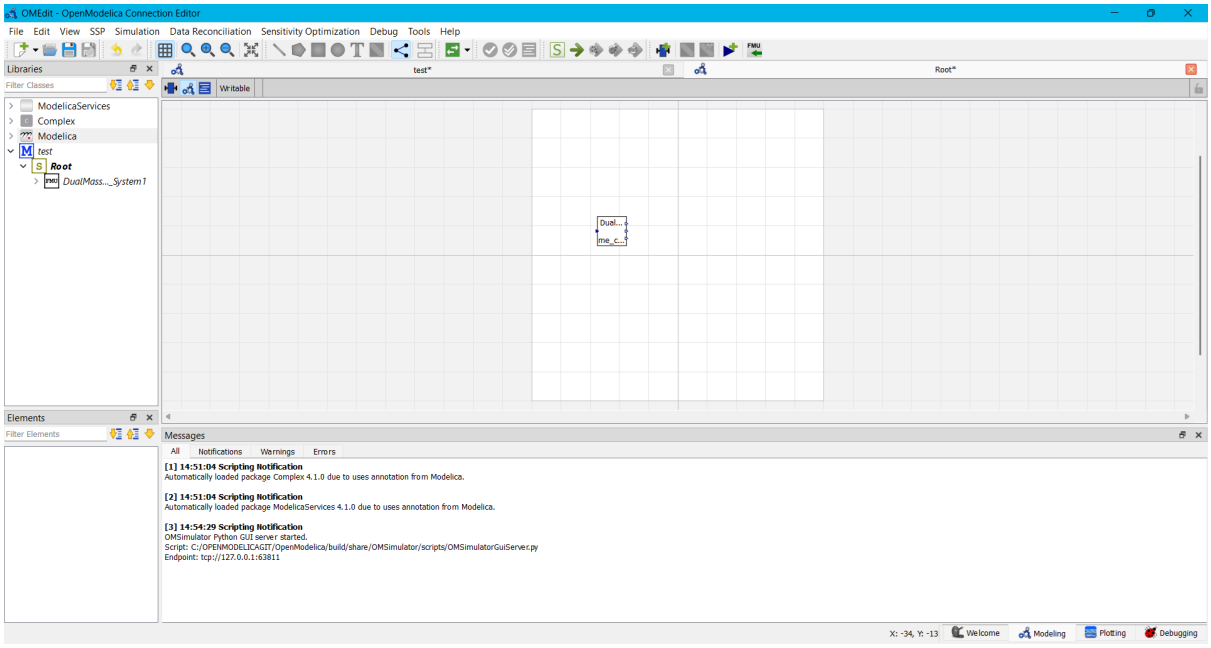



Figure 20.8: OMEdit: Root system with added FMU.

### 20.4.6 Replace SubModel

An existing sub-model can be replaced with a different FMU by right-clicking on the component in the diagram view and selecting `Replace SubModel` from the context menu.

A file browser opens to select the new FMU. The replacement is performed in two steps:

1. **Dry run** (`dryRun=true`) — OMEdit first performs a dry run without making any changes to the model. It checks for interface differences between the old and new FMU, such as added, removed, or modified connectors and parameters. If any changes are detected, they are reported in the Messages Browser and a warning dialog is shown. The model remains unchanged at this stage, allowing the user to review the impact before deciding to proceed.
2. **Replacement** (`dryRun=false`) — If the user confirms, the replacement is carried out and all detected interface changes are applied to the model. Existing connections to removed or renamed connectors are dropped, and new connectors are available for connecting.

### 20.4.7 Simulation Setup

Select `Simulation -> Simulation Setup` to configure simulation parameters before running. The dialog has two tabs: **General** and **Solver Settings**.

The **General** tab covers start time, stop time, and result file settings.

The **Solver Settings** tab is divided into two parts:

**Solver Configurations**

This table lists the named solver configurations available in the model. Each configuration has a name and a method. Click **Add** to create a new solver configuration — a new row appears in the table with a default method of `oms-ma`. The method can be changed using the combo box in the Method column.

To fine-tune a solver's numerical parameters, select the row and click **Edit**. This opens the Solver Settings dialog:

The available fields depend on the solver method:

- **Fixed-step solvers** (`oms-ma`, `euler`) — Fixed Step Size is editable; Initial Step Size, Minimum Step Size, and Maximum Step Size are disabled.

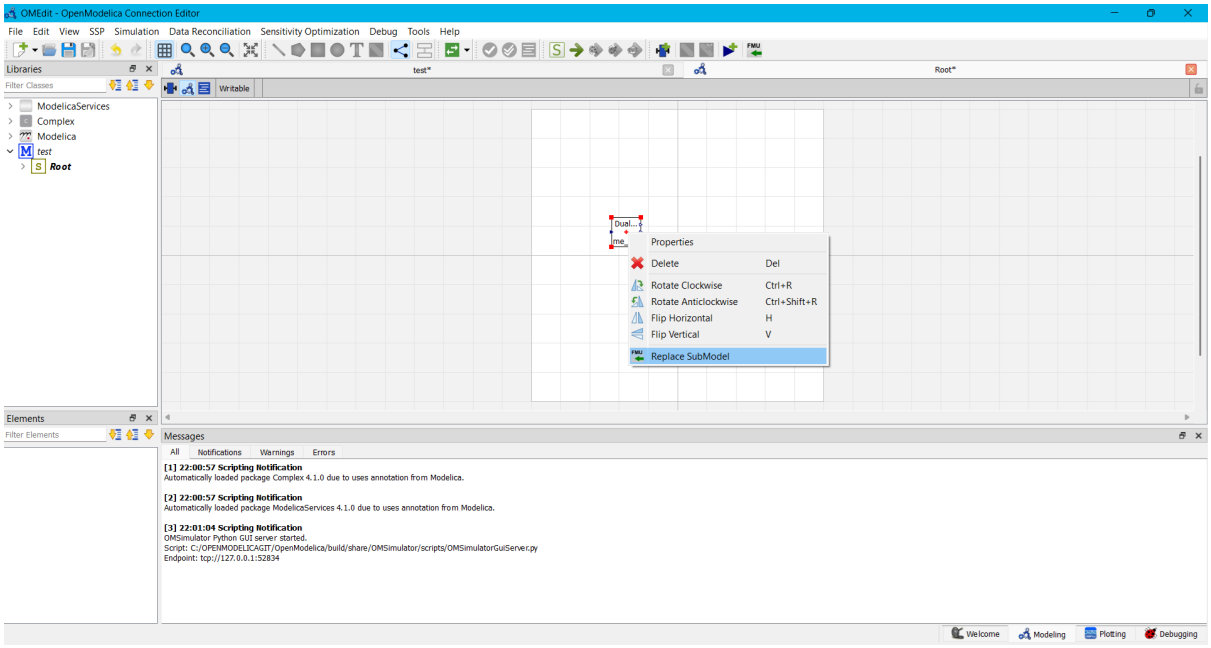



Figure 20.9: OMEdit: Replace SubModel Dialog.

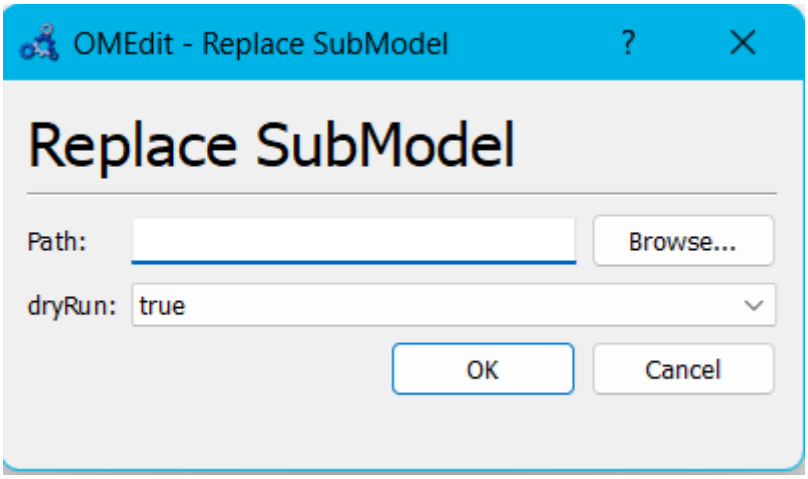



Figure 20.10: OMEdit: Replace SubModel context menu.

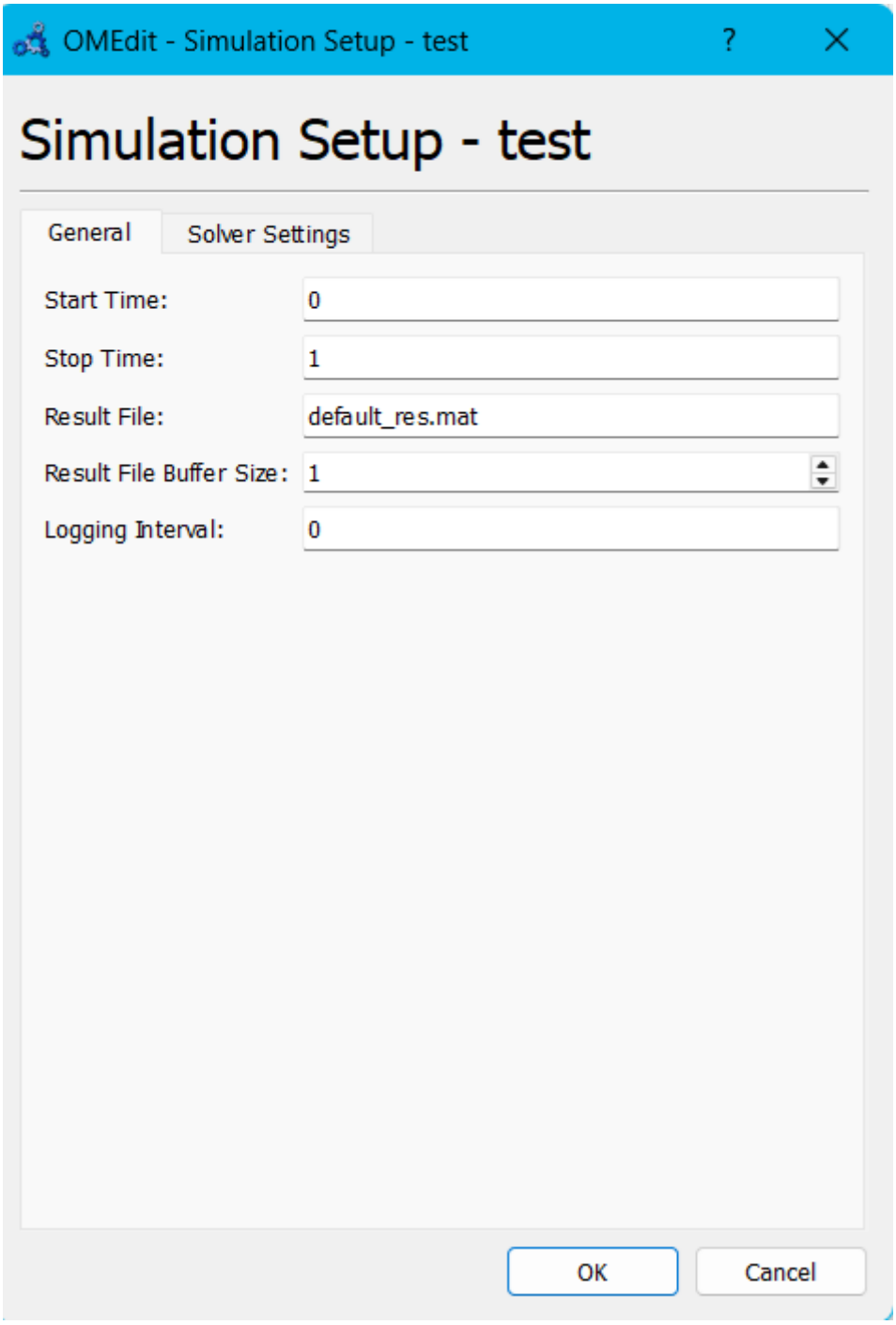



Figure 20.11: OMEdit: Simulation Setup — Solver Settings tab with a solver configuration.

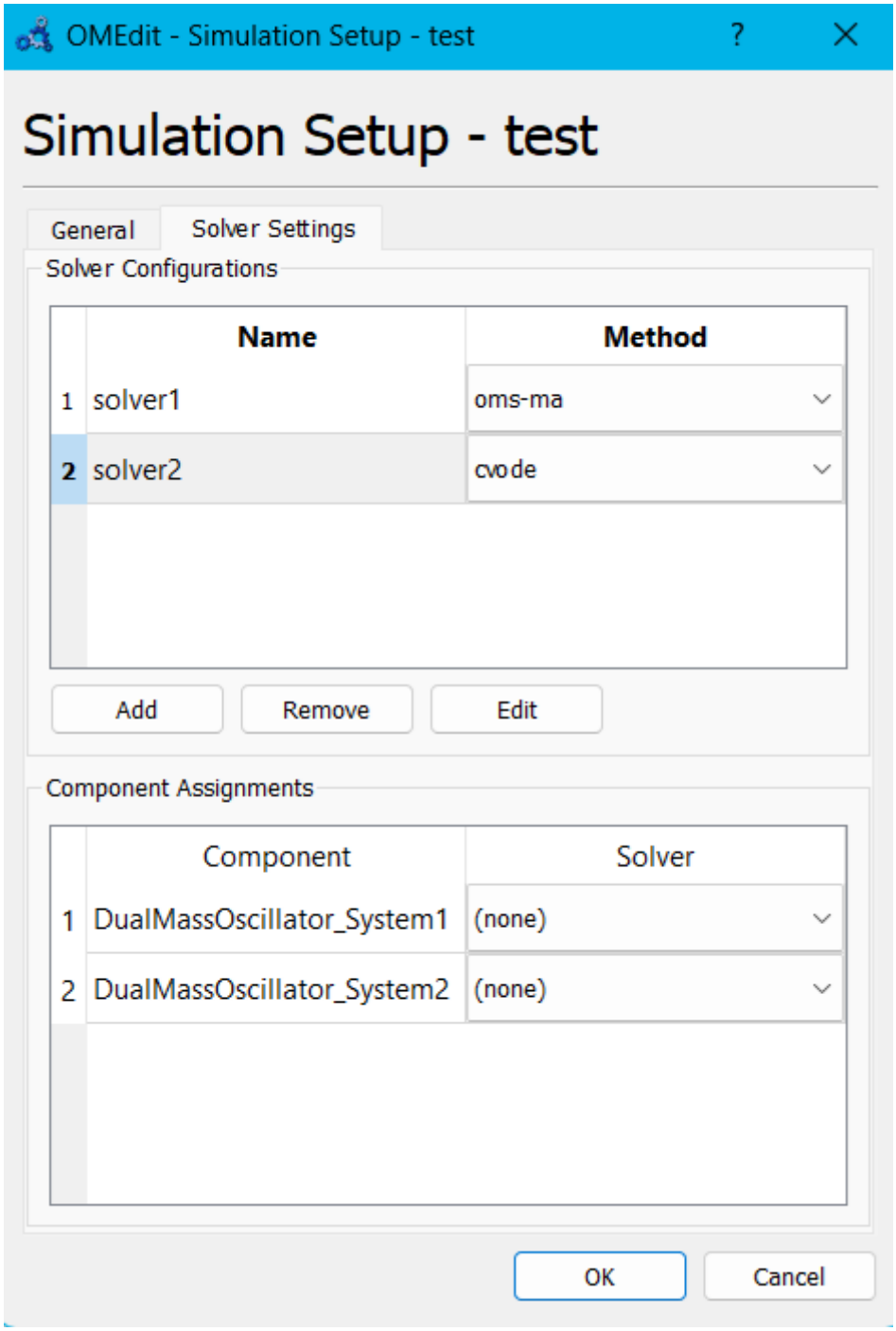



Figure 20.12: OMEdit: Simulation Setup — Solver Settings tab with a solver configuration.

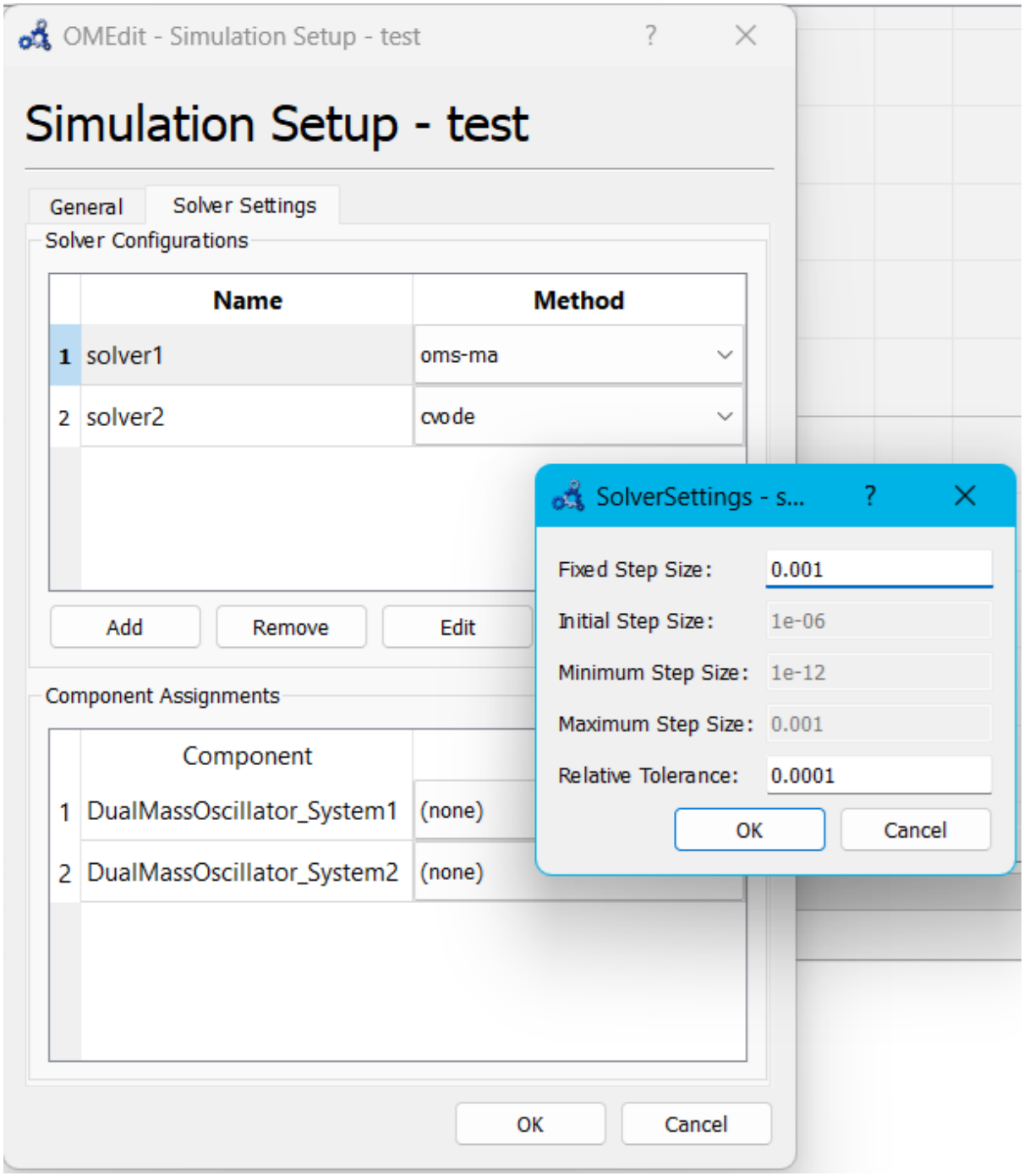



Figure 20.13: OMEdit: Solver Settings dialog.

- **Variable-step solvers** (`oms-mav`, `oms-mav-2`, `cvode`) — Initial Step Size, Minimum Step Size, Maximum Step Size, and Relative Tolerance are editable; Fixed Step Size is disabled.

Click **Remove** to delete the selected solver configuration.

**Component Assignments**

This table lists all FMU components in the model. Each component can be assigned one of the named solver configurations using the combo box in the Solver column. The available solvers are filtered by the FMI kind of each component:

- **Co-Simulation FMUs** — only co-simulation masters are selectable (`oms-ma`, `oms-mav`, `oms-mav-2`).
- **Model-Exchange FMUs** — only ODE integrators are selectable (`cvode`, `euler`).
- **me+cs FMUs** — all solvers are available.

Incompatible solvers are shown as disabled in the combo box with a tooltip explaining why. If no solver is assigned, `(none)` is used and the system default applies.

### 20.4.8 Simulate

Select the simulate button (green arrow) or `Simulation -> Simulate` to run the SSP model. Results are streamed back in real time via the simulation server.

### 20.4.9 Dual Mass Oscillator Example

The dual mass oscillator example from the test suite demonstrates a typical SSP workflow. The model is split into two sub-models, each exported as an FMU, and then connected in an SSP.

## 20.5 OMSimulatorGui

OMSimulatorGui is a lightweight, standalone graphical editor for SSP models, built directly on top of the OMSimulator Python API (*OMSimulatorPython3*). Unlike *OMEdit*, it has no dependency on omc or the rest of the OpenModelica compiler -- it only needs a plain OMSimulator installation with a couple of Python GUI packages on top, and it calls the same in-process Python API used by scripts, with no server process or ZMQ layer in between for editing.

It covers the everyday SSP editing workflow: building up a system structure with subsystems, FMU components and connectors, wiring them together on a diagram canvas, attaching parameter values and mappings (SSV/SSM), configuring solvers, and running a simulation with live progress and a result plot. It does not (yet) include a read-only XML/text viewer for the underlying SSD/SSV/SSM files -- see *Current Limitations* below.

### 20.5.1 Requirements and Enabling the Build

OMSimulatorGui is installed together with OMSimulator:

```
cmake -S . -B build
cmake --build build --target install
```

It has no compiled component -- it is pure Python, installed alongside the `OMSimulator` Python package -- but it does need a couple of extra Python packages that the core OMSimulator CLI/API does not require:

- PySide6 -- the Qt widgets, the system tree, and the diagram canvas.
- pyqtgraph -- the result plot.
- scipy -- reading `.mat` result files.

Install them into whichever Python environment OMSimulator itself runs under:

```
pip install -r src/OMSimulatorGui/requirements.txt
```

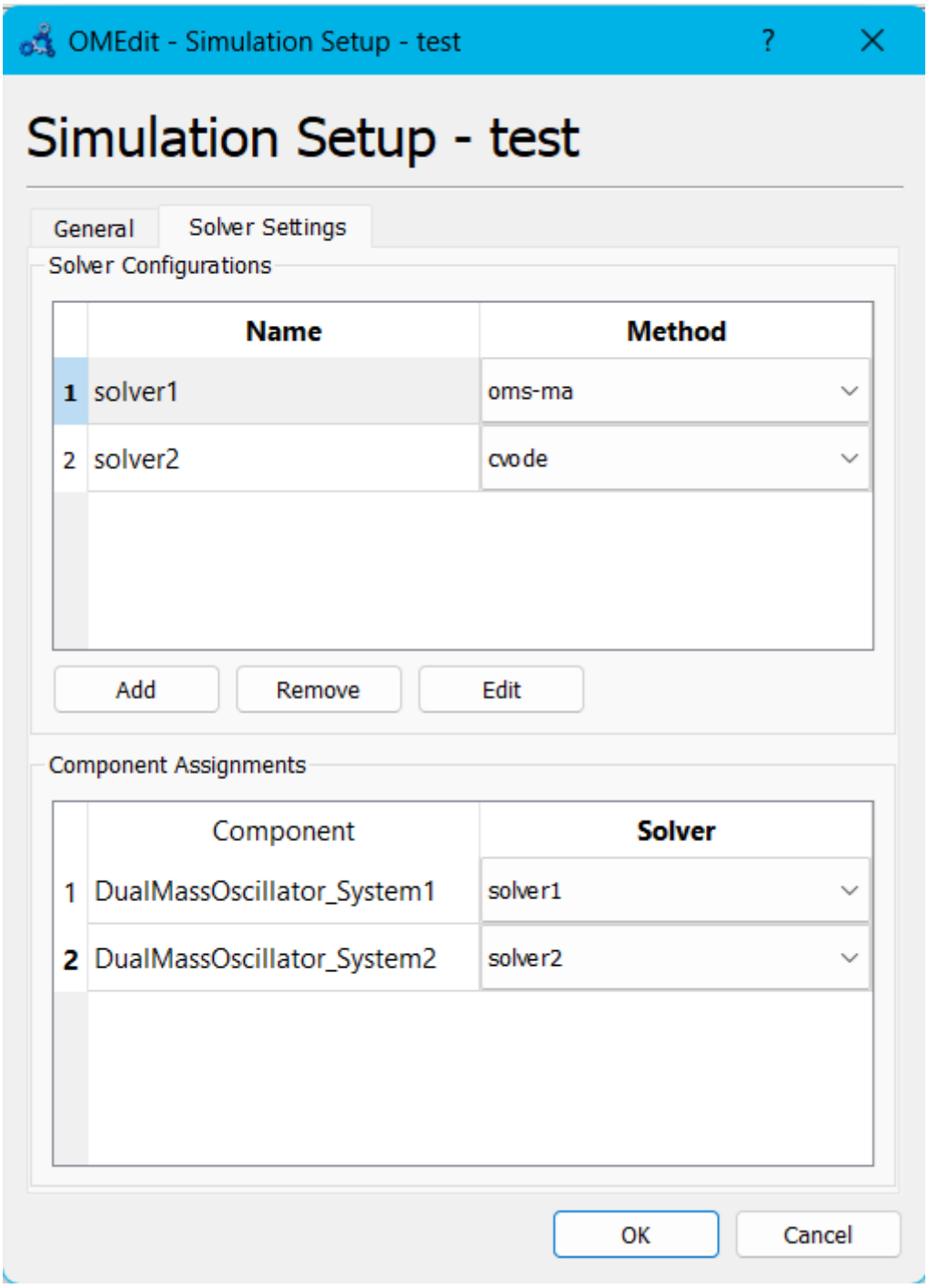



Figure 20.14: OMEdit: Solver Assignments in Components

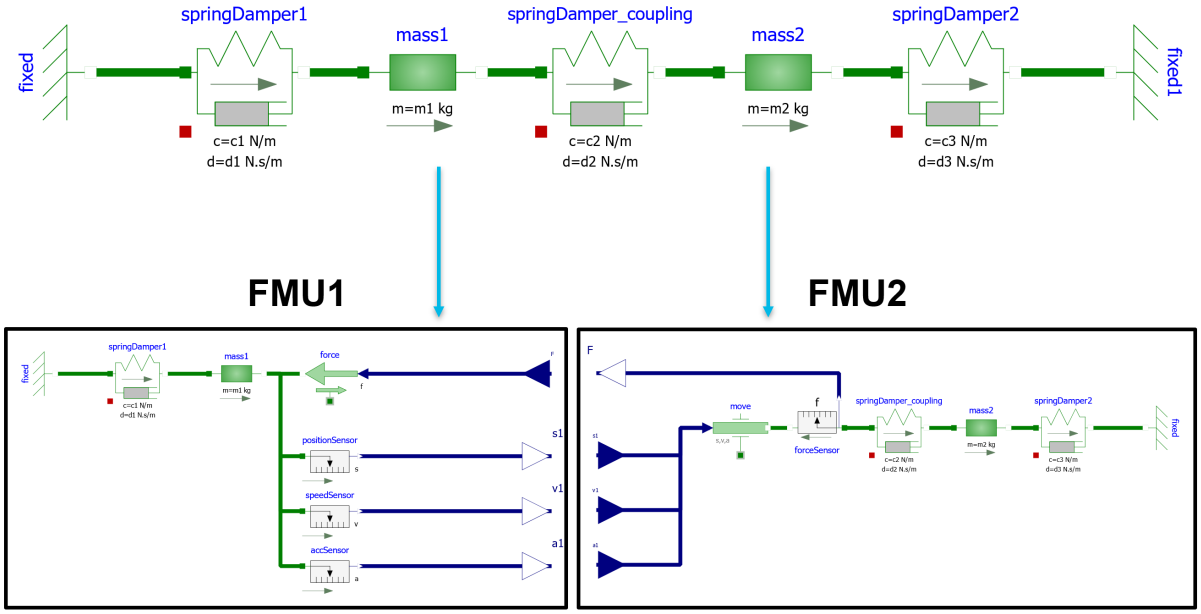



Figure 20.15: Dual mass oscillator Modelica model (diagram view) and FMUs

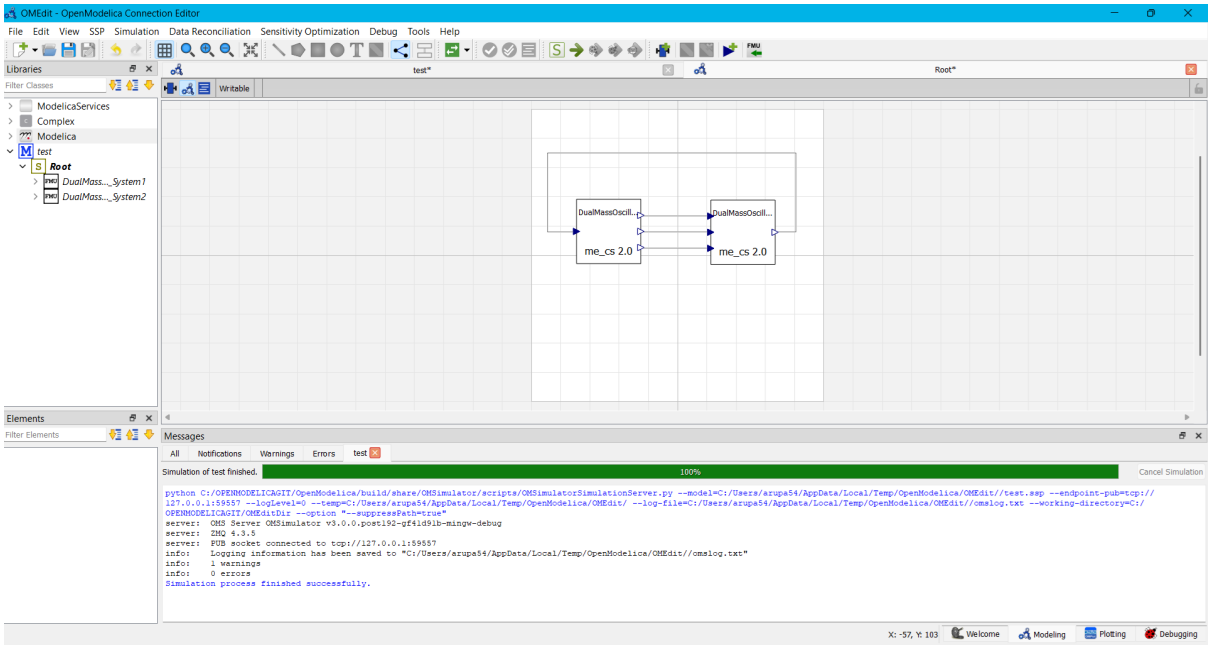



Figure 20.16: OMEdit: Simulate Dual Mass Oscillator SSP model

### 20.5.2 Installing with pip

The `OMSimulator` package on PyPI already contains the GUI: the `OMSimulatorGui` Python package is installed next to `OMSimulator` in `site-packages`.

```
pip install OMSimulator
```

The GUI's own requirements (PySide6, pyqtgraph and scipy) are *not* installed by default, so the core package stays small. If you start the GUI without them, it tells you what is missing. Install them with the `gui` extra:

```
pip install OMSimulator[gui]
```

Installing the extra is also enough when `OMSimulator` is already installed: pip only adds the missing requirements. Then start the GUI with:

```
python -m OMSimulatorGui
```

### 20.5.3 Launching

A build with OMSimulatorGui enabled installs an `OMSimulatorGui` launcher script next to `OMSimulator` itself:

```
OMSimulatorGui
```

This sets up `PYTHONPATH`/`PATH` the same way `OMSimulator.bat`/`.sh` does for the CLI, then runs `python3 -m OMSimulatorGui` (`python` on Windows). It can also be invoked directly once the `OMSimulator`/`OMSimulatorGui` packages are importable:

```
python -m OMSimulatorGui
```

Either way, the GUI runs under whichever `python` comes first on `PATH`, which must be one with the packages listed above. On Windows, the OpenModelica installer bundles a Python that already has them. Start `OMSimulatorGui` from OMEdit's *Tools > OpenModelica Command Prompt*, which puts the bundled Python first on `PATH` (or OMDev's Python, if `OMDEV` is set). From a plain command prompt, `python` may instead be another Python installed on the machine, and the GUI then fails with an error such as `No module named 'PySide6'`.

### 20.5.4 Main Window

The main window has three parts:

- A **System Tree** on the left, showing every open model as its own top-level row, each with its root system, connectors, connections, parameter files and registered resources underneath.
- A **Diagram Canvas** on the right, showing one system's contents at a time as boxes and connection lines -- systems, components (FMUs) and connectors on its boundary.
- A **toolbar** above the canvas with an **Up** button (leave the current system and go back to its parent), a **Simulation Settings** button, a **Simulate** button (green arrow), and a breadcrumb showing the current position in the system hierarchy.

Three menus tie everything together:

- **File** -- New SSP Model... (`Ctrl+N`), Open... (`Ctrl+O`), Save As... (`Ctrl+Shift+S`), Exit (`Ctrl+Q`).
- **Model** -- Simulation Settings..., Variants..., Simulate (`Ctrl+R`) -- all act on whichever model is currently active.
- **Tools** -- Options... (see *Options (Working Directory and Command Line Options)* below).
- **Help** -- About OMSimulatorGui..., showing the running OMSimulator version (the same one `OMSimulator --version` reports).

The tree and the canvas always show the same underlying model: editing on one immediately refreshes the other.

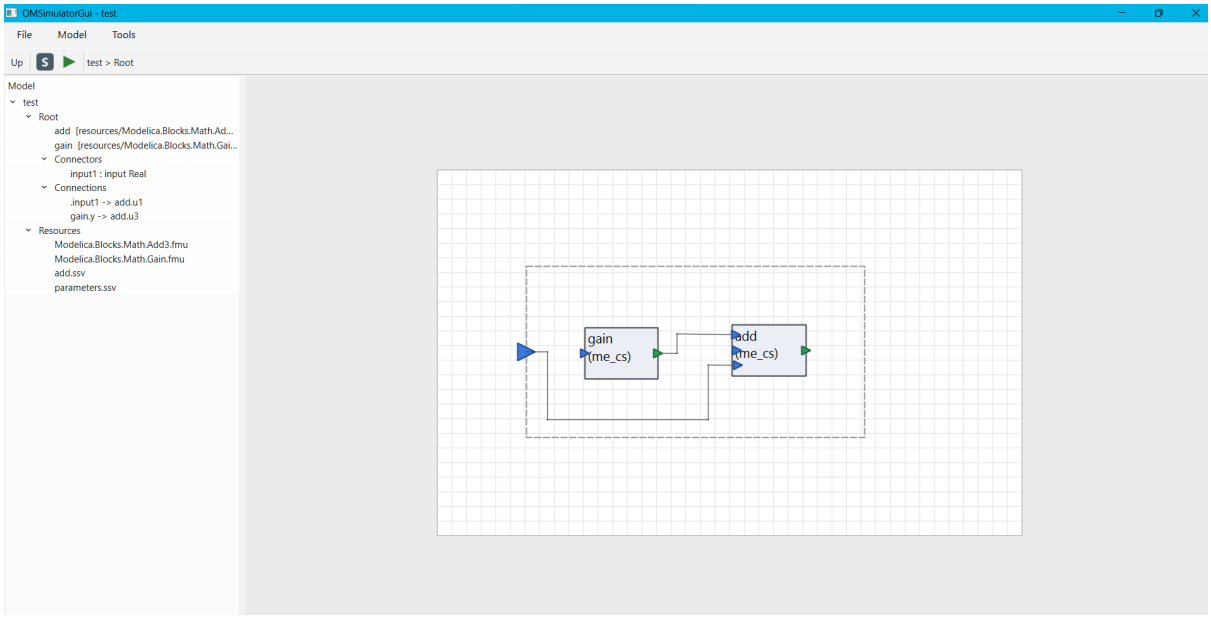



Figure 20.17: OMSimulatorGui: main window with a model open, showing the system tree (left), the diagram canvas drilled into the root system "Root" (right), and the breadcrumb "test > Root" in the toolbar.

### 20.5.5 Creating and Opening Models

**File -> New SSP Model...** opens a dialog asking for the model's name and the name of its root system, then creates a new, empty SSP model and opens it as a new tab in the tree.

**File -> Open...** opens a file browser to load an existing `.ssp` file. Several models can be open at the same time; each gets its own top-level row in the tree, and the diagram canvas and toolbar always reflect whichever model was last clicked on in the tree.

**File -> Save As...** exports the currently active model to a chosen `.ssp` path.

Multiple models can be open side by side. To close one, select its model row (or its root system row) in the tree and either press `Delete` or use **Delete** from its right-click menu -- both close the whole model, not just one part of it.

### 20.5.6 The System Tree

Each open model's row expands into its root system, which in turn shows:

- **Systems and Components** -- nested subsystems, FMU components, and result-file lookup tables (all three added via the same **Add Component...** action -- see The Diagram Canvas below), each with their own Connectors/Connections/Parameter Files/Resources underneath as applicable.
- **Connectors** -- the system's own boundary ports.
- **Connections** -- wires between two connectors at this level.
- **Parameter Files** -- SSV/SSM resources attached to this system or component (see *Parameter Files (SSV/SSM)* below).
- **Resources** -- every file registered in the SSP's shared resource pool (FMUs, SSV/SSM files, tables, ...), shown once under the model's own row.

Right-clicking a row opens a context menu appropriate to that row's kind:

- A **System** row offers Add System..., Add Component..., Add Connector..., Add Parameter File..., Export SSV/SSM Template..., Rename..., and Delete.
- A **Component** row offers Properties..., Add Parameter File..., Export SSV/SSM Template..., Rename..., and Delete.

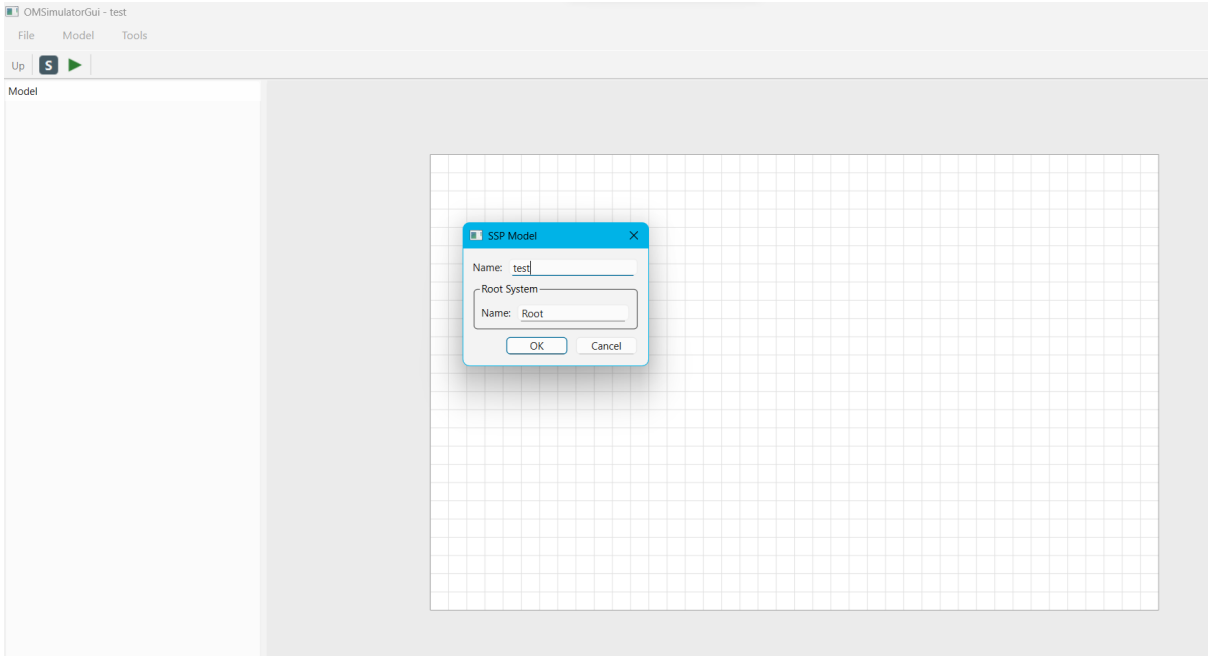



Figure 20.18: OMSimulatorGui: New SSP Model dialog, entering the model name and the root system's own name.

- A **Component Table** row (a result-file lookup table, not an FMU) offers the same actions minus Properties... -- it has no editable metadata of its own.
- A **Connector** row offers Delete.
- A **Parameter File** row offers Edit Values..., Swap Resource..., and Remove.
- A **Resource** row offers Remove.
- A model's own top-level row offers Add Resource..., Rename..., and Delete (closes the whole model).

Double-clicking a Component row opens its Properties dialog; double-clicking a Parameter File row opens Edit Values. Double-clicking a Component Table row does nothing (there is no Properties dialog for one).

### 20.5.7 The Diagram Canvas

The canvas shows one system's contents at a time. Double-click a subsystem or component box to drill into it (an FMU component opens its Properties dialog instead, since it has no contents of its own; a component table box does nothing on double-click); use the toolbar's **Up** button, or the breadcrumb, to go back out.

Right-clicking empty canvas space offers **Add System...**, **Add Component...** and **Add Connector...**, placing the new element at the click position. Right-clicking an existing box offers the same system/component actions as the tree (Add Parameter File..., Export Template..., Rename..., Delete), plus **Properties...** for an FMU component.

**Add Component...** accepts either an FMU (`.fmu`) or a result-file lookup table (`.csv`/`.mat`) through the same dialog and file browser -- matching OMEdit's own unified Add SubModel. Which kind is created depends only on the file's own extension: an FMU becomes a regular Component, while a `.csv`/`.mat` becomes a **Component Table** whose signals are always read from the file's header and always given `output` causality (there is nothing to configure on one -- no Properties dialog, no double-click action, matching OMEdit).

To connect two ports, drag from one to the other -- the connection is only created if the two connectors are causality-compatible (e.g. an output to an input), otherwise nothing happens. A connection defaults to an automatic routed path but can be reshaped by hand: drag anywhere along it to insert or move a waypoint, right-click a waypoint to remove it. Moving a box shifts any connections attached to it by the same amount, so a manually-reshaped route does not go stale.

Select a box, port, or connection and press `Delete` to remove it, or use Delete from its context menu. Double-clicking a connection itself has no effect (it does not open or delete anything).

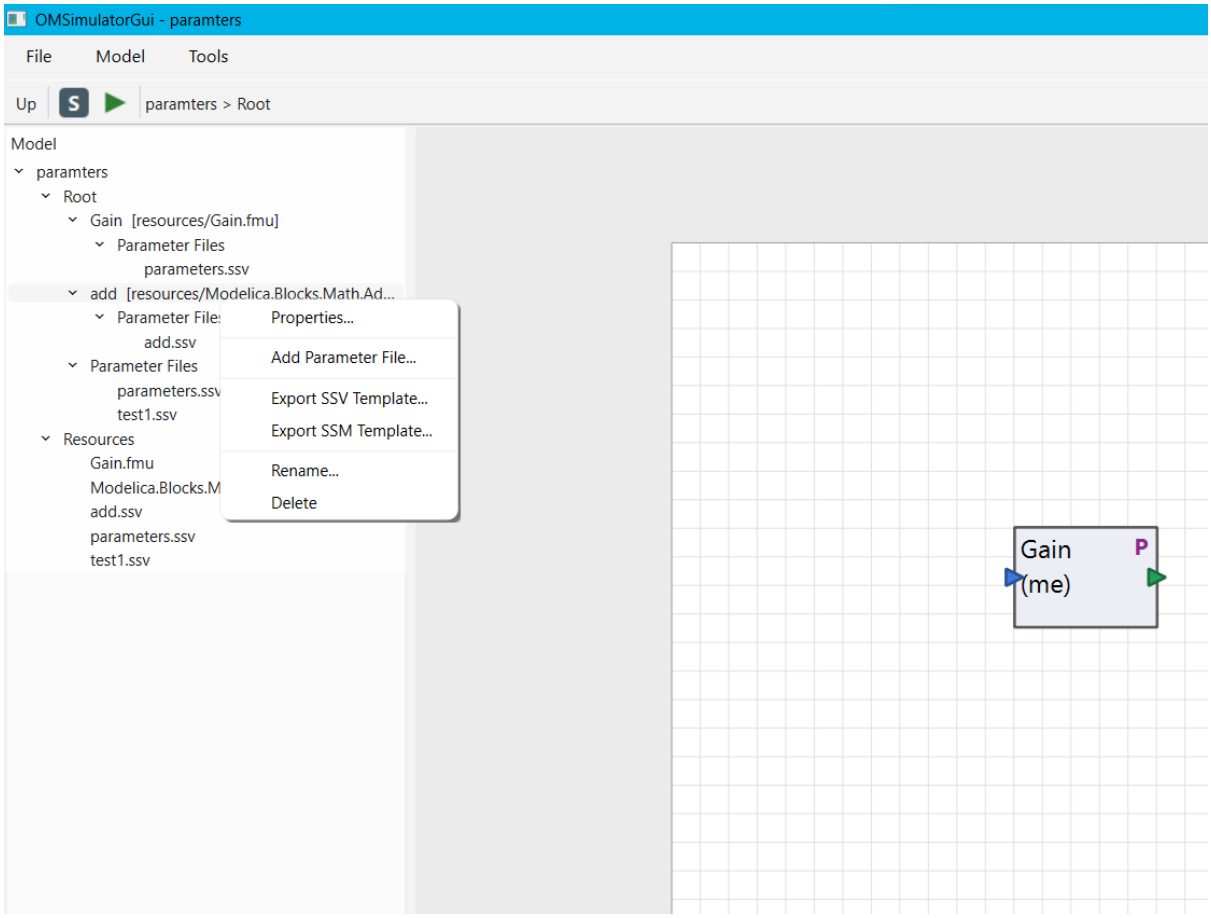



Figure 20.19: OMSimulatorGui: right-click context menu on a Component row ("add") in the tree -- Properties..., Add Parameter File..., Export SSV/SSM Template..., Rename..., Delete. Right-clicking the same component's box on the canvas offers the identical set of actions.

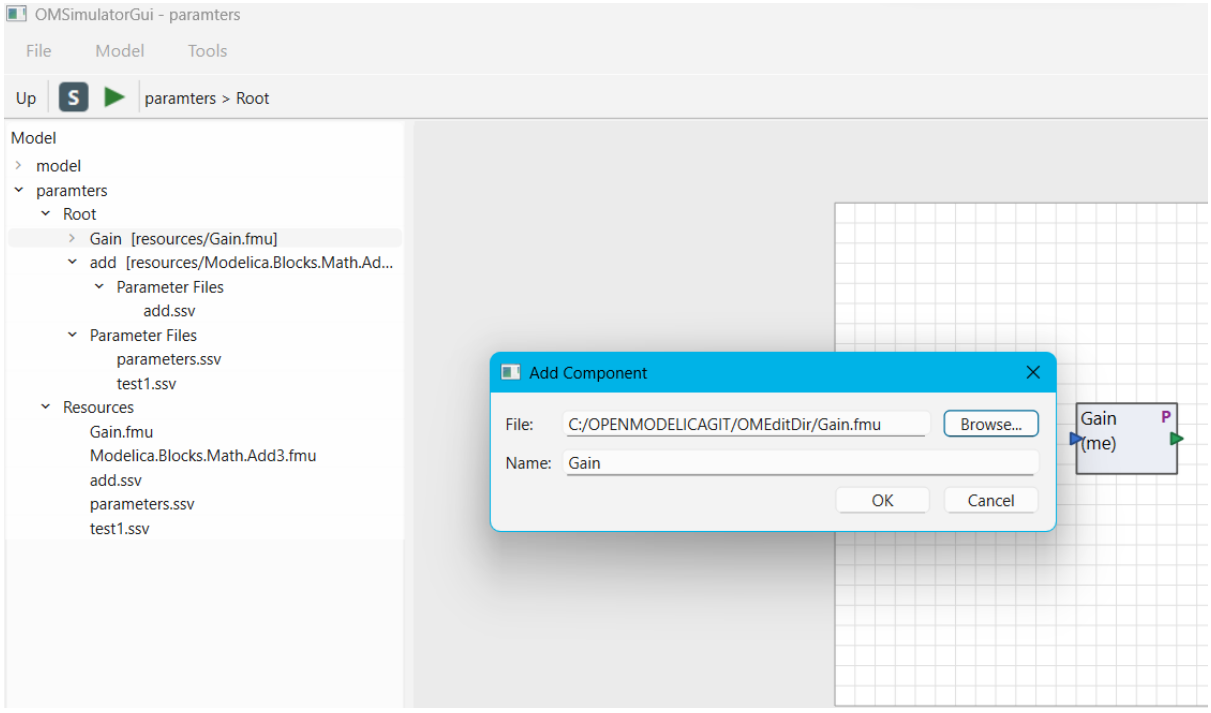



Figure 20.20: OMSimulatorGui: Add Component dialog -- a file (an FMU or a result-file table, via Browse...) and a name for the new component.

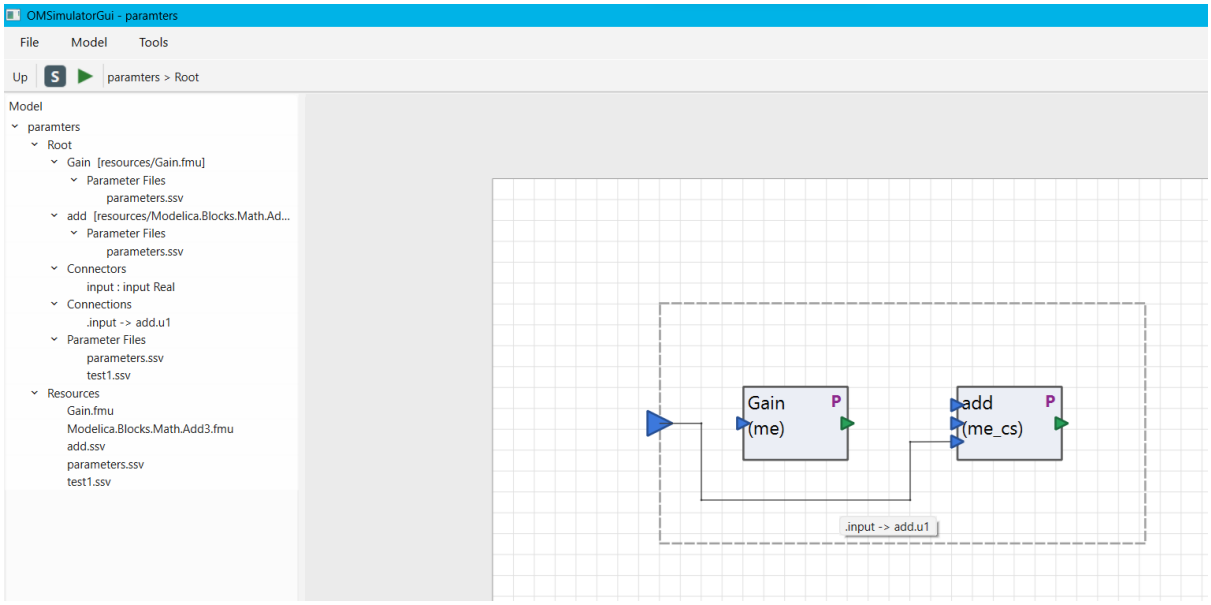



Figure 20.21: OMSimulatorGui: a manually reshaped connection (".input -> add.u1") routed below and around both boxes instead of a straight line, with its identity shown in a hover tooltip.

An input or output connector with no incoming connection can be given a constant value by double-clicking it directly on the canvas -- this opens a small **Set Value** dialog. Leaving the value field blank clears any set value (the backend then defaults it to 0); no unit needs to be entered.

### 20.5.8 Element (Component) Properties

Double-clicking an FMU component (in the tree or on the canvas) opens its **Properties** dialog, with three tabs. A component table (a `.csv`/`.mat` added via the same Add Component... action) has no such dialog -- double-clicking one does nothing, since it has no metadata or parameters to edit.

- **Info** -- FMU path, FMI kind (model-exchange/co-simulation/both) and other read-only metadata.
- **Parameters** -- editable parameter values (Real/Integer/Boolean; String parameters are not yet supported, matching OMEdit).
- **Inputs** -- editable input values, same types as above.

Only values the user actually changes are written back to the model -- an untouched parameter keeps using whatever default the FMU itself declares.

### 20.5.9 Parameter Files (SSV/SSM)

A **parameter value file** (SSV) holds a named set of parameter/input values; a **parameter mapping file** (SSM) maps those names onto a different system or component's own connector names (e.g. renaming or rescaling a value as it crosses into a subsystem). Both are ordinary SSP resources that get attached to a system or component -- never to the "whole model" as a free-floating box, so on the canvas they only ever show as a small "P" badge on the system/component box they are attached to.

**Add Parameter File...** (on a System or Component row, or its canvas box) opens a dialog to either:

- create a brand-new SSV file by entering values directly, optionally also creating a companion SSM mapping (which can be saved empty, to be filled in later), or
- browse to an existing `.ssv`/`.ssm` file on disk, or
- pick a resource **already registered** in the SSP (see Resources below) instead of creating or browsing a new one.

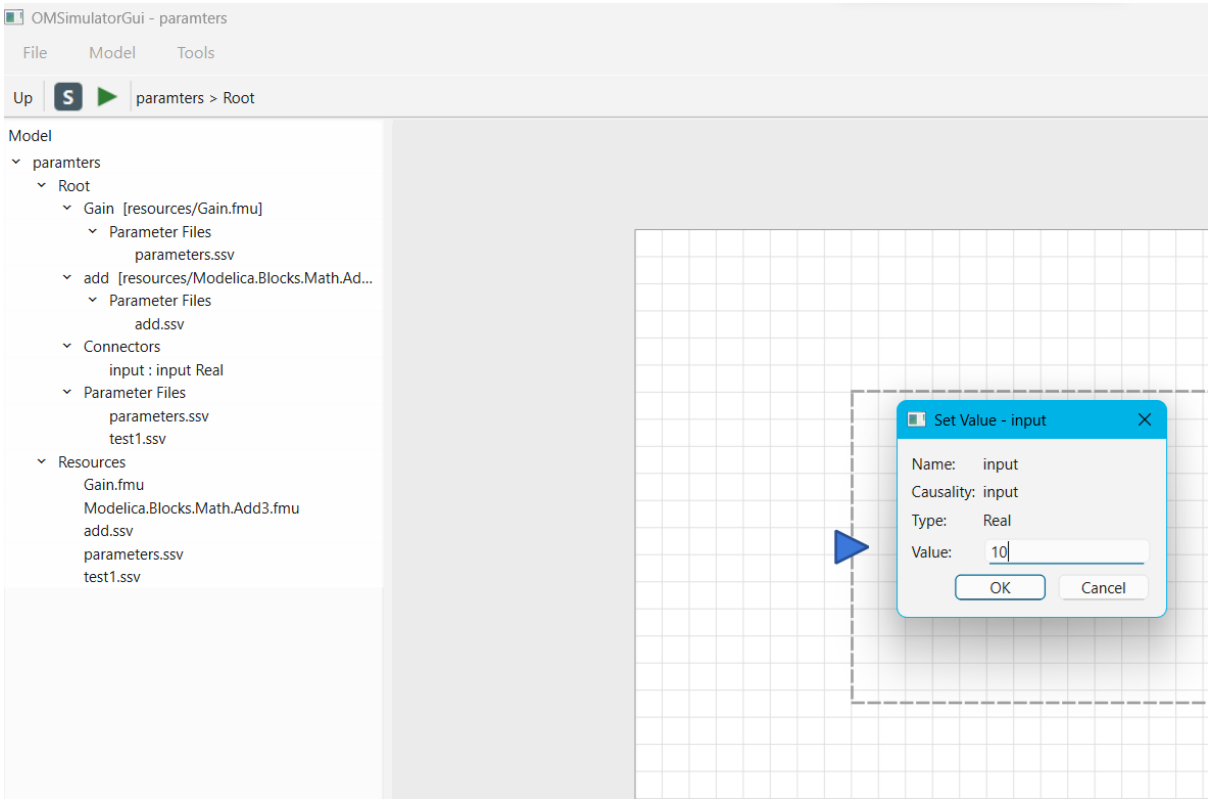



Figure 20.22: OMSimulatorGui: Set Value dialog for the root system's own "input" connector.

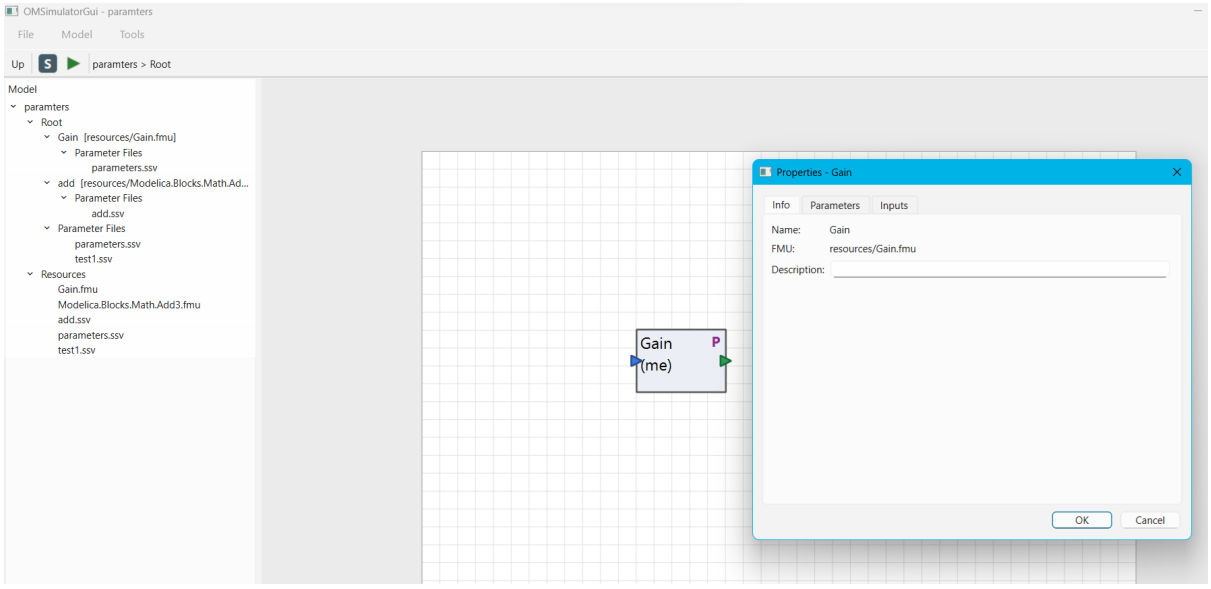



Figure 20.23: OMSimulatorGui: Properties dialog for the "Gain" component, Info tab -- the Parameters and Inputs tabs sit alongside it.

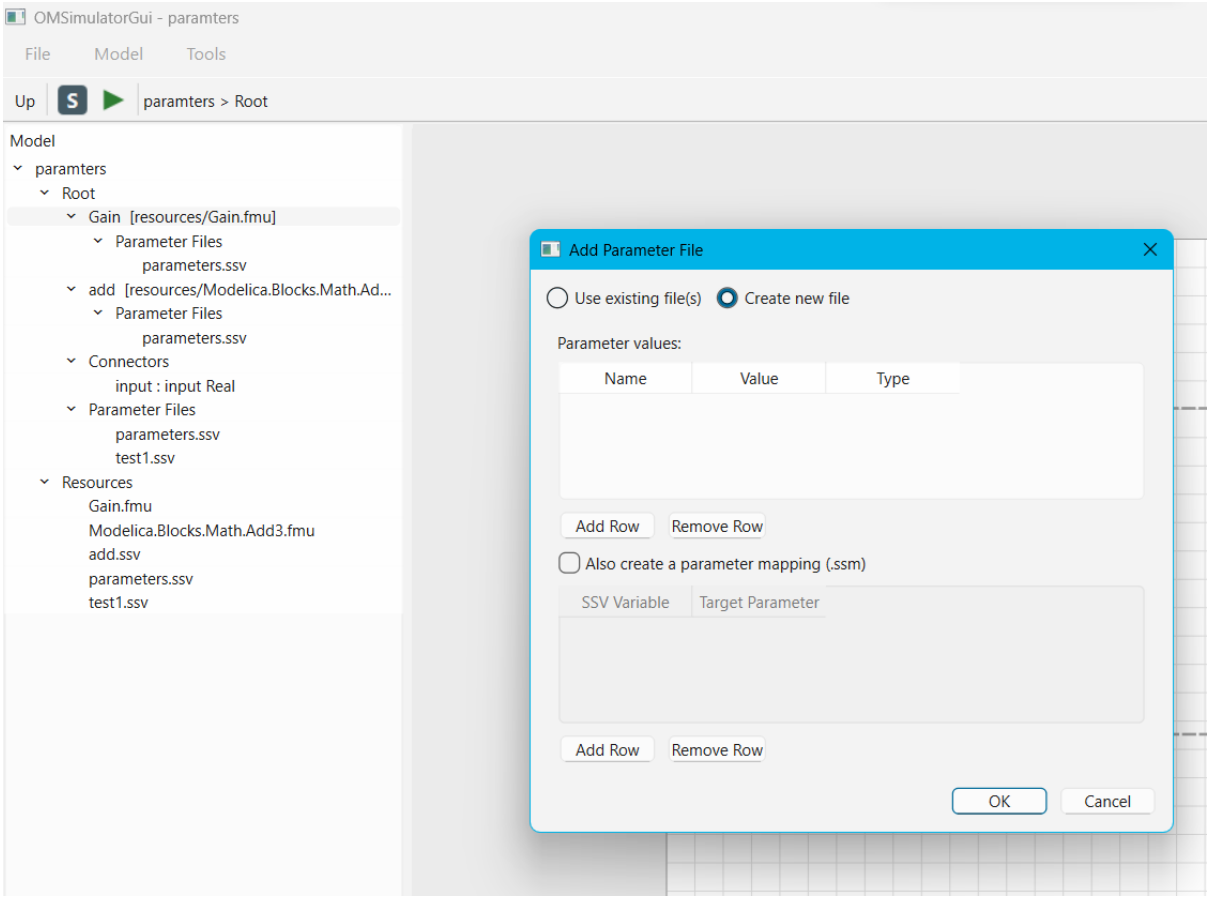



Figure 20.24: OMSimulatorGui: Add Parameter File dialog in "Create new file" mode -- a Name/Value/Type table for the SSV, plus an optional "Also create a parameter mapping (.ssm)" table underneath.

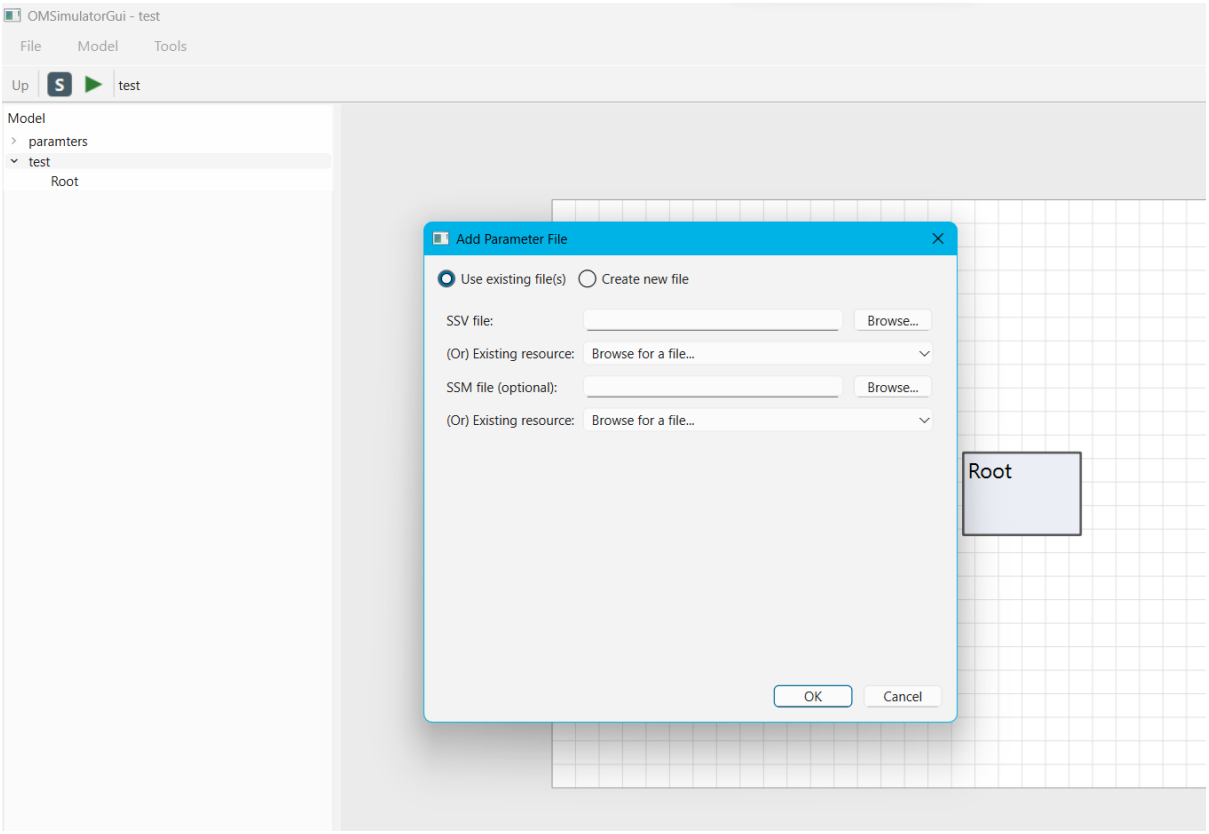



Figure 20.25: OMSimulatorGui: Add Parameter File dialog in "Use existing file(s)" mode -- an SSV file (with an "(Or) Existing resource" combo above it) and an optional SSM file, each browsable or pickable from the SSP's own registered resources.

**Edit Values...** (double-click a Parameter File row, or its badge on the canvas) reopens the attached SSV's own values for editing, and can also attach or repoint the companion SSM the same way Add Parameter File does (create new / browse / pick an existing resource).

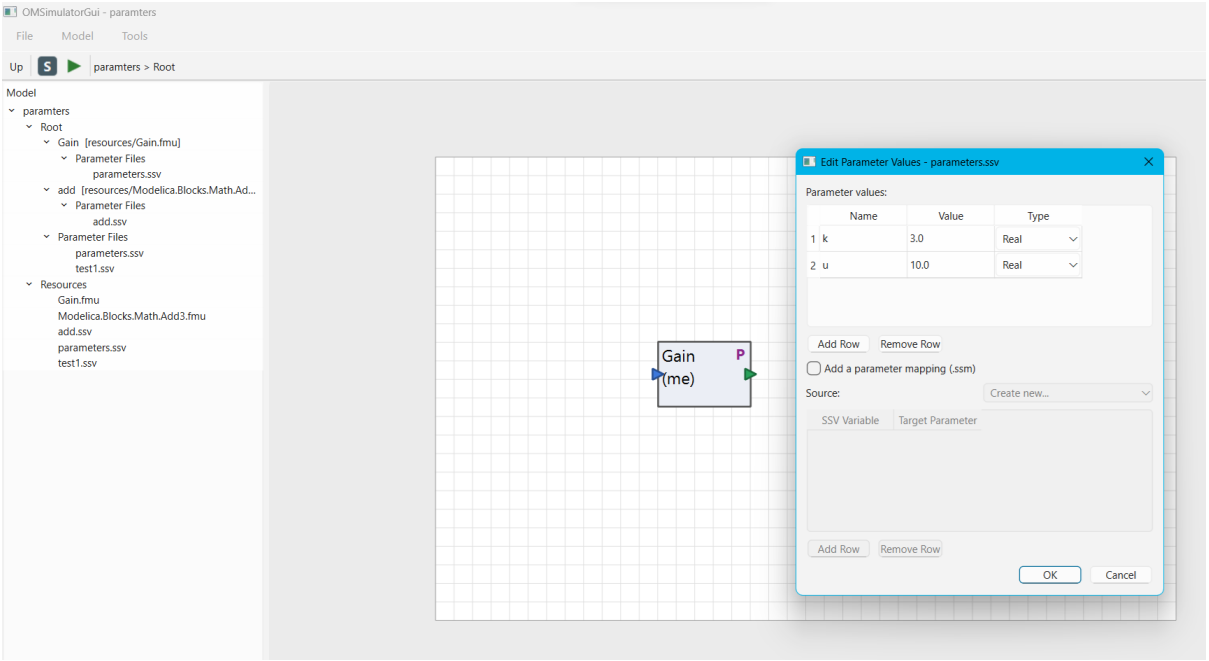



Figure 20.26: OMSimulatorGui: tree with each system/component's own "Parameter Files" group expanded, the "P" badge on the "Gain" box on the canvas, and the Edit Parameter Values dialog reopened on it -- with the "Add a parameter mapping (.ssm)" checkbox and Source picker visible underneath the values table.

**Swap Resource...** re-points an already-attached SSV reference at a *different, already-registered* SSV resource, without touching its values -- useful for switching between two alternative presets that were both added via Add Resource beforehand. Swapping drops any attached SSM mapping (a warning is shown first if one is present), since the mapping is specific to the file being swapped out.

**Export SSV Template.../Export SSM Template...** (on a System or Component row) writes a ready-made external file listing every parameter/connector target reachable under that row -- an SSV template with each target's *current* value, or an SSM template with every target listed with an empty `source=""` for hand-editing. Neither of these attaches anything to the model; they are a scaffold to hand-edit externally and bring back in later via Add Parameter File's "pick an existing resource" option.

### 20.5.10 Resources

Every FMU, SSV/SSM file, or other resource referenced anywhere in the model is registered once in the SSP's shared resource pool and listed under the model's own **Resources** group in the tree.

**Add Resource...** (on the model's own row) registers an arbitrary file without attaching it to anything -- useful for staging a file (e.g. a lookup table for a component table) before wiring it up elsewhere, or for building up a pool of SSV/SSM presets ahead of time so Add Parameter File's/Swap Resource's "existing resource" pickers have something to offer. **Remove** unregisters a resource; it fails with an in-place error if something in the model still references it.

### 20.5.11 Variants

**Model -> Variants...** opens the SSP Variants dialog, listing every variant (alternate top-level system structure) stored in the model, letting the user activate a different one or duplicate the active one under a new name.

Activating a variant swaps the root system the tree and canvas are built from -- the model's own tree row always tracks whichever variant is currently active by name.

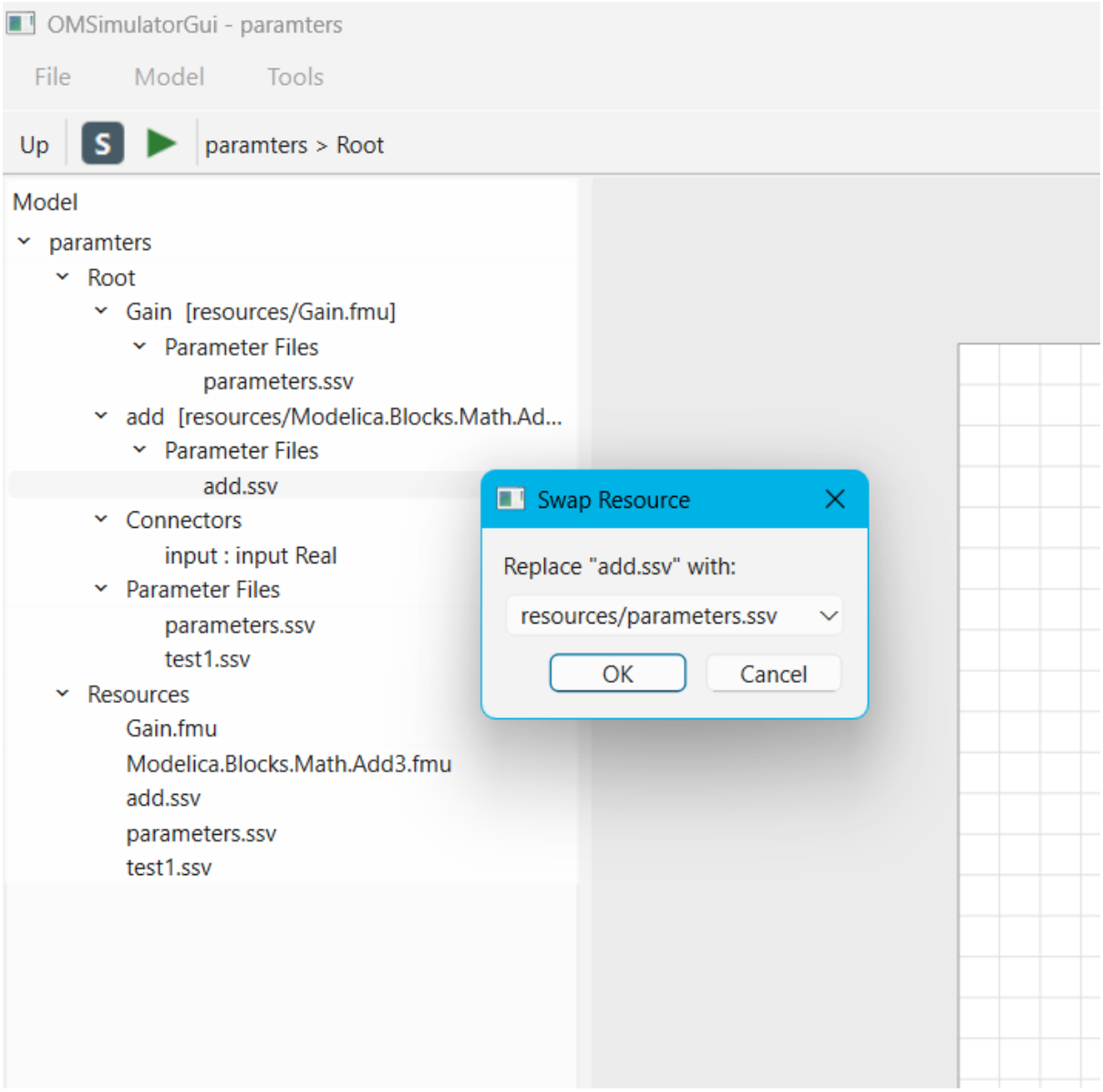



Figure 20.27: OMSimulatorGui: Swap Resource picker, replacing "add.ssv" with another already-registered `.ssv` resource.

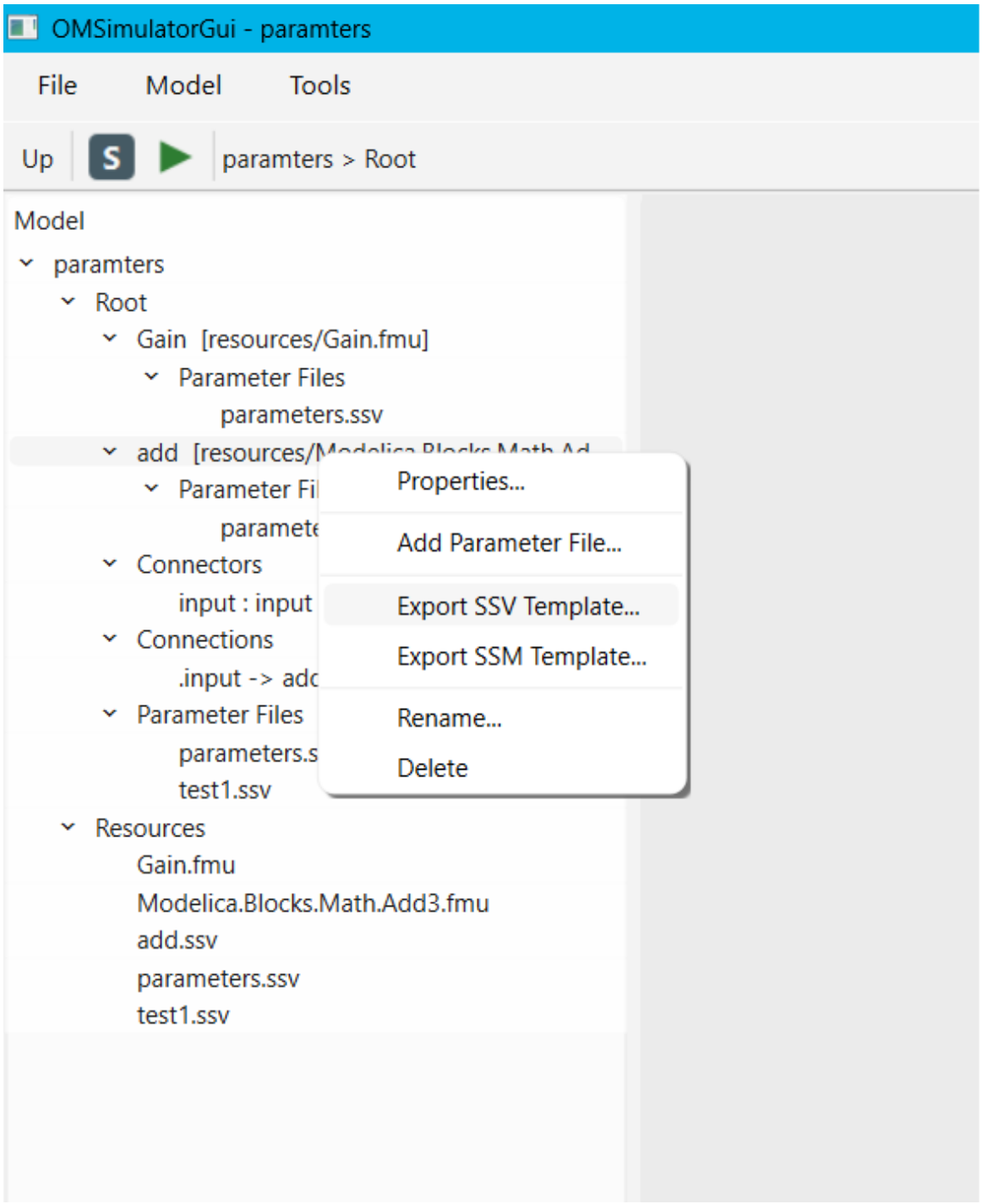



Figure 20.28: OMSimulatorGui: Export SSV Template.../Export SSM Template... on a Component row's context menu. Picking either one opens a standard Save File dialog, pre-filled with a default name.

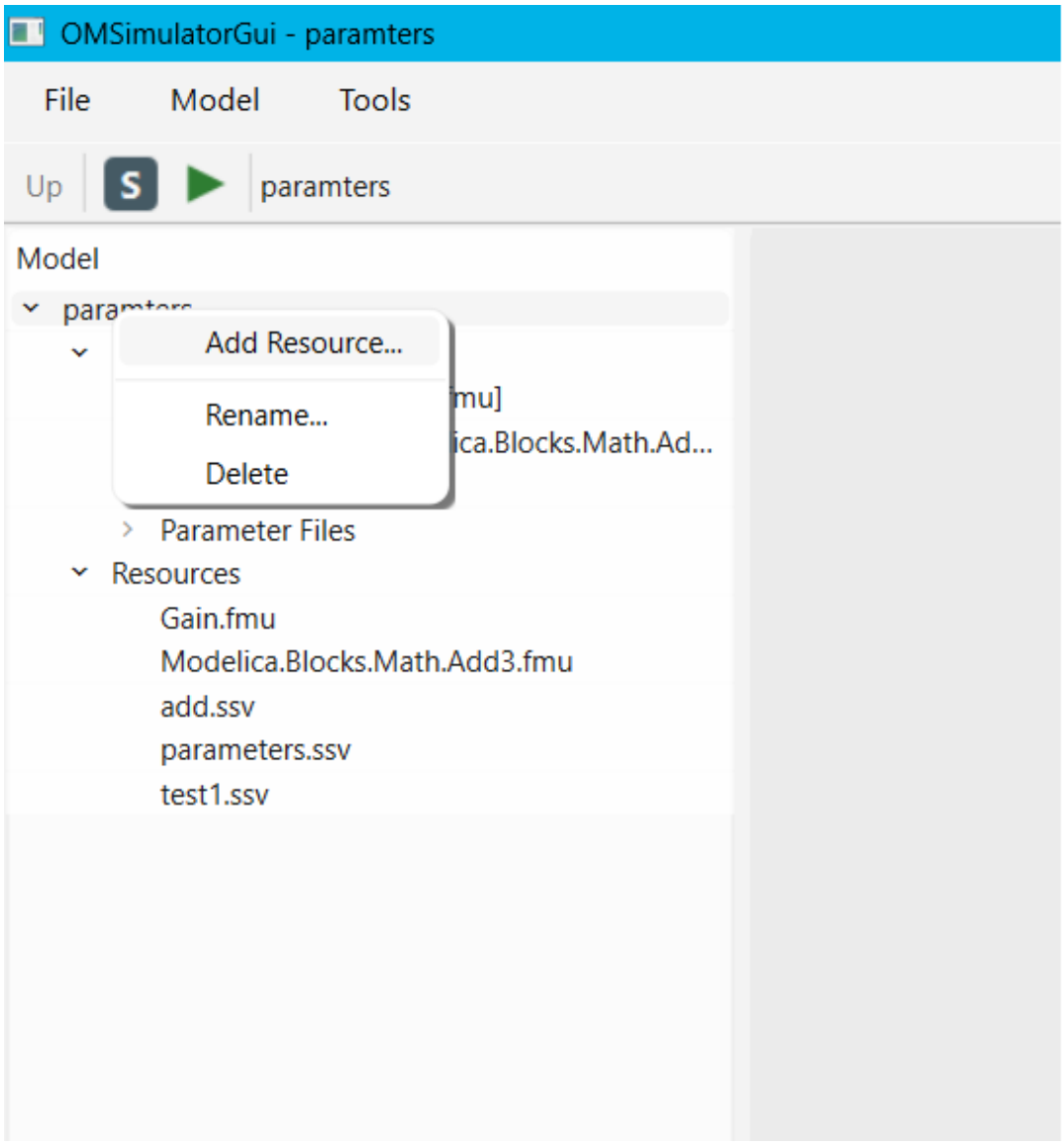



Figure 20.29: OMSimulatorGui: model row's right-click menu (Add Resource.../Rename.../ Delete) and the Resources group listing every file registered in the SSP.

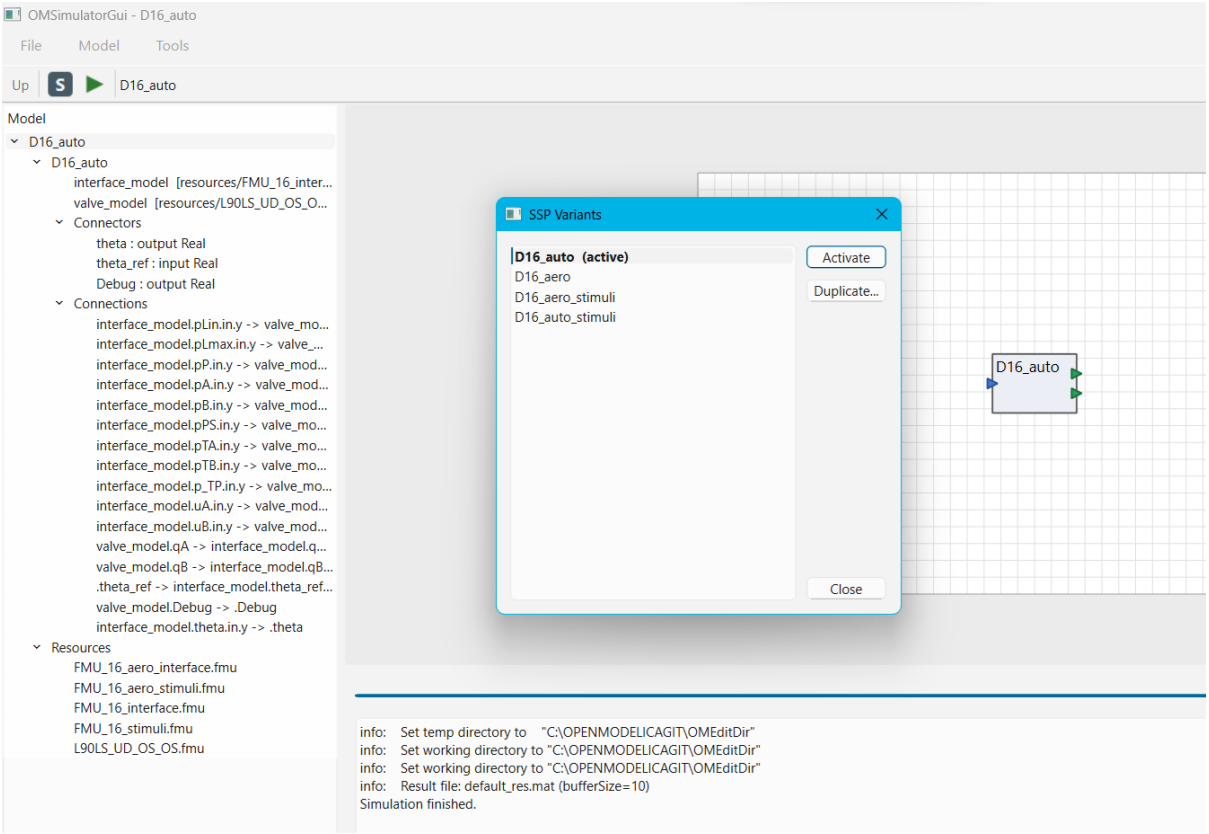



Figure 20.30: OMSimulatorGui: SSP Variants dialog for a model with four variants -- the active one marked "(active)", with Activate and Duplicate... actions.

### 20.5.12 Simulation Settings

**Model -> Simulation Settings...** (or the toolbar's "S" button) opens a per-model dialog with two tabs:

- **General** -- start time, stop time, tolerance, (maximum) step size, result file name, result file buffer size, and logging interval.
- **Solver Settings** -- named solver configurations (a name plus a method, e.g. `oms-ma`, `oms-mav`, `cvode`, `euler`) and a per-component assignment table listing every FMU component in the model. A component left unassigned falls back to the automatic default for its FMI kind.

### 20.5.13 Options (Working Directory and Command Line Options)

**Tools -> Options...** holds two global preferences, applied to every simulation run regardless of which model is open:

- **Working Directory** -- when set, every simulation exports the model into this fixed folder and runs there, so the result file lands somewhere predictable and gets overwritten on each re-run. Left blank (the default), each run instead uses a fresh temporary directory, same as before this setting existed.
- **Command Line Options** -- free text, forwarded as one or more native flags before the model is instantiated -- the same flags and the same underlying mechanism *OMSimulator's own CLI* uses (e.g. `--suppressPath=true`, `--logLevel=1`). An unrecognized flag makes the simulation fail immediately with the native flag parser's own error message.

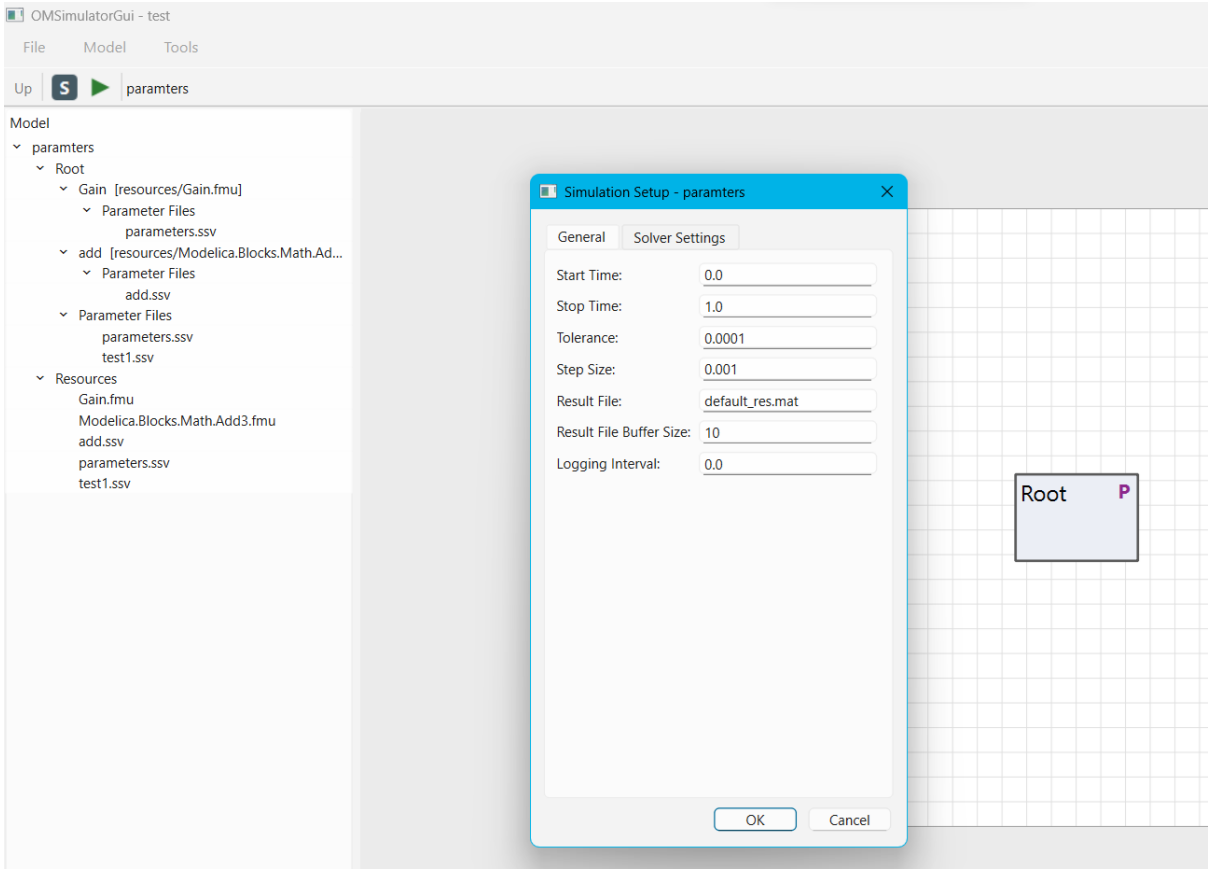



Figure 20.31: OMSimulatorGui: Simulation Setup dialog, General tab.

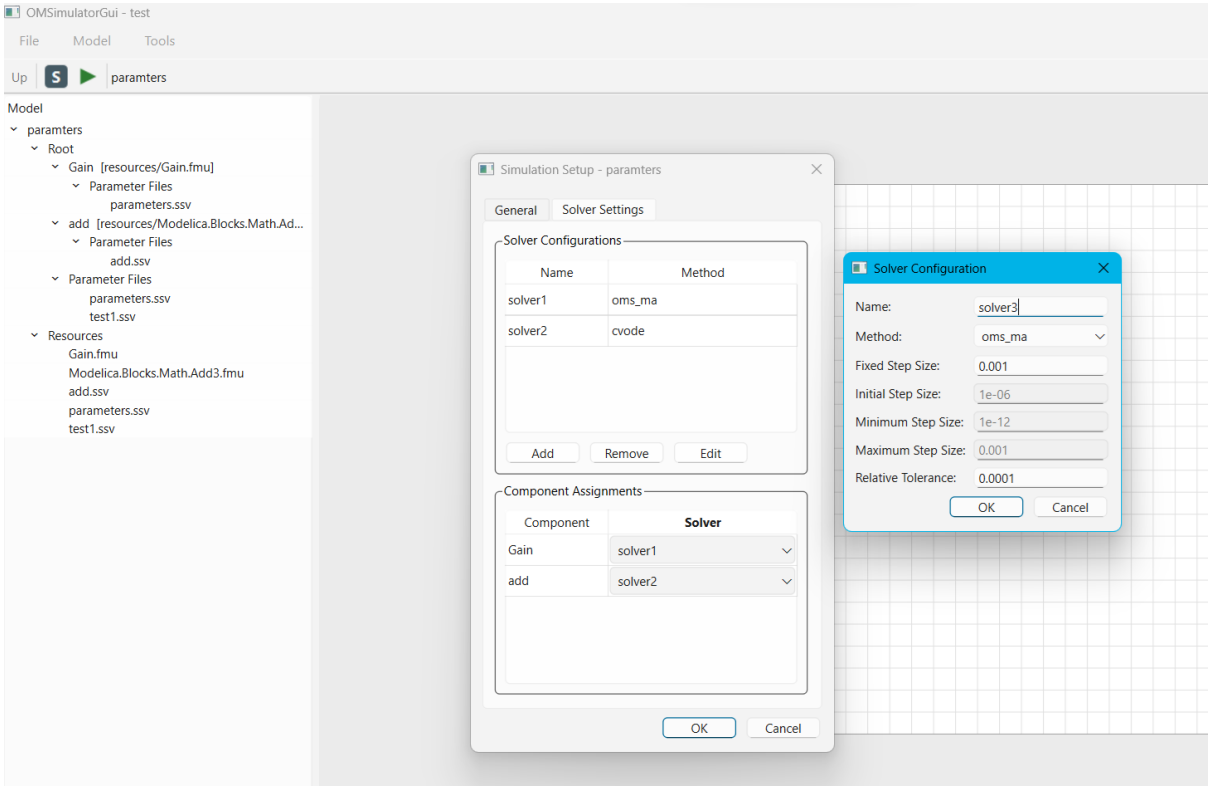



Figure 20.32: OMSimulatorGui: Simulation Setup dialog, Solver Settings tab -- two named solver configurations, each FMU component assigned to one -- with the Solver Configuration dialog open on top for editing a configuration's own numerical parameters (step sizes, relative tolerance).

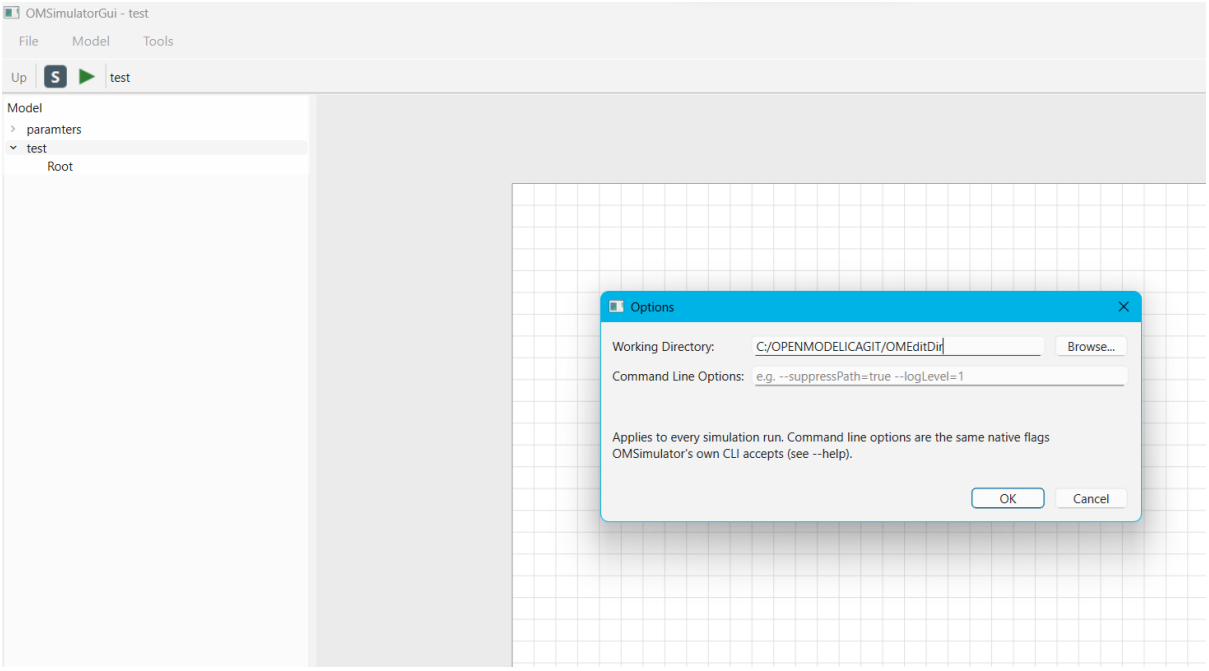



Figure 20.33: OMSimulatorGui: Tools -> Options dialog, with a Working Directory set.

### 20.5.14 Simulating and Viewing Results

**Simulate** (the toolbar's green arrow, `Ctrl+R`, or Model -> Simulate) exports the active model's current state and runs it in a separate subprocess -- crash isolation from a misbehaving FMU never takes the GUI down with it. A progress panel appears at the bottom of the window with a progress bar and **Pause**, **Stop** and **Hide** buttons; pausing and resuming take effect immediately.

When the simulation finishes, its result file (`.mat` or `.csv`) opens automatically in a **Results** window: a checkable list of every signal on the left, plotted on the right as they are checked.

### 20.5.15 Current Limitations

- No read-only XML/text viewer for the underlying SSD/SSV/SSM files yet (planned as a low-risk, self-contained addition).
- String-valued parameters/inputs are not editable (matches OMEdit's own current limitation).
- Only one variant's system structure is shown/edited at a time; switching variants resets the diagram canvas back to the model level.

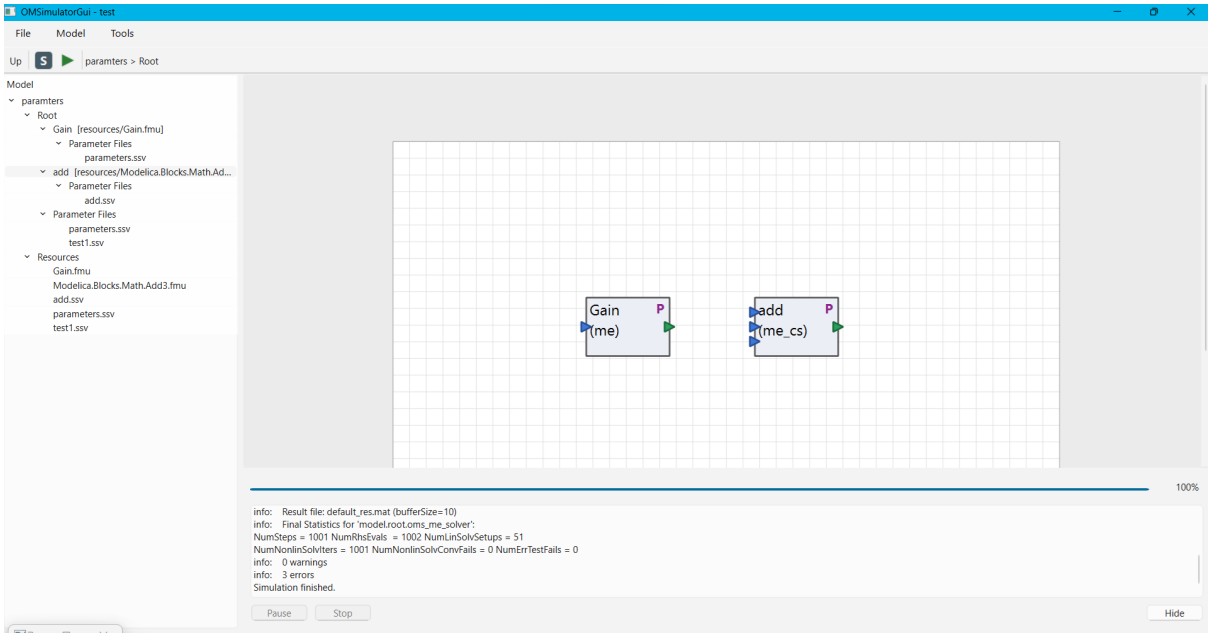



Figure 20.34: OMSimulatorGui: simulation progress panel after a run has finished -- progress at 100%, the solver's own log output above it, and Pause/Stop disabled now that there is nothing left to control.

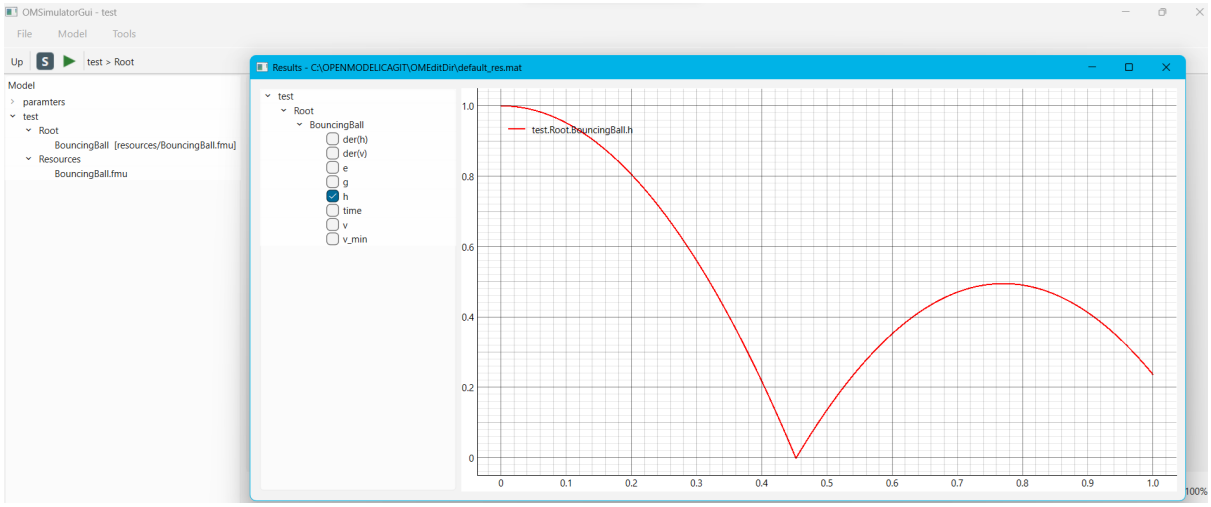



Figure 20.35: OMSimulatorGui: Results window for a bouncing ball model -- the "h" (height) signal checked in the tree on the left, plotted on the right.

CHAPTER

# TWENTYONE

# SYSTEM IDENTIFICATION

System Identification (OMSysIdent) is part of the OpenModelica tool suite, but not bundled together with the main OpenModelica distribution and thus must be fetched separately from its project site.

*OMSysIdent* is a module for the parameter estimation for linear and nonlinear parametric dynamic models (wrapped as FMUs) on top of the *OMSimulator* API. It uses the Ceres solver (http://ceres-solver.org/) for the optimization task. The module provides a *Python scripting API* as well as an *C API*.

**Note**

Notice that this module was previously part of OMSimulator. It has been extracted out of the OMSimulator project and reorganized as a separate project in September 2020. As of 2020-10-07 the project is working on Linux but some more efforts are needed for migrating the Windows build and make the build and usage of the module more convenient.

Version: a65a0ed

## 21.1 Examples

There are examples in the testsuite which use the scripting API, as well as examples which directly use the C API.

Below is a basic example from the testsuite (*HelloWorld_cs_Fit.py*) which uses the Python scripting API. It determines the parameters for the following "hello world" style Modelica model:

```
model HelloWorld
  parameter Real a = -1;
  parameter Real x_start = 1;
  Real x(start=x_start, fixed=true);
equation
  der(x) = a*x;
end HelloWorld;
```

The goal is to estimate the value of the coefficent *a* and the initial value *x_start* of the state variable *x*. Instead of real measurements, the script simply uses simulation data generated from the *HelloWorld* examples as measurement data. The array *data_time* contains the time instants at which a sample is taken and the array *data_x* contains the value of *x* that corresponds to the respective time instant.

The estimation parameters are defined by calls to function *simodel.addParameter(..)* in which the name of the parameter and a first guess for the parameter's value is stated.

Listing 21.1: HelloWorld_cs_Fit.py

```
from OMSimulator import OMSimulator
from OMSysIdent import OMSysIdent
import numpy as np

```

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```
oms = OMSimulator()

oms.setLogFile("HelloWorld_cs_Fit_py.log")
oms.setTempDirectory("./HelloWorld_cs_Fit_py/")
oms.newModel("HelloWorld_cs_Fit")
oms.addSystem("HelloWorld_cs_Fit.root", oms.system_wc)
# oms.setTolerance("HelloWorld_cs_Fit.root", 1e-5)

# add FMU
oms.addSubModel("HelloWorld_cs_Fit.root.HelloWorld", "../resources/HelloWorld.fmu")

# create simodel for model
simodel = OMSysIdent("HelloWorld_cs_Fit")
# simodel.describe()

# Data generated from simulating HelloWorld.mo for 1.0s with Euler and 0.1s step size
kNumSeries = 1
kNumObservations = 11
data_time = np.array([0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1])
inputvars = []
measurementvars = ["root.HelloWorld.x"]
data_x = np.array([1, 0.9, 0.8100000000000001, 0.7290000000000001, 0.6561, 0.
↪5904900000000001, 0.5314410000000001, 0.4782969000000001, 0.43046721, 0.387420489,␣
↪0.3486784401])

simodel.initialize(kNumSeries, data_time, inputvars, measurementvars)
# simodel.describe()

simodel.addParameter("root.HelloWorld.x_start", 0.5)
simodel.addParameter("root.HelloWorld.a", -0.5)
simodel.addMeasurement(0, "root.HelloWorld.x", data_x)
# simodel.describe()

simodel.setOptions_max_num_iterations(25)
simodel.solve("BriefReport")

status, state = simodel.getState()
# print('status: {0}; state: {1}').format(OMSysIdent.status_str(status), OMSysIdent.
↪omsi_simodelstate_str(state))

status, startvalue1, estimatedvalue1 = simodel.getParameter("root.HelloWorld.a")
status, startvalue2, estimatedvalue2 = simodel.getParameter("root.HelloWorld.x_start")
# print('HelloWorld.a startvalue1: {0}; estimatedvalue1: {1}'.format(startvalue1,␣
↪estimatedvalue1))
# print('HelloWorld.x_start startvalue2: {0}; estimatedvalue2: {1}'.format(startvalue2,
↪ estimatedvalue2))
is_OK1 = estimatedvalue1 > -1.1 and estimatedvalue1 < -0.9
is_OK2 = estimatedvalue2 > 0.9 and estimatedvalue2 < 1.1
print('HelloWorld.a estimation is OK: {0}'.format(is_OK1))
print('HelloWorld.x_start estimation is OK: {0}'.format(is_OK2))

# del simodel
oms.terminate("HelloWorld_cs_Fit")
oms.delete("HelloWorld_cs_Fit")
```

Running the script generates the following console output:

```
iter      cost      cost_change  |gradient|   |step|    tr_ratio  tr_radius  ls_iter␣
↪iter_time  total_time
 0  4.069192e-01    0.00e+00    2.20e+00   0.00e+00   0.00e+00  1.00e+04        0   ␣
↪7.91e-03    7.93e-03
 1  4.463938e-02    3.62e-01    4.35e-01   9.43e-01   8.91e-01  1.92e+04        1   ␣
↪7.36e-03    1.53e-02
 2  7.231043e-04    4.39e-02    5.16e-02   3.52e-01   9.85e-01  5.75e+04        1   ␣
↪7.26e-03    2.26e-02
 3  1.046555e-07    7.23e-04    4.74e-04   4.40e-02   1.00e+00  1.73e+05        1   ␣
↪7.31e-03    3.00e-02
 4  2.192358e-15    1.05e-07    5.77e-08   6.05e-04   1.00e+00  5.18e+05        1   ␣
↪7.15e-03    3.71e-02
 5  7.377320e-26    2.19e-15    2.05e-13   9.59e-08   1.00e+00  1.55e+06        1   ␣
↪7.42e-03    4.46e-02
Ceres Solver Report: Iterations: 6, Initial cost: 4.069192e-01, Final cost: 7.377320e-
↪26, Termination: CONVERGENCE

=====================================
Total duration for parameter estimation: 44msec.
Result of parameter estimation (check 'Termination' status above whether solver␣
↪converged):

HelloWorld_cs_Fit.root.HelloWorld.a(start=-0.5, *estimate*=-1)
HelloWorld_cs_Fit.root.HelloWorld.x_start(start=0.5, *estimate*=1)

=====================================
HelloWorld.a estimation is OK: True
HelloWorld.x_start estimation is OK: True
info:    Logging information has been saved to "HelloWorld_cs_Fit_py.log"
```

## 21.2 Python and C API

### 21.2.1 addInput

Add input values for external model inputs.

If there are several measurement series, all series need to be conducted with the same external inputs!

#### Python

**Args:**

**var**
(str) Name of variable..

**values**
(np.array) Array of input values for respective time instants in *simodel.initialize()*.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.addInput(var, values)
```

#### C

```
oms_status_enu_t omsi_addInput(void* simodel, const char* var, const double* values,␣
↪size_t nValues);
```

### 21.2.2 addMeasurement

Add measurement values for a fitting variable.

#### Python

**Args:**

**iSeries**
(int) Index of measurement series.

**var**
(str) Name of variable..

**values**
(np.array) Array of measured values for respective time instants in *simodel.initialize()*.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.addMeasurement(iSeries, var, values)
```

#### C

```
oms_status_enu_t omsi_addMeasurement(void* simodel, size_t iSeries, const char* var,␣
↪const double* values, size_t nValues);
```

### 21.2.3 addParameter

Add parameter that should be estimated.

#### PYTHON

**Args:**

**var**
(str) Name of parameter.

**startvalue**
(float) Start value of parameter.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.addParameter(var, startvalue)
```

#### C

```
oms_status_enu_t omsi_addParameter(void* simodel, size_t iSeries, const char* var,␣
↪const double* values, size_t nValues);
```

### 21.2.4 describe

Print summary of SysIdent model.

#### PYTHON

```
status = simodel.describe()
```

#### C

```
oms_status_enu_t omsi_describe(void* simodel);
```

### 21.2.5 freeSysIdentModel

Unloads a model.

#### PYTHON

Not available in Python. Related external C function called by class destructor.

#### C

```
void omsi_freeSysIdentModel(void* simodel);
```

### 21.2.6 getParameter

Get parameter that should be estimated.

#### PYTHON

**Args:**

**var**
(str) Name of parameter.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

**startvalue**
(float) Start value of parameter.

**estimatedvalue**
(float) Estimated value of parameter.

```
status, startvalue, estimatedvalue = simodel.getParameter(var)
```

#### C

```
oms_status_enu_t omsi_getParameter(void* simodel, const char* var, double* startvalue,
↪ double* estimatedvalue);
```

### 21.2.7 getState

Get state of SysIdent model object.

#### PYTHON

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

**state**
(int) State of SysIdent model (*omsi_simodelstate_t*).

```
status, state = simodel.getState()
```

#### C

```
oms_status_enu_t omsi_getState(void* simodel, omsi_simodelstate_t* state);
```

### 21.2.8 initialize

This function initializes a given composite model. After this call, the model is in simulation mode.

#### PYTHON

**Args:**

**nSeries**
(int) Number of measurement series.

**time**
(numpy.array) Array of measurement/input time instants.

**inputvars**
(list of str) List of names of input variables (empty list if none).

**measurementvars**
(list of str) List of names of observed measurement variables.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.initalize(nSeries, time, inputvars, measurementvars)
```

#### C

```
oms_status_enu_t omsi_initialize(void* simodel, size_t nSeries, const double* time,␣
↪size_t nTime, char const* const* inputvars, size_t nInputvars, char const* const*␣
↪measurementvars, size_t nMeasurementvars);
```

### 21.2.9 newSysIdentModel

Creates an empty model for parameter estimation.

#### PYTHON

The corresponding Python function is the class constructor.

**Args:**

**ident**
(str) Name of the model instance.

**Returns:**

**simodel**
SysIdent model instance.

```
simodel = OMSysIdent(ident)
```

#### C

```
void* omsi_newSysIdentModel(const char* ident);
```

### 21.2.10 oms_status_str

Mapping of enum C-API status code (oms_status_enu_t) to string.

The C enum is reproduced below for convenience.

```
typedef enum {
  oms_status_ok,
  oms_status_warning,
  oms_status_discard,
  oms_status_error,
  oms_status_fatal,
  oms_status_pending
} oms_status_enu_t;
```

#### PYTHON

**Args:**

**status**
(int) The C-API status code.

**Returns:**

**status_str**
(str) String representation of status code.

The range of values of `status` corresponds to the C enum (by implicit conversion). This is a static Python method (`@staticmethod`).

```
status_str = oms_status_str(status)
```

#### C

Not available.

### 21.2.11 omsi_simodelstate_str

Mapping of enum C-API state code (omsi_simodelstate_t) to string.

The C enum is reproduced below for convenience.

```
typedef enum {
  omsi_simodelstate_constructed,    //!< After omsi_newSysIdentModel
  omsi_simodelstate_initialized,    //!< After omsi_initialize
  omsi_simodelstate_convergence,    //!< After omsi_solve if Ceres minimizer returned␣
↪with ceres::TerminationType::CONVERGENCE
  omsi_simodelstate_no_convergence, //!< After omsi_solve if Ceres minimizer returned␣
↪with ceres::TerminationType::NO_CONVERGENCE
  omsi_simodelstate_failure         //!< After omsi_solve if Ceres minimizer returned␣
↪with ceres::TerminationType::FAILURE
} omsi_simodelstate_t;
```

#### PYTHON

**Args:**

**state**
(int) State of SysIdent model.

**Returns:**

**simodelstate_str**
(str) String representation of state code.

The range of values of `state` corresponds to the C enum (by implicit conversion). This is a static Python method (`@staticmethod`).

```
simodelstate_str = omsi_simodelstate_str(state)
```

#### C

Not available.

### 21.2.12 setOptions_max_num_iterations

Set Ceres solver option *Solver::Options::max_num_iterations*.

#### PYTHON

**Args:**

**max_num_iterations**
(int) Maximum number of iterations for which the solver should run (default: 25).

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.setOptions_max_num_iterations(max_num_iterations)
```

#### C

```
oms_status_enu_t omsi_setOptions_max_num_iterations(void* simodel, size_t max_num_
↪iterations);
```

### 21.2.13 solve

Solve parameter estimation problem.

#### PYTHON

**Args:**

**reporttype**
(str) Print report and progress information after call to Ceres solver. Supported report types: *""*, *"BriefReport"*, *"FullReport"*, where *""* denotes no output.

**Returns:**

**status**
(int) The C-API status code (*oms_status_enu_t*).

```
status = simodel.solve(reporttype)
```

### C

```c
oms_status_enu_t omsi_solve(void* simodel, const char* reporttype);
```

CHAPTER

# TWENTYTWO

# OPENMODELICA ENCRYPTION

The encryption module allows the library developers to encrypt their libraries for different platforms. Note that you need a special version of OpenModelica with encryption support to do that, which is only released in binary form. This version contains an OpenModelica-specific private key that is used internally to decrypt the encrypted libraries for code generation only, not for display purposes.

If you are a library developer and are interested in distributing your library in encrypted form for use with OpenModelica, please contact us for further information. Please note that distributing the special version of OpenModelica with encryption support to the users of your library requires you to be a Level 2 member of the Open Source Modelica Consortium.

If you are a user of an encrypted library that is supported by OpenModelica, please contact your library supplier for information on how to get the special version of OpenModelica that runs it.

## 22.1 Encrypting the Library

In order to encrypt the Modelica package call *buildEncryptedPackage(TopLevelPackageName)* from mos script or from **OMEdit** right click the package in Libraries Browser and select *Export Encrypted Package* or select *Export > Export Encrypted Package* from the menu.

All the Modelica files are encrypted and the whole library is zipped into a single file i.e., *PackageName.mol*. Note that you can only encrypt Modelica packages saved in a folder structure. The complete folder structure remains as it is. No encryption is done on the resource files.

## 22.2 Loading an Encrypted Library

To load the encrypted package call *loadEncryptedPackage(EncryptedPackage.mol)* from the mos script or from **OMEdit** *File > Load Encrypted Package*.

## 22.3 Notes

- Encryption support in OpenModelica does not include any license management, i.e., restricting the usage of a certain libraries based on some conditions, e.g., having paid a fee. It is only meant to prevent end users from seeing the Modelica source code of the encrypted parts of the libraries, for reasons of confidentiality or IP protection.
- The parts of the library that are protected by encryption are specified by the access control annotations defined by the Modelica Language Specification, Section 18.9.
- The generated C code corresponding to the encrypted parts of the library is obfuscated: all comments are removed, and all component names are replaced by generic names such as n1, n2, n3, etc. This prevents easy reverse-engineering of the encrypted library starting from generated simulation code.
- Encryption in OpenModelica is based on the SEMLA (Standardized Encryption of Modelica Libraries and Artifacts) module from Modelon AB, which provides a tool-independent framework for Modelica library encryption.

CHAPTER

# TWENTYTHREE

# OMNOTEBOOK WITH DRMODELICA AND DRCONTROL

This chapter covers the OpenModelica electronic notebook subsystem, called OMNotebook, together with the DrModelica tutoring system for teaching Modelica, and DrControl for teaching control together with Modelica. Both are using such notebooks.

## 23.1 Interactive Notebooks with Literate Programming

Interactive Electronic Notebooks are active documents that may contain technical computations and text, as well as graphics. Hence, these documents are suitable to be used for teaching and experimentation, simulation scripting, model documentation and storage, etc.

### 23.1.1 Mathematica Notebooks

Literate Programming [Knu84] is a form of programming where programs are integrated with documentation in the same document. Mathematica notebooks [Wol96] is one of the first WYSIWYG (What-You-See-Is-What-You-Get) systems that support Literate Programming. Such notebooks are used, e.g., in the MathModelica modeling and simulation environment, see e.g. Figure 23.1 below and Chapter 19 in [Fri04].

### 23.1.2 OMNotebook

The OMNotebook software [Axe05, Fernstrom06] is a new open source free software that gives an interactive WYSIWYG realization of Literate Programming, a form of programming where programs are integrated with documentation in the same document.

The OMNotebook facility is actually an interactive WYSIWYG realization of Literate Programming, a form of programming where programs are integrated with documentation in the same document. OMNotebook is a simple open-source software tool for an electronic notebook supporting Modelica.

A more advanced electronic notebook tool, also supporting mathematical typesetting and many other facilities, is provided by Mathematica notebooks in the MathModelica environment, see Figure 23.1.

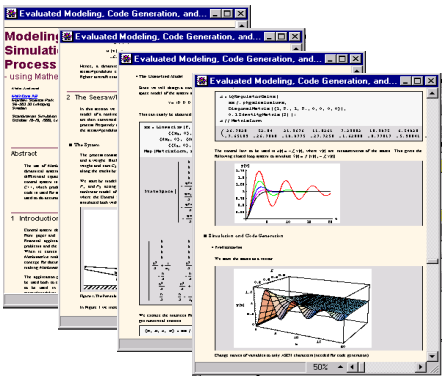



Figure 23.1: Examples of Mathematica notebooks in the MathModelica modeling and simulation environment.

Traditional documents, e.g. books and reports, essentially always have a hierarchical structure. They are divided into sections, subsections, paragraphs, etc. Both the document itself and its sections usually have headings as labels for easier navigation. This kind of structure is also reflected in electronic notebooks. Every notebook corresponds to one document (one file) and contains a tree structure of cells. A cell can have different kinds of contents, and can even contain other cells. The notebook hierarchy of cells thus reflects the hierarchy of sections and subsections in a traditional document such as a book.

## 23.2 DrModelica Tutoring System - an Application of OMNotebook

Understanding programs is hard, especially code written by someone else. For educational purposes it is essential to be able to show the source code and to give an explanation of it at the same time.

Moreover, it is important to show the result of the source code's execution. In modeling and simulation it is also important to have the source code, the documentation about the source code, the execution results of the simulation model, and the documentation of the simulation results in the same document. The reason is that the problem solving process in computational simulation is an iterative process that often requires a modification of the original mathematical model and its software implementation after the interpretation and validation of the computed results corresponding to an initial model.

Most of the environments associated with equation-based modeling languages focus more on providing efficient numerical algorithms rather than giving attention to the aspects that should facilitate the learning and teaching of the language. There is a need for an environment facilitating the learning and understanding of Modelica. These are the reasons for developing the DrModelica teaching material for Modelica and for teaching modeling and simulation.

An earlier version of DrModelica was developed using the MathModelica (now Wolfram SystemModeler) environment. The rest of this chapter is concerned with the OMNotebook version of DrModelica and on the OMNotebook tool itself.

DrModelica has a hierarchical structure represented as notebooks. The front-page notebook is similar to a table of contents that holds all other notebooks together by providing links to them. This particular notebook is the first page the user will see (Figure 23.2).

In each chapter of DrModelica the user is presented a short summary of the corresponding chapter of the Modelica book [Fri04]. The summary introduces some *keywords*, being hyperlinks that will lead the user to other notebooks describing the keywords in detail.

Now, let us consider that the link "*HelloWorld*" in DrModelica Section is clicked by the user. The new HelloWorld notebook (see Figure 23.3), to which the user is being linked, is not only a textual description but also contains one or more examples explaining the specific keyword. In this class, HelloWorld, a differential equation is specified.

No information in a notebook is fixed, which implies that the user can add, change, or remove anything in a notebook. Alternatively, the user can create an entirely new notebook in order to write his/her own programs or copy examples from other notebooks. This new notebook can be linked from existing notebooks.

When a class has been successfully evaluated the user can simulate and plot the result, as previously depicted in Figure 23.3 for the simple HelloWorld example model.

After reading a chapter in DrModelica the user can immediately practice the newly acquired information by doing the exercises that concern the specific chapter. Exercises have been written in order to elucidate language constructs step by step based on the pedagogical assumption that a student learns better "*using the strategy of learning by doing*". The exercises consist of either theoretical questions or practical programming assignments. All exercises provide answers in order to give the user immediate feedback.

Figure 23.4 shows part of Chapter 9 of the DrModelica teaching material. Here the user can read about language constructs, like algorithm sections, when-statements, and reinit equations, and then practice these constructs by solving the exercises corresponding to the recently studied section.

Exercise 1 from Chapter 9 is shown in Figure 23.5. In this exercise the user has the opportunity to practice different language constructs and then compare the solution to the answer for the exercise. Notice that the answer is not visible until the *Answer* section is expanded. The answer is shown in Figure 23.6.

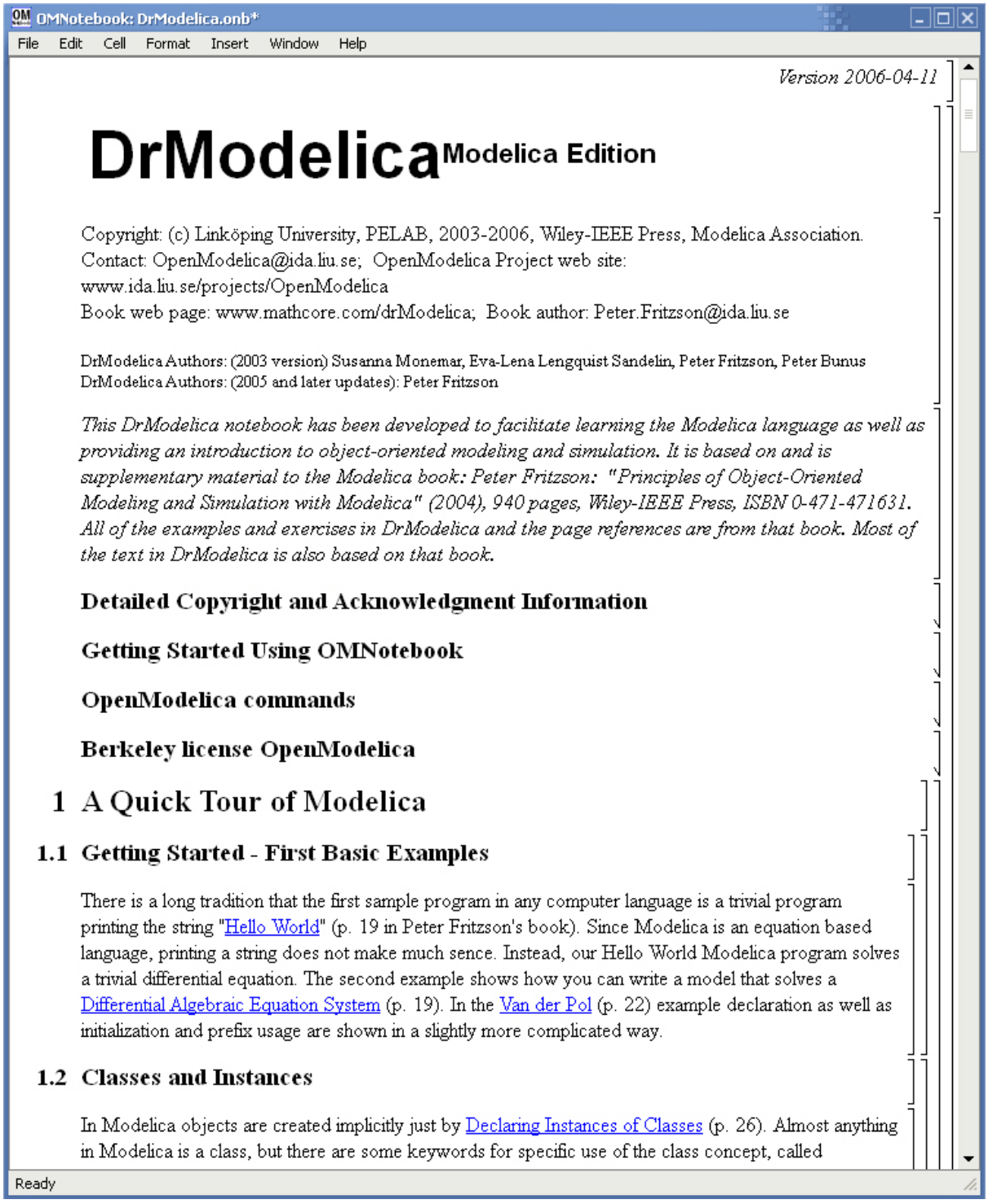



Figure 23.2: The front-page notebook of the OMNotebook version of the DrModelica tutoring system.

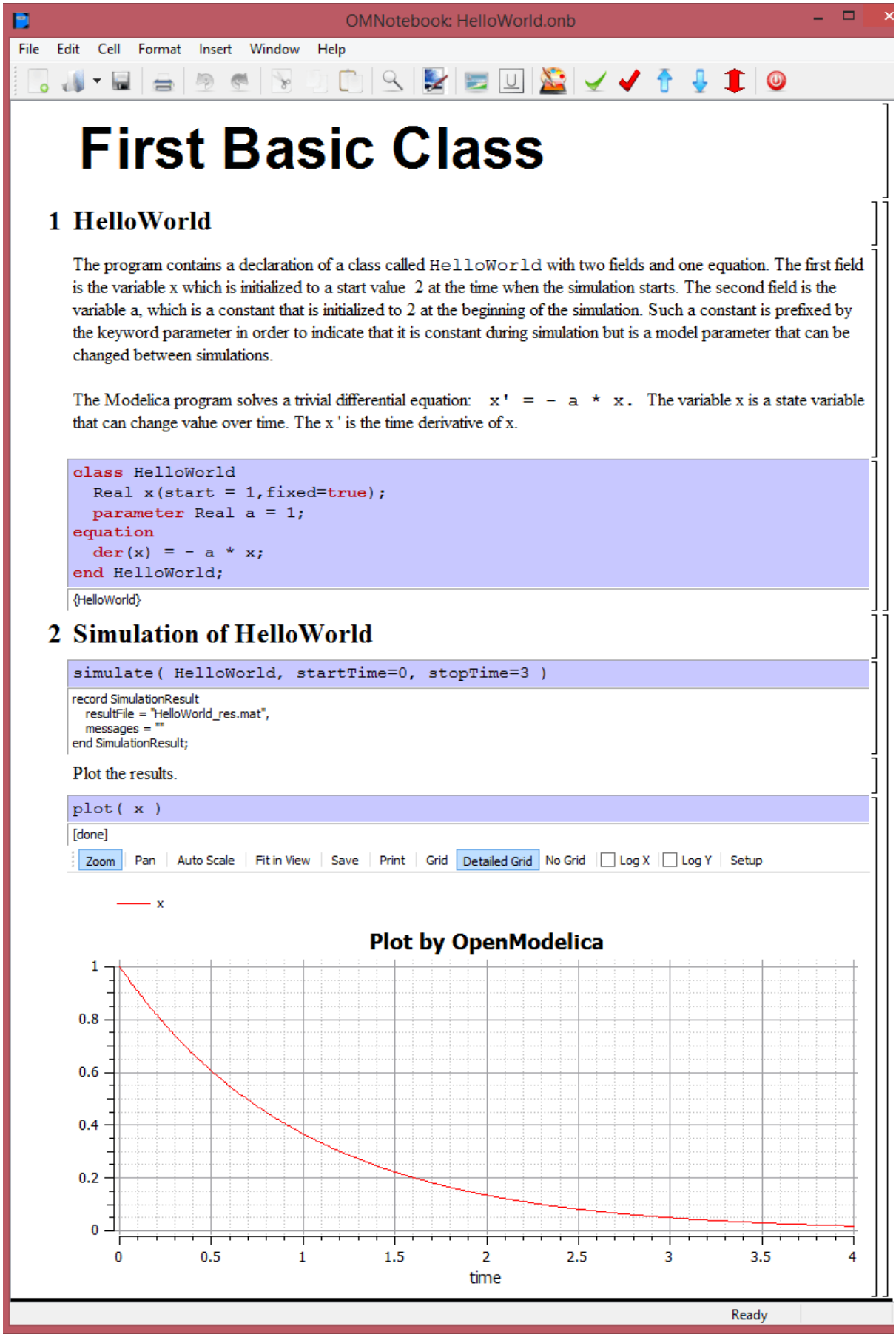



Figure 23.3: The HelloWorld class simulated and plotted using the OMNotebook version of DrModelica.

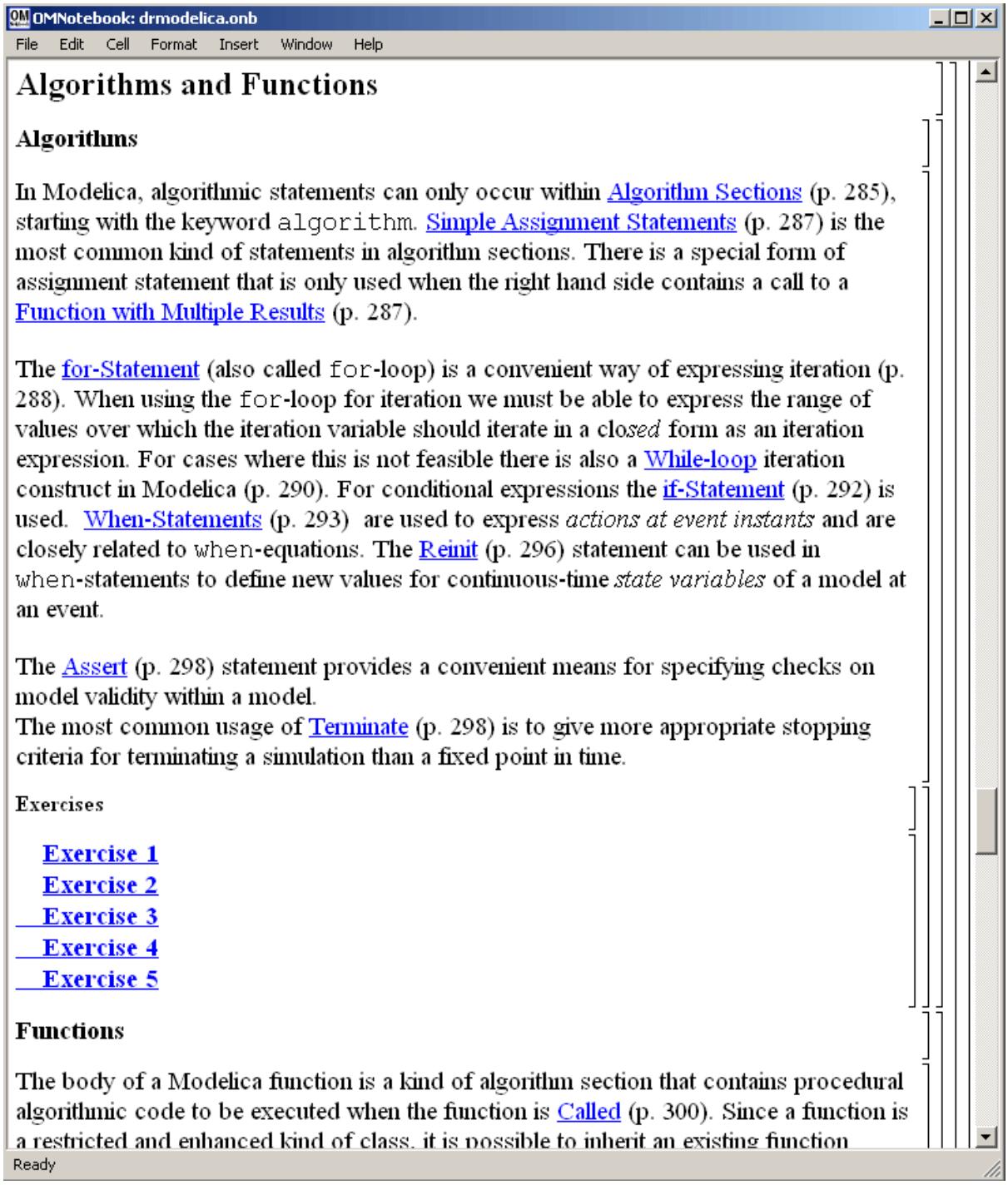



Figure 23.4: DrModelica Chapter on Algorithms and Functions in the main page of the OMNotebook version of DrModelica.

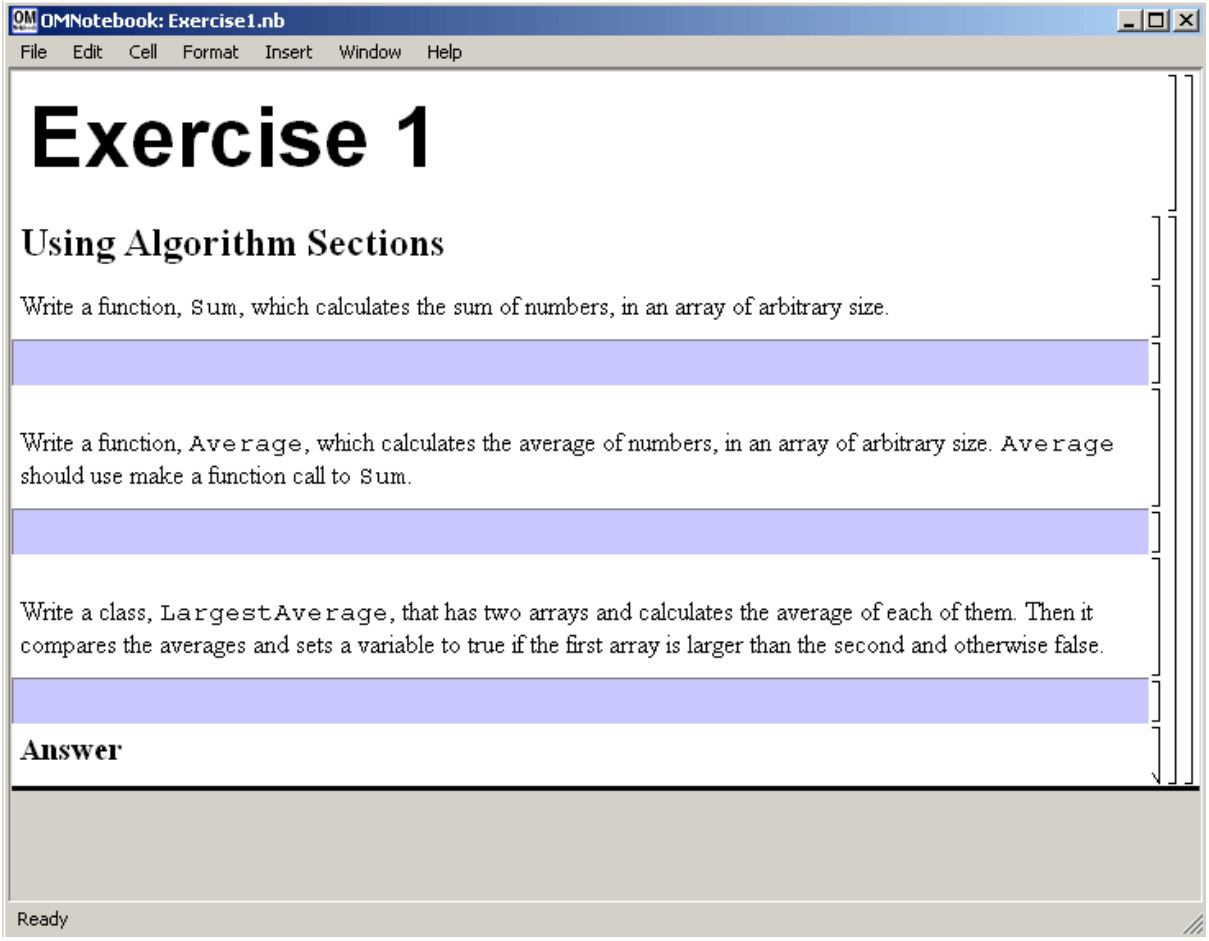



Figure 23.5: Exercise 1 in Chapter 9 of DrModelica.

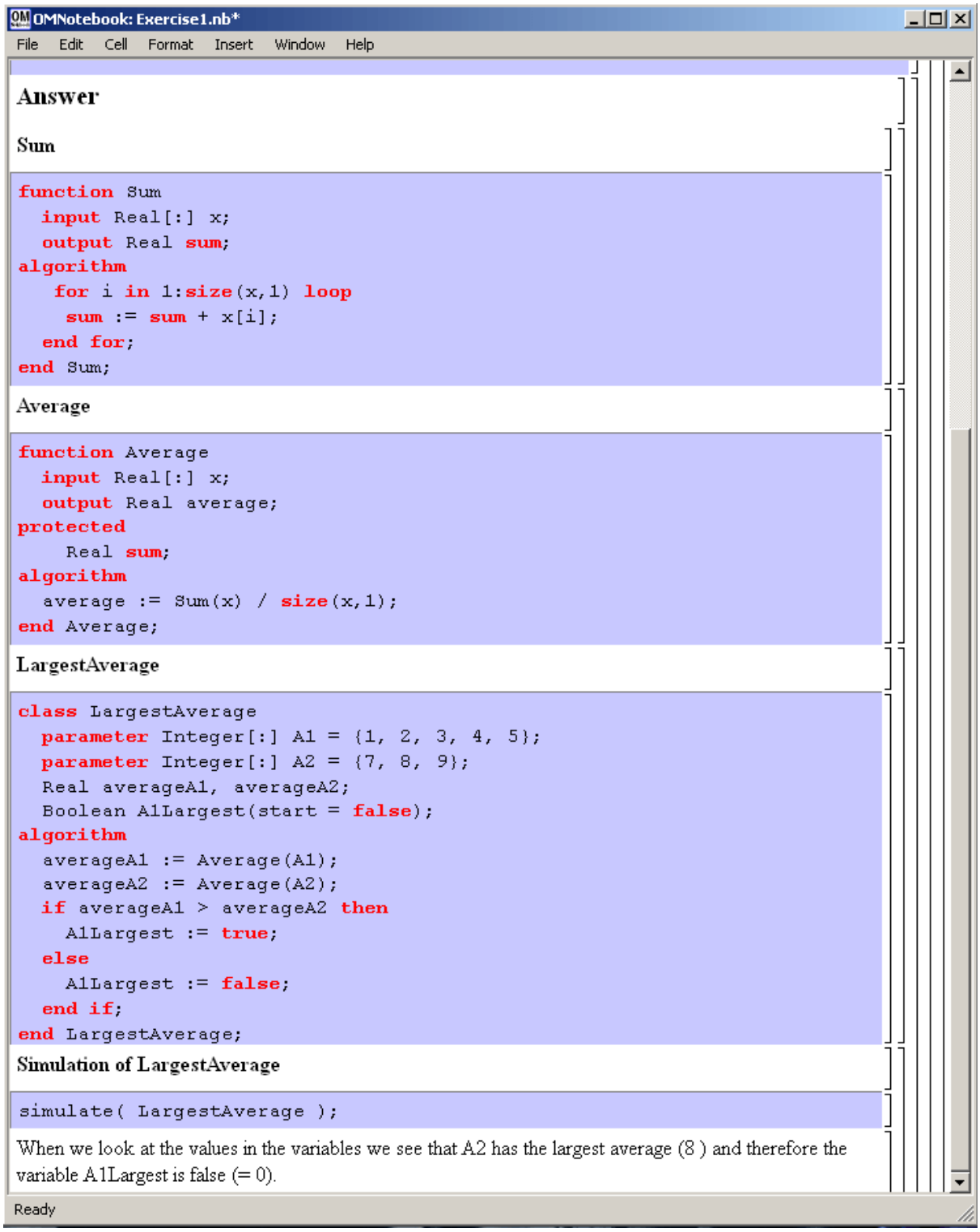



Figure 23.6: The answer section to Exercise 1 in Chapter 9 of DrModelica.

## 23.3 DrControl Tutorial for Teaching Control Theory

DrControl is an interactive OMNotebook document aimed at teaching control theory. It is included in the OpenModelica distribution and appears under the directory:

```
>>> getInstallationDirectoryPath() + "/share/omnotebook/drcontrol"
"«OPENMODELICAHOME»/share/omnotebook/drcontrol"
```

The front-page of DrControl resembles a linked table of content that can be used as a navigation center. The content list contains topics like:

- Getting started
- The control problem in ordinary life
- Feedback loop
- Mathematical modeling
- Transfer function
- Stability
- Example of controlling a DC-motor
- Feedforward compensation
- State-space form
- State observation
- Closed loop control system.
- Reconstructed system
- Linear quadratic optimization
- Linearization

Each entry in this list leads to a new notebook page where either the theory is explained with Modelica examples or an exercise with a solution is provided to illustrate the background theory. Below we show a few sections of DrControl.

### 23.3.1 Feedback Loop

One of the basic concepts of control theory is using feedback loops either for neutralizing the disturbances from the surroundings or a desire for a smoother output.

In Figure 23.7, control of a simple car model is illustrated where the car velocity on a road is controlled, first with an open loop control, and then compared to a closed loop system with a feedback loop. The car has a mass m, velocity y, and aerodynamic coefficient $\alpha$. The $\vartheta$ is the road slope, which in this case can be regarded as noise.

Lets look at the Modelica model for the open loop controlled car:

$$m\dot{y} = u - \alpha y - mg * sin(\theta)$$

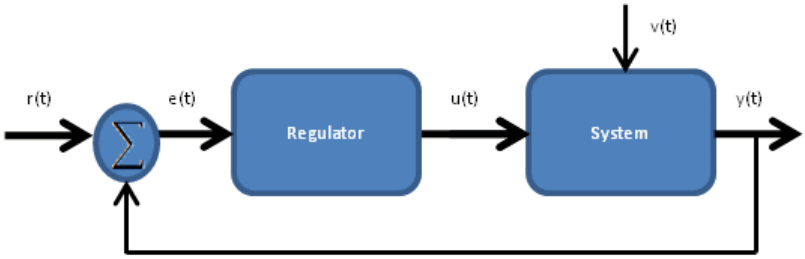
```
model noFeedback
  import SI = Modelica.SIunits;
  SI.Velocity y;                              // output signal without noise, theta =␣
↪0 -> v(t) = 0
  SI.Velocity yNoise;                         // output signal with noise,    theta <>
↪ 0 -> v(t) <> 0
  parameter SI.Mass m = 1500;
  parameter Real alpha = 200;
  parameter SI.Angle theta = 5*3.141592/180;
```

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File Edit Cell Format Insert Window Help

# Feedback

One important method in designing control system is a feedback loop. It can be used to eliminate the influence of noise or to decrease the output error.

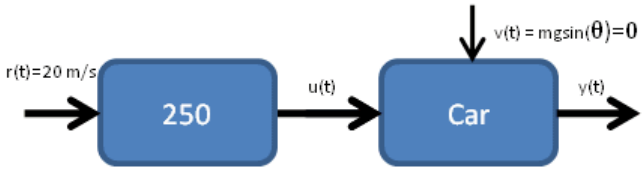



## 1 Example

Assume that we want to control the speed of a car on the road. The car has a mass m, velocity y, and aerodynamic coefficient α. The θ is the road slope, which in this case can be regarded as noise.

$$m\dot{y} = u - \alpha y - mgsin(\theta)$$

If we want a reference speed of 20 m/s for a car with m=1500 kg, α=250 Ns/m, θ=0 rad, how high should the amplification factor be in the regulator?
Try with u = 250*r.




### 1.1 Open Loop

```
loadModel(Modelica)
```

```
true
```

```
model noFeedback
  import SI = Modelica.SIunits;
  SI.Velocity y;                                  // output signal without
noise, theta = 0 -> v(t) = 0
  SI.Velocity yNoise;                             // output signal with noise
```

Figure 23.7: Feedback loop.

(continued from previous page)

```
  parameter SI.Acceleration g = 9.82;
  SI.Force u;
  SI.Velocity r=20;
equation
  m*der(y)=u-alpha*y;                          // signal without noise
  m*der(yNoise)=u-alpha*yNoise-m*g*sin(theta); // with noise
  u = 250*r;
end noFeedback;
```

By applying a road slope angle different from zero the car velocity is influenced which can be regarded as noise in this model. The output signal in `omnotebook-open-loop` is stable but an overshoot can be observed compared to the reference signal. Naturally the overshoot is not desired and the student will in the next exercise learn how to get rid of this undesired behavior of the system.

```
>>> loadModel(Modelica, {"3.2.3"})
true
>>> simulate(noFeedback, stopTime=100)
record SimulationResult
    resultFile = "",
    simulationOptions = "startTime = 0.0, stopTime = 100.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'noFeedback', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "Failed to build model: noFeedback",
    timeFrontend = 0.0,
    timeBackend = 0.0,
    timeSimCode = 0.0,
    timeTemplates = 0.0,
    timeCompile = 0.0,
    timeSimulation = 0.0,
    timeTotal = 0.0
end SimulationResult;
```

**Error**

[<interactive>:2:3-2:31:writable] Error: Import Modelica.SIunits not found in scope <top>.

[<interactive>:3:3-3:16:writable] Error: Class SI.Velocity not found in scope noFeedback.

**Error**

Unable to execute gnuplot directive

expected str, bytes or os.PathLike object, not NoneType Traceback (most recent call last): File "/var/lib/jenkins/ws/OpenModelica/build_usersguide/source/sphinxcontribopenmodelica.py", line 290, in run filename = os.path.abspath(self.options.get('filename') or sendExpression("currentSimulationResult")) ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ File "<frozen posixpath>", line 415, in abspath TypeError: expected str, bytes or os.PathLike object, not NoneType

The closed car model with a proportional regulator is shown below:

$$u = K * (r - y)$$

```
model withFeedback
  import SI = Modelica.SIunits;
  SI.Velocity y;                                  // output signal with feedback link␣
↪and without noise, theta = 0 -> v(t) = 0
  SI.Velocity yNoise;                             // output signal with feedback link␣
↪and noise,    theta <> 0 -> v(t) <> 0
  parameter SI.Mass m = 1500;
  parameter Real alpha = 250;
  parameter SI.Angle theta = 5*3.141592/180;
  parameter SI.Acceleration g = 9.82;
  SI.Force u;
  SI.Force uNoise;
  SI.Velocity r=20;
equation
  m*der(y)=u-alpha*y;
  m*der(yNoise)=uNoise-alpha*yNoise-m*g*sin(theta);
  u = 5000*(r-y);
  uNoise = 5000*(r-yNoise);
end withFeedback;
```

**Error**

[<interactive>:1:1-1:0:writable] Error: Variable currentSimulationResult not found in scope <global scope>.

By using the information about the current level of the output signal and re-tune the regulator the output quantity can be controlled towards the reference signal smoothly and without an overshoot, as shown in `omnotebook-closed-loop`.

In the above simple example the flat modeling approach was adopted since it was the fastest one to quickly obtain a working model. However, one could use the object oriented approach and encapsulate the car and regulator models in separate classes with the Modelica connector mechanism in between.

```
>>> loadModel(Modelica, {"3.2.3"})
true
>>> simulate(withFeedback, stopTime=10)
record SimulationResult
    resultFile = "",
    simulationOptions = "startTime = 0.0, stopTime = 10.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'withFeedback', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "Failed to build model: withFeedback",
    timeFrontend = 0.0,
    timeBackend = 0.0,
    timeSimCode = 0.0,
    timeTemplates = 0.0,
    timeCompile = 0.0,
    timeSimulation = 0.0,
    timeTotal = 0.0
end SimulationResult;
```

**Error**

[<interactive>:2:3-2:31:writable] Error: Import Modelica.SIunits not found in scope <top>.

[<interactive>:3:3-3:16:writable] Error: Class SI.Velocity not found in scope withFeedback.

**Error**

Unable to execute gnuplot directive

expected str, bytes or os.PathLike object, not NoneType Traceback (most recent call last): File "/var/lib/jenkins/ws/OpenModelica/build_usersguide/source/sphinxcontribopenmodelica.py", line 290, in run filename = os.path.abspath(self.options.get('filename') or sendExpression("currentSimulationResult")) ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

File "<frozen posixpath>", line 415, in abspath TypeError: expected str, bytes or os.PathLike object, not NoneType

### 23.3.2 Mathematical Modeling with Characteristic Equations

In most systems the relation between the inputs and outputs can be described by a linear differential equation. Tearing apart the solution of the differential equation into homogenous and particular parts is an important technique taught to the students in engineering courses, also illustrated in Figure 23.8.

$$\frac{\partial^n y}{\partial t^n} + a_1 \frac{\partial^{n-1} y}{\partial t^{n-1}} + \ldots + a_n y = b_0 \frac{\partial^m u}{\partial t^m} + \ldots + b_{m-1} \frac{\partial u}{\partial t} + b_m u$$

Now let us examine a second order system:

$$\ddot{y} + a_1 \dot{y} + a_2 y = 1$$

```
model NegRoots
  Real y;
  Real der_y;
  parameter Real a1 = 3;
  parameter Real a2 = 2;
equation
  der_y = der(y);
  der(der_y) + a1*der_y + a2*y = 1;
end NegRoots;
```

**Error**

[<interactive>:1:1-1:0:writable] Error: Variable currentSimulationResult not found in scope <global scope>.

Choosing different values for $a_1$ and $a_2$ leads to different behavior as shown in Figure 23.9 and Figure 23.10.

In the first example the values of $a_1$ and $a_2$ are chosen in such way that the characteristic equation has negative real roots and thereby a stable output response, see Figure 23.9.

```
>>> simulate(NegRoots, stopTime=10)
record SimulationResult
    resultFile = "«DOCHOME»/NegRoots_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 10.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'NegRoots', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info     | The initialization finished␣
↪successfully without homotopy method.
```

(continues on next page)

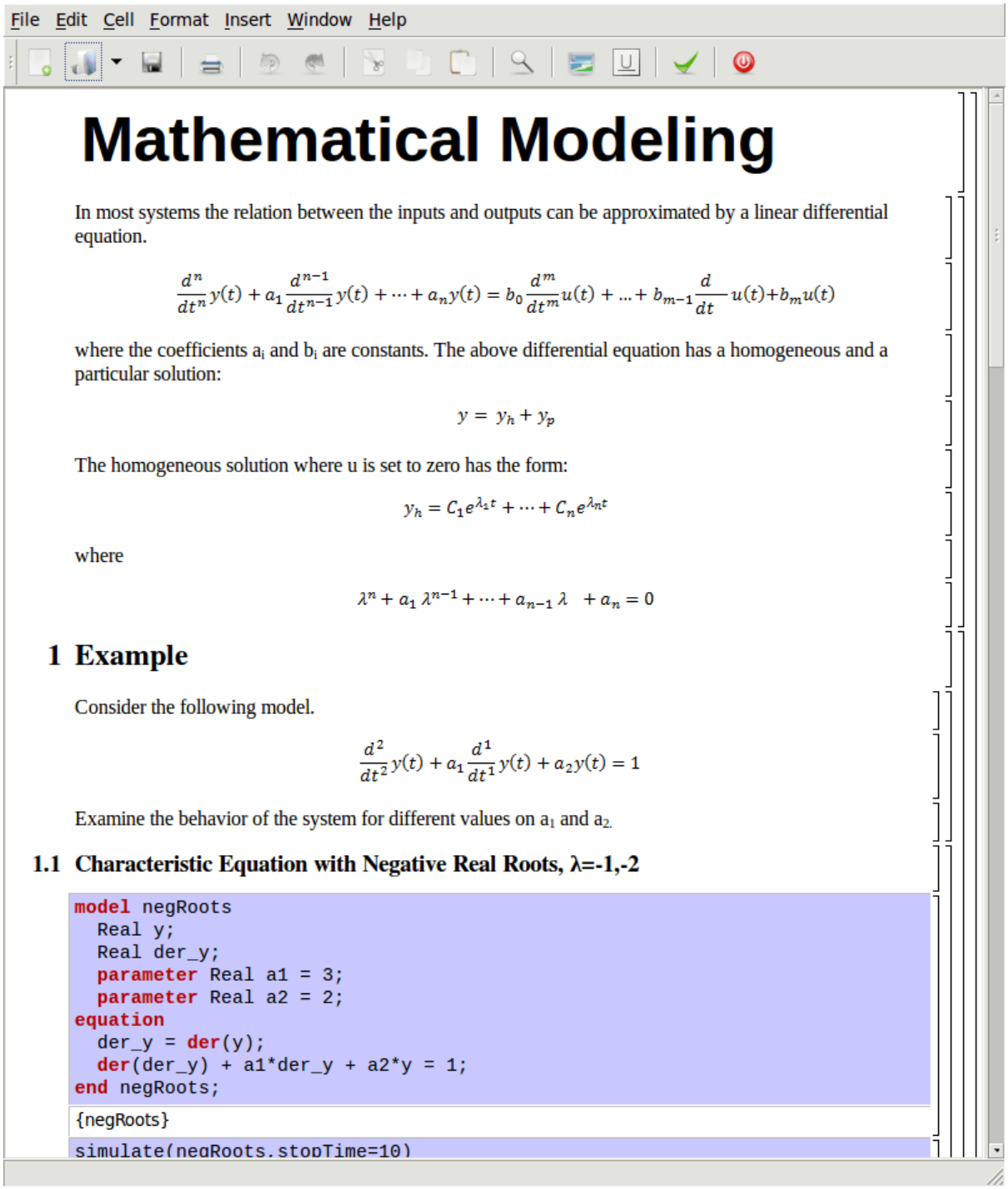



Figure 23.8: Mathematical modeling with characteristic equation.

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```
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.002484917,
    timeBackend = 0.005126339000000001,
    timeSimCode = 9.84794e-4,
    timeTemplates = 0.003510584,
    timeCompile = 0.4288276689999999,
    timeSimulation = 0.013770006000000001,
    timeTotal = 0.45480034699999994
end SimulationResult;
```

**Warning**

Warning: The initial conditions are not fully specified. For more information set -d=initialization. In OMEdit Tools->Options->Simulation->Show additional information from the initialization process, in OMNotebook call setCommandLineOptions("-d=initialization").

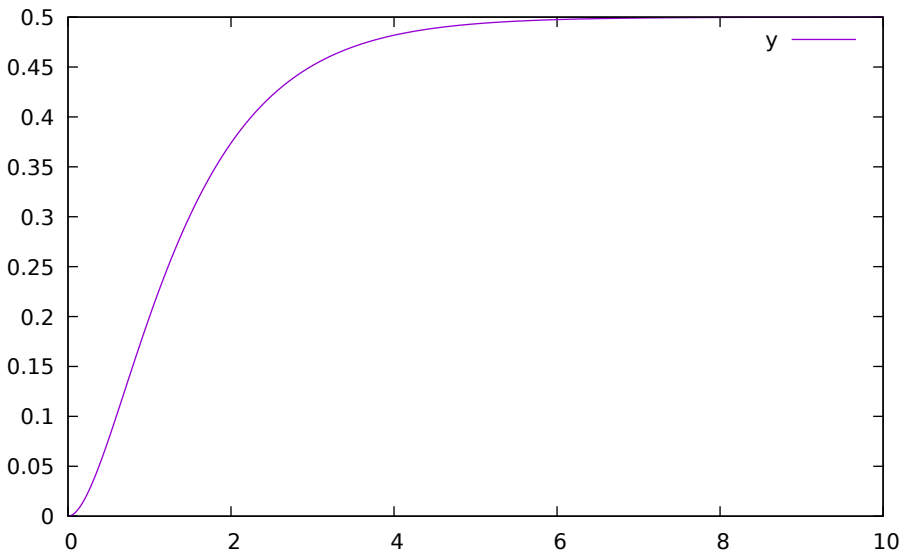



Figure 23.9: Characteristic equation with real negative roots.

The importance of the sign of the roots in the characteristic equation is illustrated in Figure 23.9 and Figure 23.10, e.g., a stable system with negative real roots and an unstable system with positive imaginary roots resulting in oscillations.

```
model ImgPosRoots
  Real y;
  Real der_y;
  parameter Real a1 = -2;
  parameter Real a2 = 10;
equation
  der_y = der(y);
  der(der_y) + a1*der_y + a2*y = 1;
end ImgPosRoots;
```

```
>>> simulate(ImgPosRoots, stopTime=10)
record SimulationResult
    resultFile = "«DOCHOME»/ImgPosRoots_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 10.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'ImgPosRoots', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.0038273480000000004,
    timeBackend = 0.008057402,
    timeSimCode = 0.0012511500000000001,
    timeTemplates = 0.0035677350000000003,
    timeCompile = 0.43808200700000005,
    timeSimulation = 0.009990181,
    timeTotal = 0.46490467700000004
end SimulationResult;
```

**Warning**

Warning: The initial conditions are not fully specified. For more information set -d=initialization. In OMEdit Tools->Options->Simulation->Show additional information from the initialization process, in OMNotebook call setCommandLineOptions("-d=initialization").

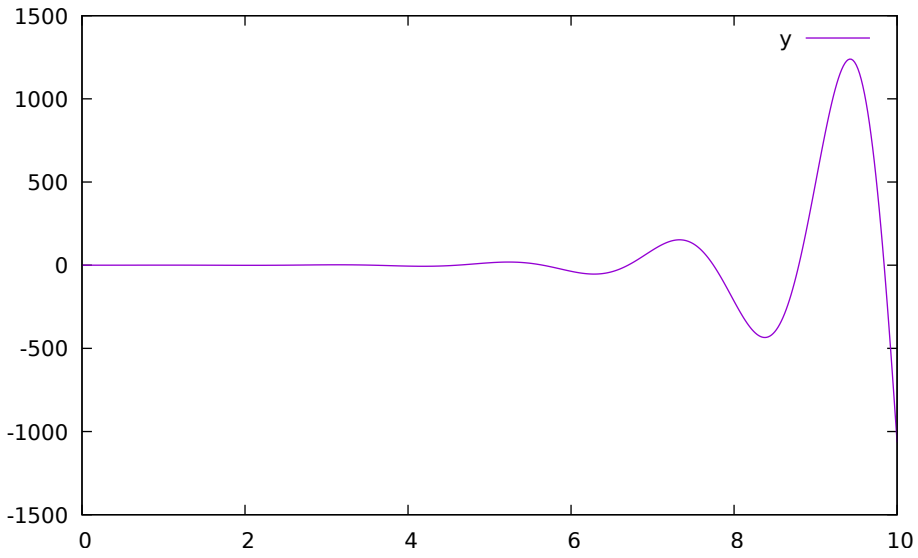



Figure 23.10: Characteristic equation with imaginary roots with positive real part.

The theory and application of Kalman filters is also explained in the interactive course material.

In reality noise is present in almost every physical system under study and therefore the concept of noise is also introduced in the course material, which is purely Modelica based.

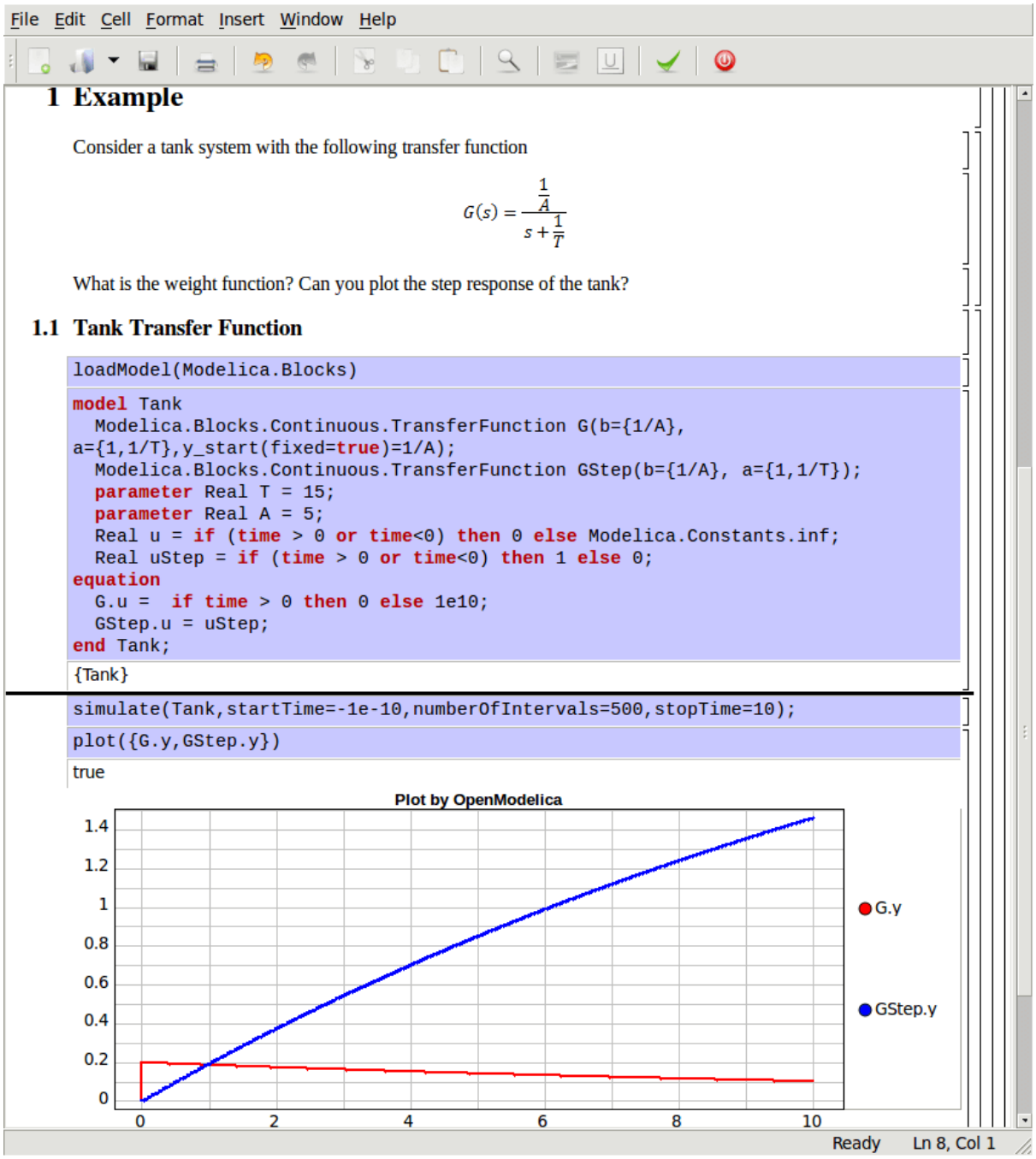



Figure 23.11: Step and pulse (weight function) response.

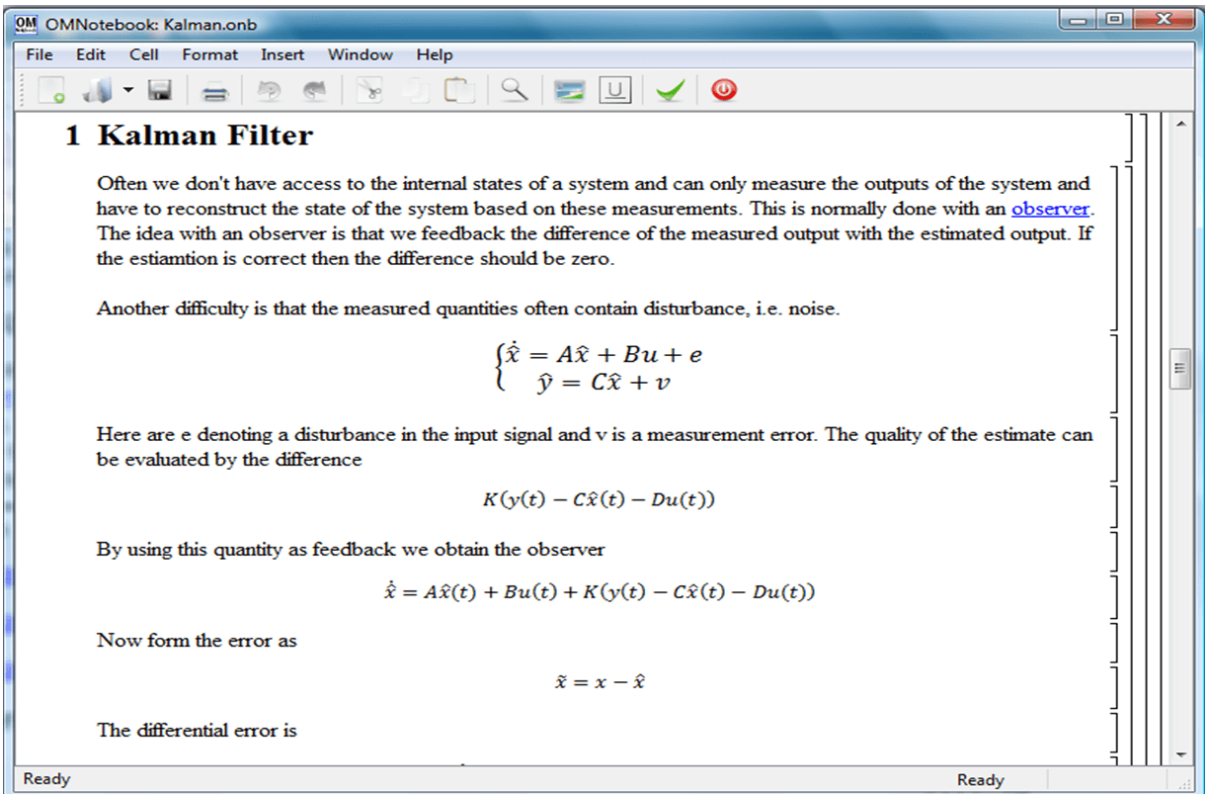



Figure 23.12: Theory background about Kalman filter.

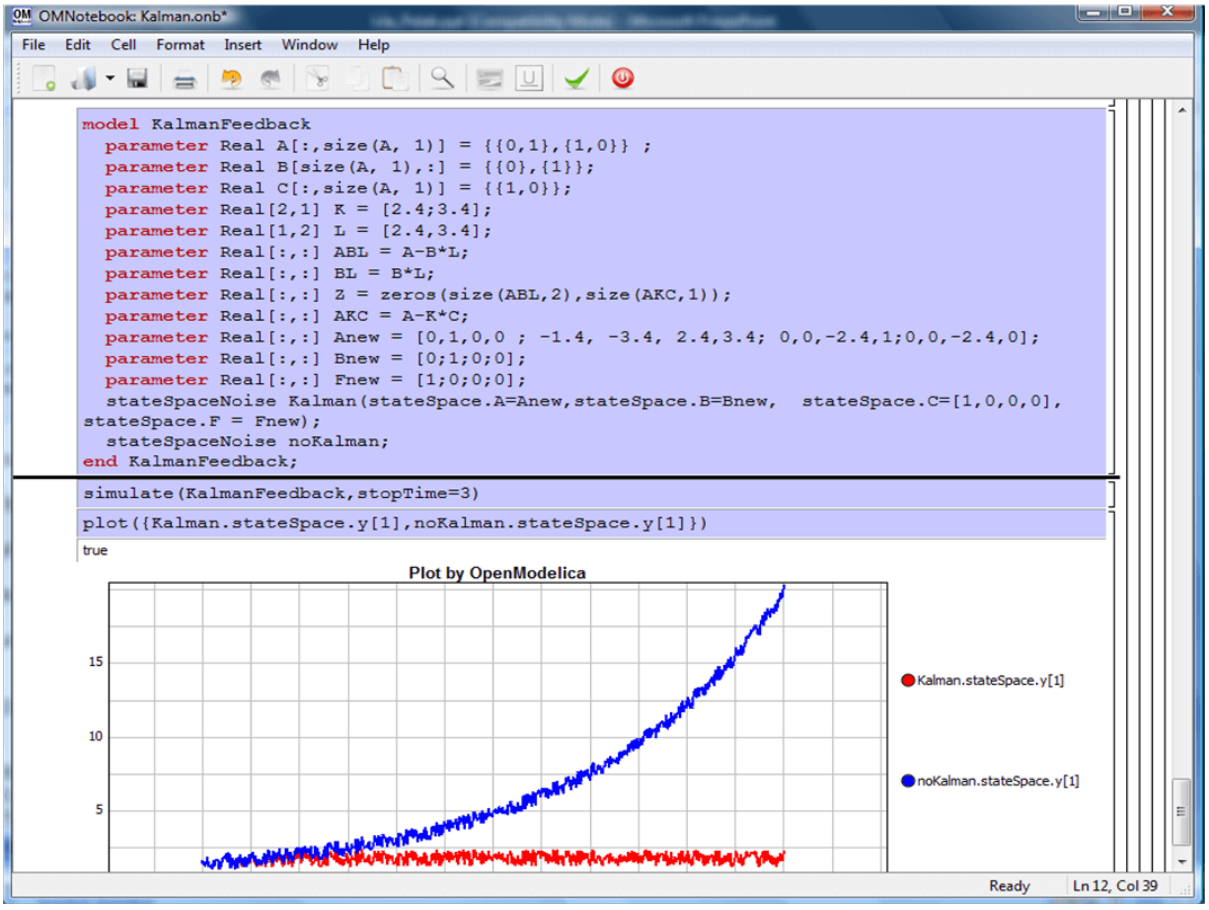



Figure 23.13: Comparison of a noisy system with feedback link in DrControl.

## 23.4 OpenModelica Notebook Commands

OMNotebook currently supports the commands and concepts that are described in this section.

### 23.4.1 Cells

Everything inside an OMNotebook document is made out of cells. A cell basically contains a chunk of data. That data can be text, images, or other cells. OMNotebook has four types of cells: headercell, textcell, inputcell, and groupcell. Cells are ordered in a tree structure, where one cell can be a parent to one or more additional cells. A tree view is available close to the right border in the notebook window to display the relation between the cells.

- ***Textcell* - This cell type is used to display ordinary text and**
  images. Each textcell has a style that specifies how text is displayed. The cell´s style can be changed in the menu Format->Styles, example of different styles are: Text, Title, and Subtitle. The Textcell type also has support for following links to other notebook documents.
- ***Inputcell* - This cell type has support for syntax highlighting and**
  evaluation. It is intended to be used for writing program code, e.g. Modelica code. Evaluation is done by pressing the key combination Shift+Return or Shift+Enter. All the text in the cell is sent to OMC (OpenModelica Compiler/interpreter), where the text is evaluated and the result is displayed below the inputcell. By double-clicking on the cell marker in the tree view, the inputcell can be collapsed causing the result to be hidden.
- ***Latexcell* - This cell type has support for evaluation of latex scripts.**
  It is intended to be mainly used for writing mathematical equations and formulas for advanced documentation in OMNotebook. Each Latexcell supports a maximum of one page document output.To evaluate this cell, latex must be installed in your system.The users can copy and paste the latex scripts and start the evaluation.Evaluation is done by pressing the key combination Shift+Return or Shift+Enter or the green color eval button present in the toolbar. The script in the cell is sent to latex compiler, where it is evaluated and the output is displayed hiding the latex source. By double-clicking on the cell marker in the tree view,the latex source is displayed for further modification.
- ***Groupcell* - This cell type is used to group together other cell. A**
  groupcell can be opened or closed. When a groupcell is opened all the cells inside the groupcell are visible, but when the groupcell is closed only the first cell inside the groupcell is visible. The state of the groupcell is changed by the user double-clicking on the cell marker in the tree view. When the groupcell is closed the marker is changed and the marker has an arrow at the bottom.

### 23.4.2 Cursors

An OMNotebook document contains cells which in turn contain text. Thus, two kinds of cursors are needed for positioning, text cursor and cell cursor:

- ***Textcursor* - A cursor between characters in a cell, appearing as a**
  small vertical line. Position the cursor by clicking on the text or using the arrow buttons.
- ***Cellcursor* - This cursor shows which cell currently has the input**
  focus. It consists of two parts. The main cellcursor is basically just a thin black horizontal line below the cell with input focus. The cellcursor is positioned by clicking on a cell, clicking between cells, or using the menu item Cell->Next Cell or Cell->Previous Cell. The cursor can also be moved with the key combination Ctrl+Up or Ctrl+Down. The dynamic cellcursor is a short blinking horizontal line. To make this visible, you must click once more on the main cellcursor (the long horizontal line). NOTE: In order to paste cells at the cellcursor, the *dynamic cellcursor must be made active* by clicking on the main cellcursor (the horizontal line).

### 23.4.3 Selection of Text or Cells

To perform operations on text or cells we often need to select a range of characters or cells.

- ***Select characters* - There are several ways of selecting characters,**
  e.g. double-clicking on a word, clicking and dragging the mouse, or click followed by a shift-click at

an adjacent positioin selects the text between the previous click and the position of the most recent shift-click.

- ***Select cells* - Cells can be selected by clicking on them. Holding**
  down Ctrl and clicking on the cell markers in the tree view allows several cells to be selected, one at a time. Several cells can be selected at once in the tree view by holding down the Shift key. Holding down Shift selects all cells between last selected cell and the cell clicked on. This only works if both cells belong to the same groupcell.

### 23.4.4 File Menu

The following file related operations are available in the file menu:

- ***Create a new notebook* - A new notebook can be created using the**
  menu File->New or the key combination Ctrl+N. A new document window will then open, with a new document inside.
- ***Open a notebook* - To open a notebook use File->Open in the menu or**
  the key combination Ctrl+O. Only files of the type .onb or .nb can be opened. If a file does not follow the OMNotebook format or the FullForm Mathematica Notebook format, a message box is displayed telling the user what is wrong. Mathematica Notebooks must be converted to fullform before they can be opened in OMNotebook.
- ***Save a notebook* - To save a notebook use the menu item File->Save**
  or File->Save As. If the notebook has not been saved before the save as dialog is shown and a filename can be selected. OMNotebook can only save in xml format and the saved file is not compatible with Mathematica. Key combination for save is Ctrl+S and for save as Ctrl+Shift+S. The saved file by default obtains the file extension .onb.
- ***Print* - Printing a document to a printer is done by pressing the**
  key combination Ctrl+P or using the menu item File->Print. A normal print dialog is displayed where the usually properties can be changed.
- ***Import old document* - Old documents, saved with the old version of**
  OMNotebook where a different file format was used, can be opened using the menu item File->Import->Old OMNotebook file. Old documents have the extension .xml.
- ***Export text* - The text inside a document can be exported to a text**
  document. The text is exported to this document without almost any structure saved. The only structure that is saved is the cell structure. Each paragraph in the text document will contain text from one cell. To use the export function, use menu item File->Export->Pure Text.
- ***Close a notebook window* - A notebook window can be closed using the**
  menu item File->Close or the key combination Ctrl+F4. Any unsaved changes in the document are lost when the notebook window is closed.
- ***Quitting OMNotebook* - To quit OMNotebook, use menu item File->Quit**
  or the key combination Crtl+Q. This closes all notebook windows; users will have the option of closing OMC also. OMC will not automatically shutdown because other programs may still use it. Evaluating the command quit() has the same result as exiting OMNotebook.

### 23.4.5 Edit Menu

- ***Editing cell text* - Cells have a set of of basic editing functions.**
  The key combination for these are: Undo (Ctrl+Z), Redo (Ctrl+Y), Cut (Ctrl+X), Copy (Ctrl+C) and Paste (Ctrl+V). These functions can also be accessed from the edit menu; Undo (Edit->Undo), Redo (Edit->Redo), Cut (Edit->Cut), Copy (Edit->Copy) and Paste (Edit->Paste). Selection of text is done in the usual way by double-clicking, triple-clicking (select a paragraph), dragging the mouse, or using (Ctrl+A) to select all text within the cell.
- ***Cut cell* - Cells can be cut from a document with the menu item**
  Edit->Cut or the key combination Ctrl+X. The cut function will always cut cells if cells have been selected in the tree view, otherwise the cut function cuts text.

- *Copy cell* - **Cells can be copied from a document with the menu item**
  Edit->Copy or the key combination Ctrl+C. The copy function will always copy cells if cells have been selected in the tree view, otherwise the copy function copy text.
- *Paste cell* - **To paste copied or cut cells the cell cursor must be**
  selected in the location where the cells should be pasted. This is done by clicking on the cell cursor. Pasteing cells is done from the menu Edit->Paste or the key combination Ctrl+V. If the cell cursor is selected the paste function will always paste cells. OMNotebook share the same application-wide clipboard. Therefore cells that have been copied from one document can be pasted into another document. Only pointers to the copied or cut cells are added to the clipboard, thus the cell that should be pasted must still exist. Consequently a cell can not be pasted from a document that has been closed.
- *Find* - **Find text string in the current notebook, with the options**
  match full word, match cell, search within closed cells. Short command Ctrl+F.
- *Replace* - **Find and replace text string in the current notebook,**
  with the options match full word, match cell, search+replace within closed cells. Short command Ctrl+H.
- *View expression* - **Text in a cell is stored internally as a subset**
  of HTML code and the menu item Edit->View Expression let the user switch between viewing the text or the internal HTML representation. Changes made to the HTML code will affect how the text is displayed.

### 23.4.6 Cell Menu

- *Add textcell* - **A new textcell is added with the menu item Cell->Add**
  Cell (previous cell style) or the key combination Alt+Enter. The new textcell gets the same style as the previous selected cell had.
- *Add inputcell* - **A new inputcell is added with the menu item**
  Cell->Add Inputcell or the key combination Ctrl+Shift+I.
- *Add latexcell* - **A new latexcell is added with the menu item**
  Cell->Add Latexcell or the key combination Ctrl+Shift+E.
- *Add groupcell* - **A new groupcell is inserted with the menu item**
  Cell->Groupcell or the key combination Ctrl+Shift+G. The selected cell will then become the first cell inside the groupcell.
- *Ungroup groupcell* - **A groupcell can be ungrouped by selecting it in**
  the tree view and using the menu item Cell->Ungroup Groupcell or by using the key combination Ctrl+Shift+U. Only one groupcell at a time can be ungrouped.
- *Split cell* - **Spliting a cell is done with the menu item Cell->Split**
  cell or the key combination Ctrl+Shift+P. The cell is splited at the position of the text cursor.
- *Delete cell* - **The menu item Cell->Delete Cell will delete all cells**
  that have been selected in the tree view. If no cell is selected this action will delete the cell that have been selected by the cellcursor. This action can also be called with the key combination Ctrl+Shift+D or the key Del (only works when cells have been selected in the tree view).
- *Cellcursor* - **This cell type is a special type that shows which cell**
  that currently has the focus. The cell is basically just a thin black line. The cellcursor is moved by clicking on a cell or using the menu item Cell->Next Cell or Cell->Previous Cell. The cursor can also be moved with the key combination Ctrl+Up or Ctrl+Down.

### 23.4.7 Format Menu

- *Textcell* - **This cell type is used to display ordinary text and**
  images. Each textcell has a style that specifies how text is displayed. The cells style can be changed in the menu Format->Styles, examples of different styles are: Text, Title, and Subtitle. The Textcell type also have support for following links to other notebook documents.

- *Text manipulation* - **There are a number of different text**
  manipulations that can be done to change the appearance of the text. These manipulations include operations like: changing font, changing color and make text bold, but also operations like: changing the alignment of the text and the margin inside the cell. All text manipulations inside a cell can be done on single letters, words or the entire text. Text settings are found in the Format menu. The following text manipulations are available in OMNotebook:

> Font family

> Font face (Plain, Bold, Italic, Underline)

> Font size

> Font stretch

> Font color

> Text horizontal alignment

> Text vertical alignment

> Border thickness

> Margin (outside the border)

> Padding (inside the border)

### 23.4.8 Insert Menu

- *Insert image* - **Images are added to a document with the menu item**
  Insert->Image or the key combination Ctrl+Shift+M. After an image has been selected a dialog appears, where the size of the image can be chosen. The images actual size is the default value of the image. OMNotebook stretches the image accordantly to the selected size. All images are saved in the same file as the rest of the document.
- *Insert link* - **A document can contain links to other OMNotebook file**
  or Mathematica notebook and to add a new link a piece of text must first be selected. The selected text make up the part of the link that the user can click on. Inserting a link is done from the menu Insert->Link or with the key combination Ctrl+Shift+L. A dialog window, much like the one used to open documents, allows the user to choose the file that the link refers to. All links are saved in the document with a relative file path so documents that belong together easily can be moved from one place to another without the links failing.

### 23.4.9 Window Menu

- *Change window* - **Each opened document has its own document window.**
  To switch between those use the Window menu. The window menu lists all titles of the open documents, in the same order as they were opened. To switch to another document, simple click on the title of that document.

### 23.4.10 Help Menu

- *About OMNotebook* - **Accessing the about message box for OMNotebook**
  is done from the menu Help->About OMNotebook.
- *About Qt* - **To access the message box for Qt, use the menu**
  Help->About Qt.
- *Help Text* - **Opening the help text (document OMNotebookHelp.onb) for**
  OMNotebook can be done in the same way as any OMNotebook document is opened or with the menu Help->Help Text. The menu item can also be triggered with the key F1.

### 23.4.11 Additional Features

- *Links* - **By clicking on a link, OMNotebook will open the document**
  that is referred to in the link.
- *Update link* - **All links are stored with relative file path.**
  Therefore OMNotebook has functions that automatically updating links if a document is resaved in another folder. Every time a document is saved, OMNotebook checks if the document is saved in the same folder as last time. If the folder has changed, the links are updated.
- *Evaluate whole Notebook* - **All the cells present in the Notebook can**
  be evaluated in one step by pressing the red color evalall button in the toolbar. The cells are evaluated in the same order as they are in the Notebook.However the latexcells cannot be evaluated by this feature.
- *Evaluate several cells* - **Several inputcells can be evaluated at**
  the same time by selecting them in the treeview and then pressing the key combination Shift+Enter or Shift+Return. The cells are evaluated in the same order as they have been selected. If a groupcell is selected all inputcells in that groupcell are evaluated, in the order they are located in the groupcell.
- *Moving and Reordering cells in a Notebook* - **It is possible to shift cells**
  to a new position and change the hierarchical order of the document.This can be done by clicking the cell and press the Up and Down arrow button in the tool bar to move either Up or Down. The cells are moved one cell above or below.It is also possible to move a cell directly to a new position with one single click by pressing the red color bidirectional UpDown arrow button in the toolbar. To do this the user has to place the cell cursor to a position where the selected cells must be moved. After selecting the cell cursor position, select the cells you want to shift and press the bidirectional UpDown arrow button. The cells are shifted in the same order as they are selected.This is especially very useful when shifting a group cell.
- *Command completion* - **Inputcells have command completion support,**
  which checks if the user is typing a command (or any keyword defined in the file commands.xml) and finish the command. If the user types the first two or three letters in a command, the command completion function fills in the rest. To use command completion, press the key combination Ctrl+Space or Shift+Tab. The first command that matches the letters written will then appear. Holding down Shift and pressing Tab (alternative holding down Ctrl and pressing Space) again will display the second command that matches. Repeated request to use command completion will loop through all commands that match the letters written. When a command is displayed by the command completion functionality any field inside the command that should be edited by the user is automatically selected. Some commands can have several of these fields and by pressing the key combination Ctrl+Tab, the next field will be selected inside the command. > Active Command completion: Ctrl+Space / Shift+Tab > Next command: Ctrl+Space / Shift+Tab > Next field in command: Ctrl+Tab'
- *Generated plot* - **When plotting a simulation result, OMC uses the**
  program Ptplot to create a plot. From Ptplot OMNotebook gets an image of the plot and automatically adds that image to the output part of an inputcell. Like all other images in a document, the plot is saved in the document file when the document is saved.
- *Stylesheet* -**OMNotebook follows the style settings defined in**
  stylesheet.xml and the correct style is applied to a cell when the cell is created.
- *Automatic Chapter Numbering* - **OMNotebook automatically numbers**
  different chapter, subchapter, section and other styles. The user can specify which styles should have chapter numbers and which level the style should have. This is done in the stylesheet.xml file. Every style can have a <chapterLevel> tag that specifies the chapter level. Level 0 or no tag at all, means that the style should not have any chapter numbering.
- *Scrollarea* - **Scrolling through a document can be done by using the**
  mouse wheel. A document can also be scrolled by moving the cell cursor up or down.
- *Syntax highlighter* - **The syntax highlighter runs in a separated**
  thread which speeds up the loading of large document that contains many Modelica code cells. The syntax highlighter only highlights when letters are added, not when they are removed. The color settings for the different types of keywords are stored in the file modelicacolors.xml. Besides defining the text

color and background color of keywords, whether or not the keywords should be bold or/and italic can be defined.

- ***Change indicator* - A star (*) will appear behind the filename in**
  the title of notebook window if the document has been changed and needs saving. When the user closes a document that has some unsaved change, OMNotebook asks the user if he/she wants to save the document before closing. If the document never has been saved before, the save-as dialog appears so that a filename can be choosen for the new document.
- ***Update menus* - All menus are constantly updated so that only menu**
  items that are linked to actions that can be performed on the currently selected cell is enabled. All other menu items will be disabled. When a textcell is selected the Format menu is updated so that it indicates the text settings for the text, in the current cursor position.

## 23.5 References

**Todo**

Add these into extrarefs.bib and cite them somewhere

Eric Allen, Robert Cartwright, Brian Stoler. DrJava: A lightweight pedagogic environment for Java. In Proceedings of the 33rd ACM Technical Symposium on Computer Science Education (SIGCSE 2002) (Northern Kentucky - The Southern Side of Cincinnati, USA, February 27 - March 3, 2002).

Anders Fernström, Ingemar Axelsson, Peter Fritzson, Anders Sandholm, Adrian Pop. OMNotebook - Interactive WYSIWYG Book Software for Teaching Programming. In Proc. of the Workshop on Developing Computer Science Education - How Can It Be Done?. Linköping University, Dept. Computer & Inf. Science, Linköping, Sweden, March 10, 2006.

Eva-Lena Lengquist-Sandelin, Susanna Monemar, Peter Fritzson, and Peter Bunus. DrModelica - A Web-Based Teaching Environment for Modelica. In Proceedings of the 44th Scandinavian Conference on Simulation and Modeling (SIMS'2003), available at www.scan-sims.org. Västerås, Sweden. September 18-19, 2003.

CHAPTER

# TWENTYFOUR

# OPTIMIZATION WITH OPENMODELICA

The following facilities for model-based optimization are provided with OpenModelica:

- *Built-in Dynamic Optimization using Annotations* using dynamic optimization is the recommended way of performing dynamic optimization with OpenModelica.
- *Dynamic Optimization with OpenModelica and CasADi*. Use this if you want to employ the CasADi tool for dynamic optimization.
- Classical *Parameter Sweep Optimization using OMOptim*. Use this if you have a static optimization problem.

## 24.1 Built-in Dynamic Optimization using Annotations

*This part of the OM manual is a contribution by Massimo Ceraolo and Vitalij Ruge.*

### 24.1.1 Foreword

Dynamic optimization using Annotations is the most user-friendly way to perform Dynamic Optimization(DO) in OpenModelica, since it allows the OMEdit graphical user interface to be used.

It is also more powerful that the Built-in Dynamic Optimization using Optimica language extensions, since it allows final constraints.

### 24.1.2 Formulation limitations and algorithm

We can formulate the optimization problem as follows:

$$\min_{u(t)} \left[ M\left(\mathbf{x}\left(t_f\right), \mathbf{u}\left(t_f\right), t_f\right) + \int_{t_0}^{t_f} L\left(\mathbf{x}(t), \mathbf{u}(t), t\right) \mathrm{dt} \right] \quad \begin{array}{l}\text{optimization purpose} \\ (M \textit{ is the Mayer Term} \\ L \textit{ is the Lagrange Term})\end{array} \tag{24.1}$$

$$\mathbf{0} = \mathbf{f}\left(\mathbf{x}(t), \dot{\mathbf{x}}(t), \mathbf{u}(t), t\right) \quad \begin{array}{l}\text{dynamical description} \\ \text{of the system}\end{array} \tag{24.2}$$

$$\mathbf{0} \leq \mathbf{g}\left(\mathbf{x}(t), \mathbf{u}(t), t\right) \quad \begin{array}{l}\text{path constraints} \\ \text{e.g. physical limits of components}\end{array} \tag{24.3}$$

$$\mathbf{0} = \mathbf{r}_0\left(\mathbf{x}\left(t_0\right), t_0\right) \quad \text{Initial constraint} \tag{24.4}$$

$$\mathbf{0} = \mathbf{r}_f(\mathbf{x}\left(t_f\right) \mathbf{u}\left(t_f\right), t_f) \quad \text{Final constraint} \tag{24.5}$$

Where $\mathbf{u}(t)$ is the vector of input variables, on which DO works to try to get the desired minimum, and $\mathbf{x}(t)$ is the vector of state variables.

The equations above can be implemented in OpenModelica using the full power of Modelica language, and therefore there is a good freedom and flexibility, under the obvious constraint that the system must be regular enough for the convergence to take place.

However, there are limitations in the possibility operational limits can be set.

The formulation of operational limits in (3) is general, since it allows to use non-boxed constrains. Consider for instance a battery. The energy the battery can deliver is a function of the power we use to charge or discharge it.

Therefore, the actual limit should be described as:

$$E_{\min}(P) \leq E_{\text{bat}} \leq E_{\max}(P)$$

Moreover, (3) is time-variant (the third argument of function $g$).

The OpenModelica optimization through annotations accepts as path constraints only time-invariant box constraints, so eq (3) is expressed in the simpler form:

$$\mathbf{x}_{\min} \leq \mathbf{x}(t) \leq \mathbf{x}_{\max}$$

$$\mathbf{u}_{\min} \leq \mathbf{u}(t) \leq \mathbf{u}_{\max}$$

$$g_{\min} \leq g(\mathbf{x}(t), \mathbf{u}(t)) \leq g_{\max}$$

OpenModelica uses the Radau IIA discretization scheme of order 1 or 5 depending on user input.

Using the first order the Radau IIA is equivalent to implicit Euler and to compute states, output and cost function only the values at the end of each interval are evaluated. E.g., if we have StopTime=1 and Interval=0.25, only values for t=0.25, t=0.5, t=0.75, t=1 will be considered. Therefore, the resulting value of the control variable at t=0 may be even totally wrong, since it has no influence on the result.

### 24.1.3 Syntax

OpenModelica provides specific annotations to allow the optimization problem to be described, as an alternative to the use of Optimica language. They are listed and commented below.

- *Request for an optimization*. We must use two simulation flags and a command line option. These can conveniently be inserted into the code, to avoid selecting them manually all the time, as follows:

```
__OpenModelica_simulationFlags(s = "optimization", optimizerNP="1"),
__OpenModelica_commandLineOptions = "+g=Optimica",
```

  OptimizerNP gives the number of colloction points and can be only 1 or 3. As already said the RadauIIA order is 2*OptimizerNP-1.

  *The user is recommended to use as a first attempt optimizerNP=1. In case of questionable results, they can try optimizerNP=3.*

  For the simulation, it is known that the stability ranges are different. At the same time, we lose stability with higher order (see[1]).

  Note that Optimica command-line option is added even if we do not use Optimica specific language constructs; this it is required for the use of optimization-related annotations.

- *Select optimization parameters*. We must specify StartTime, StopTime, Interval, and Tolerance. The first two have the same meaning as in time simulations. Interval not only defines the output interval (as in time simulations), but has a more specific meaning: it defines the interval between two successive collocation points. I.e., optimization is done splitting the whole timespan in sparts having interval as length. Therefore this value may have a huge effects on the simulation output. For typical runs, number of intervals values from 100 to 1000-2000 could be adequate. These values are obviously set through the experiment annotation, e.g.:

```
experiment(StartTime = 0, StopTime = 20, Tolerance = 1e-07, Interval = 0.02),
```

  the default tolerance is 1e-6. The user is warned that enlarging this value may affect the output quality adversely by large amounts (an example will be provided later). Going up to 1e-8 may be advisable in some cases.

- *Define the variable(s) to be determined by DO*. The variables the DO must determine must have the input attribute. They can have (with parameter variability) *min* and *max* attributes, which are interpreted as boxed path constraints on input. It is recommended to also define a start value for them, since it is used for initialization (see sect. *DO Initialization*). Here's an example:

[1] Hairer, Ernst and Wanner, Gerhard, Radau Methods, 2015, pp 1213-1216, DOI 10.1007/978-3-540-70529-1_139.

```
input Real u1(start=0.5, min=0.0, max = 100/par1);
input Real u2(start=0.5, min=0.0, max = 1.0);
```

- *Indicate the minimisation goal*. We can indicate whether we must just minimise a quantity, or the integral of a quantity (see (1)., as follows:

```
Real totalCost = xxx annotation(isMayer = true); //minimize totalCost(tf)
Real specificCost = xxx annotation(isLagrange = true); //minimize integral of␣
↪specificCost (tf)
```

  Several isMayer and isLagrange goals can be set. The actual goal will be the sum of all goals (isMayer goals as they are, isLagrange goals first integrated between $t_0$ and $t_f$).

  Obviously, it is possible in Modelica to use just isMayer=true also for Lagrange terms, integrating the Laplace integrand inside the model, but the internal numeric treatment will be different.

- *Describe the system*. This is done in the usual Modelica way. Here we can exploit the huge power of modelica language and tools to automatically convert a system described in physical (and possibly graphical) terms into DAE equations

- *Define path constraints*. As we said previously, they must be boxed and time-invariant. They are expressed using annotations as in the following example (taken from the full example described in the next section):

```
Real energyConstr(min = 0, max = energyMax) = storage.energy␣
↪annotation(isConstraint = true); //timespan constraint on storage energy
```

  Here, we see that the constraints are described through min and max values.

- *Define initial constraints*. These are set using the existing modelica syntax to indicate initial values

- *Define final constraints*. These are set using a specific annotation, as in the following example (taken from the full example described in the next section):

```
annotation(isFinalConstraint = true);
```

  Some special care must be taken when dealing with final constraints. We must be sure that OM front-end does not do alias elimination of the constrained variable, since in that case it could pass on bounds from final constraints to the merged variable, and these final constraints would become path constraints. To avoid this potentially harmful alias elimination we must add to the final constrant an auxiliary parameter, as follows.

```
parameter Real p = 1 "Auxiliary parameter for energy final constraint";
Real energyConstr(min = 0, max = energyMax) = storage.energy␣
↪annotation(isConstraint = true); //timespan constraint on storage energy
Real energyFinConstr(min = energyIni, max = energyIni) = p * storage.energy␣
↪annotation(isFinalConstraint = true); //final time constraint on storage energy
```

  The auxiliary parameter can also be used for scaling the constrained variable, so that it is roughly around one, so easing convergence. This could be done for instance as follows:

```
parameter Real p = 1e-3 "Auxiliary parameter for energy final constraint";
Real energyConstr(min = 0, max = energyMax) = storage.energy␣
↪annotation(isConstraint = true); //timespan constraint on storage energy
Real energyFinConstr(min = p*energyIni, max = p*energyIni) = p * storage.energy␣
↪annotation(isFinalConstraint = true); //final time constraint on storage energy
```

### 24.1.4 Preparing the system

To allow DO to operate in good conditions it is very important that the system has continuous derivatives.

Here we just give two examples:

- In case of a combiTimeTable is used to describe non-linear algebraic functions, it is highly recommended to use Continuous derivative for the smoothness parameter
- If we need to use the absolute value of a variable, we have derivative discontinuity around zero. This can be avoided, with negligible loss of precision, substituting $abs(x)$ with $sqrt(x^2 + \varepsilon)$, where eps is very low in comparison with the values $x$ usually assumes during the simulation.
- Carefully consider having in the code asserts that cause simulation to stop. If for instance we have an assert that stops simulation when a variable gets outside its limiting value, it may happen that during the optimisation cycle the limit is hit and simulation is stopped, which may not be desirable. Asserts can still be left in place, adding a boolean variable, e.g.:

```
parameter Boolean insideDynOpt=true; // "true asks skipping the next assert␣
↪inside dyn. optimization";
assert(SOC <= SOCmax or insideDynOpt, "\n****\n" + "Battery is fully charged:\n"
+ "State of charge reached maximum limit (=" + String(SOCmax) + ")" + "\n****\n
↪");
```

### 24.1.5 Initialization

DO algorithm requires initialization. This is controlled through the simulation flag *ipopt_init*. This flag has three options: *SIM*, *CONST*, *FILE*. The preferred option can be selected adding the model the system annotation *__OpenModelica_simulationFlags*. For instance, the following example requires optimisation with *SIM* ` initialisation:

```
__OpenModelica_simulationFlags(s = "optimization", optimizerNP = "1", ipopt_
↪init= "SIM")
```

The three options operate as follows:

- *SIM* (the default). With this option, OM first makes an ordinary simulation; the simulation result is the initial "point" for the optimization. During this simulation the input is constantly kept at its value "start".
- *CONST*. With this option, the initial "point" for optimization is with all the quantities being constant, and equal to their "start" values
- *FILE*. In this case the initial point for optimization is taken from a file, created by a previous simulation, usually with a non-constant input (otherwise it would be simpler to use *SIM*). OpenModelica maps the variables between file and optimization via their name. The syntax is as in the following example:

```
__OpenModelica_simulationFlags(ipopt_init="FILE" -iif "simModel_res.mat
↪"),
```

### 24.1.6 Example 1: minimum time to destination

This example refers to a car, which is requested to cover the max possible distance using power from an engine which has a torque limitation and a power limitation.

The torque limitation is transformed in a maximum force that the wheels can transfer to the road to pus the car.

This is a very easy dynamic optimization problem, whose solution is the so-called bang-bang control: accelerate at the maximum possible degree, then, when half of the road is reached, decelerate with the maximum possible degree.

The code is very simple and it is as follows:

```
model BangBang2021 "Model to verify that optimization gives bang-bang optimal control"

  parameter Real m = 1;
  parameter Real p = 1 "needed for final constraints";

  Real a;
```

(continues on next page)

(continued from previous page)

```
  Real v(start = 0);
  Real pos(start = 0);
  Real pow(min = -30, max = 30) = f * v annotation(isConstraint = true);

  input Real f(min = -10, max = 10);

  Real costPos(nominal = 1) = -pos "minimize -pos(tf)" annotation(isMayer=true);

  Real conSpeed(min = 0, max = 0) = p * v " 0<= p*v(tf) <=0"␣
↪annotation(isFinalConstraint = true);

equation

  der(pos) = v;
  der(v) = a;
  f = m * a;

annotation(experiment(StartTime = 0, StopTime = 1, Tolerance = 1e-07, Interval = 0.
↪01),
__OpenModelica_simulationFlags(s="optimization", optimizerNP="1"),
__OpenModelica_commandLineOptions="+g=Optimica");

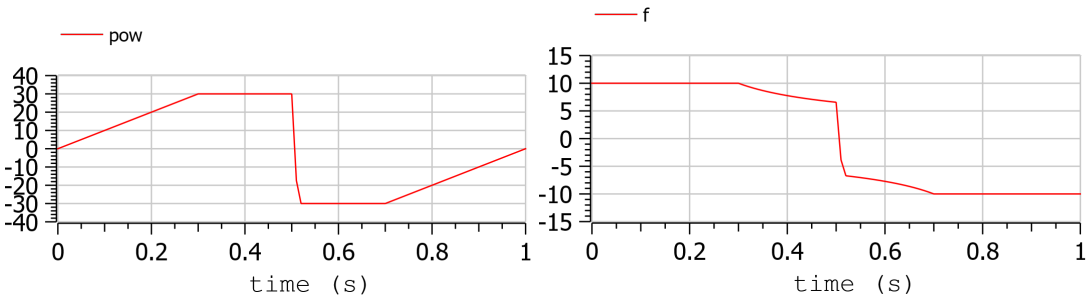
end BangBang2021;
```

The constraint on power is especially worth considering. Above, we stated that path constraints can be $g_{\min} \leq g(\mathbf{x}(t), \mathbf{u}(t), t) \leq g_{\max}$. Here we have box limits on *pow*, which are expressed as limits on *g(v,f) = f*v = pow*

$$-30 \leq v * f = f * v \leq 30$$

This usage of constraints allows implementing variable (non-boxed) constraints, which are not allowed explicitly. Doing this the above code implements through *g(.)* a variable (so non-boxed) limit on force *f*.

The results can be expressed in terms of force and power applied to the vehicle. They are as follows:




and they are as expected.

In this model we don't use the Modelica capability to automatically determine the system equations from the graphical description of a system. In other words, the above general formulation $0 = f(\mathbf{x}(t), \dot{\mathbf{x}}(t), \mathbf{u}(t), t)$ is explicitly written as follows:

```
der(pos) = v;
der(v) = a;
```

In the following example, we will use this capability extensively.

### 24.1.7 Example 2: hybrid vehicle minimum consumption

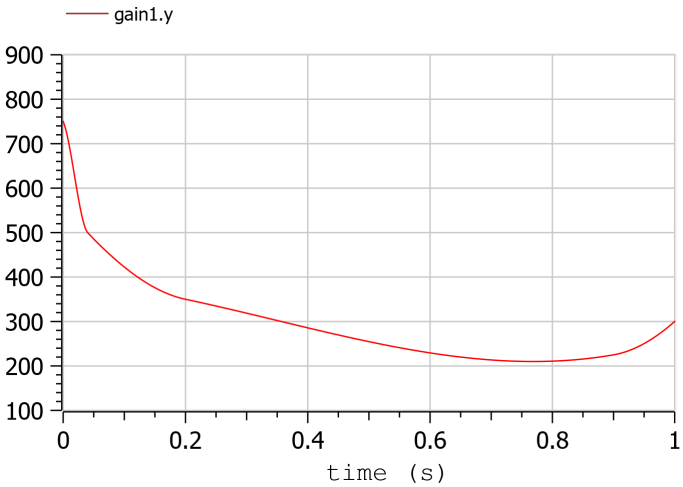
This example refers to the electricity generation of a hybrid vehicle. These vehicles can choose at any time which amount of the propulsion power must be taken from a battery and which from the Internal combustion engine.

In this example the engine can be switched ON and off without penalty, so the DO can choose both when the ICE must be ON /OFF; and the power it must deliver when it is ON.

Objective of the control is to minimise the fuel consumption. This must be done keeping the energy inside the storage at the final time, equal to the one at t=0 (otherwise it is easy to have zero consumption: just keep the Internal Combustion Engine OFF all the time!)

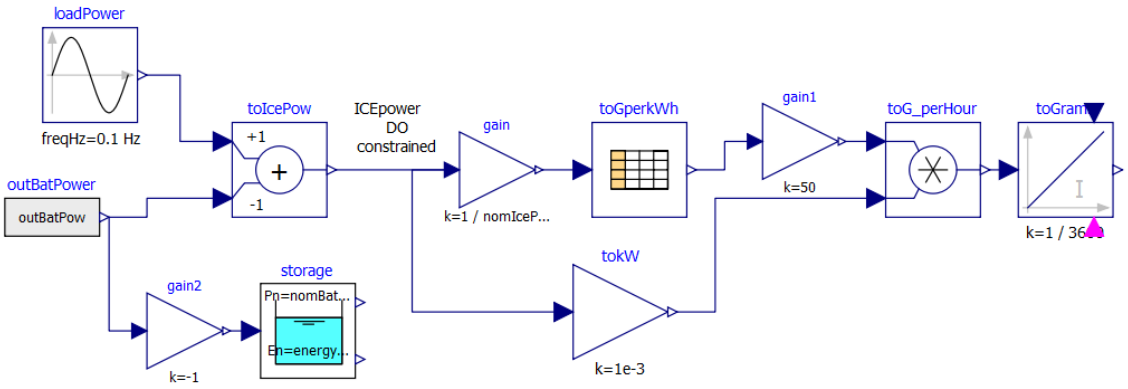
For simplicity's sake, the propulsion power, in this simple example is taken as being a sine wave plus an offset (needed to make the average positive). When the power is positive the wheels transfer power to the road, when negative they recover it (storing it into the battery).

To find the optimum, a fuel consumption curve is added, as follows:




The minimum is 210 g/kWh, and occurs when the ICE power is at the 76.8 % of the nominal power

The system diagram is as follows




The DO algorithm is required to determine the battery power outBatPower (positive when the battery delivers power) so that to minimise the fuel consumption toGrams. Block toGperkWh is normalised, so that it can be used for different engines, adapting the horizontal scale through gain, and the vertical's through gain1.

This diagram defines the system, whose equations will be automatically determined by OpenModelica, through model flattening. However, some code must be manually written to perform DO.

Here the code is as follows:

```
//*** DO-related rows

input Real outBatPow;

//
Real totalCost = toGrams.y "minimize totalCost(tf)" annotation( isMayer=true);
//

Real energyConstr(min = 0, max = energyMax) = storage.energy annotation(isConstraint␣
↪= true); //timespan constraint on storage energy

parameter Real fecp = 1 "final energy constraint parameter";

Real energyFinConstr(min = energyIni, max = energyIni) = fecp * storage.energy␣
↪annotation(isFinalConstraint = true);//final time constraint on storage energy

Real icePowerConstr(min = 0) = itoIcePow.y annotation(isConstraint=true); //timespan␣
↪constraint on Ice power

//*** End of DO-related rows
```

A few comments:

- The choice isMayer=true on the objective function totalCost requires its final value to be actually minimised, not its integral (as would have been in case of the keyword isLaplace=true)
- We have two different constraints on the storage energy: the storage energy must all the time be between 0 and the maximum allowed, and at the end of the simulation must be brought back to its initial value.
- ICE can only deliver power, not absorb; so, we expect all the (regenerative) braking power and energy to be sent into the storage

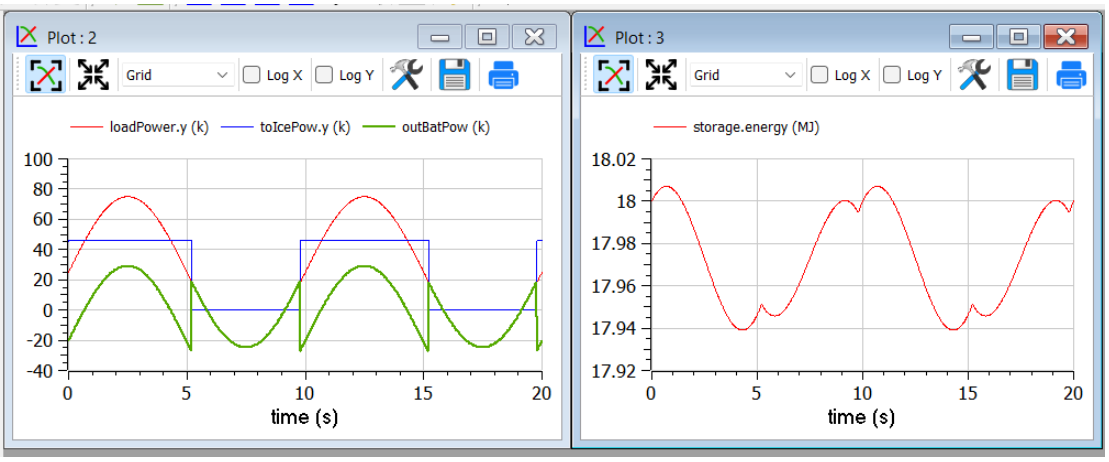
### 24.1.8 Ideal storage

Here we consider the storage to be ideal: the flow of power in and out causes no losses to occur

In this case the solution of our optimization problem is trivial:

- The Ice must supply the average power requested by the load, and when it does this it must do it at the optimal point which, as seen above is when its power is at the 76.8% of its nominal value
- The battery supplies the load power minus ICE power.

Using iceNominalPower=60 kW we get the following output:




We see, as expected that the ICE is switched ON and OFF; and when it is ON it delivers at its 76.8 % of nominal power, i.e. at 46.1 kW. The battery delivers the difference, and when the load is negative absorbs all the power

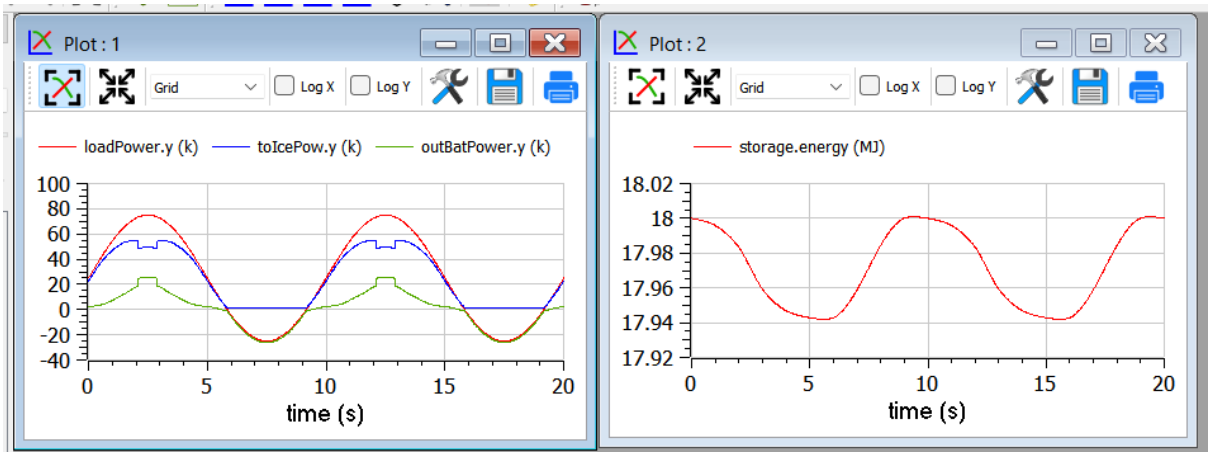
from it. The control is such that the energy at the end of the transient is the same as the one at t=0.

This result is good and confirms what we expected.

### Effects of tolerance

We mentioned that reduction of tolerance may affect the result adversely by large, especially when the minimum, as in this case is very flat (since the specific fuel consumption curve used for our example is very flat).

In the following picture we see the result of the previous section as it appears when we release tolerance by changing it from 1e-7 to and 1e-6. Now the result is badly wrong (and the total cost has changed from to 25.6g 29.9g).



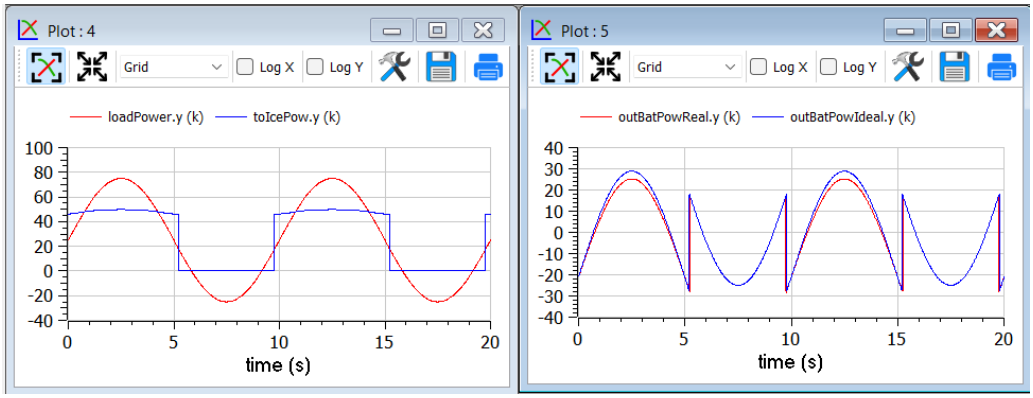

### More realistic storage

To the DO to be useful, it must obviously go beyond what is exactly expected. Therefore, we repeat the simulation adding the simulation of some losses inside the battery. According to scientific literature, losses here are modelled through the following formula:

$$L(t) = 0.03|P_{\text{batt}}(t)| + 0.04\frac{P^2_{\text{batt}}(t)}{P_{batt,nom}}$$

Which reflects that they in part are proportional to the absolute value of battery current, partly to its square. The coefficients are typical for power electronic converters interfacing a battery.

Inside the code, however, the formula introduced is structurally different, since it has been transformed to avoid the derivative discontinuity of the absolute value of a quantity around zero, using a trick like the one reported in sect. 1.4.

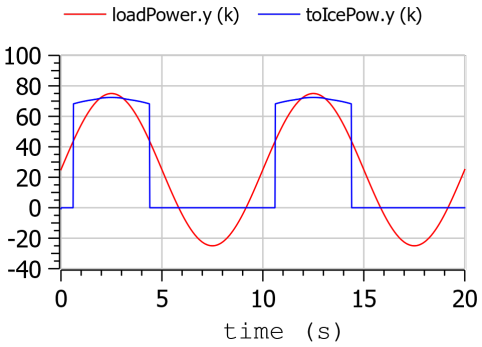



We see that now the optimiser changes the Ice power when in ON state, to reduce the battery power at its peak, since the losses formula pushes towards lower powers.

### Adding storage power limitation

As a last case for example 2, we ass tome limitation on the power that can be exchanged by the battery. This can be physically due to limitations of either the battery or the inverter connected to it.

To show better the effect, we first rise the ICE power to 100 kW, so that the interval of ICE operation is smaller:




Then we change the following row of code:

```
input Real outBatPow;
```

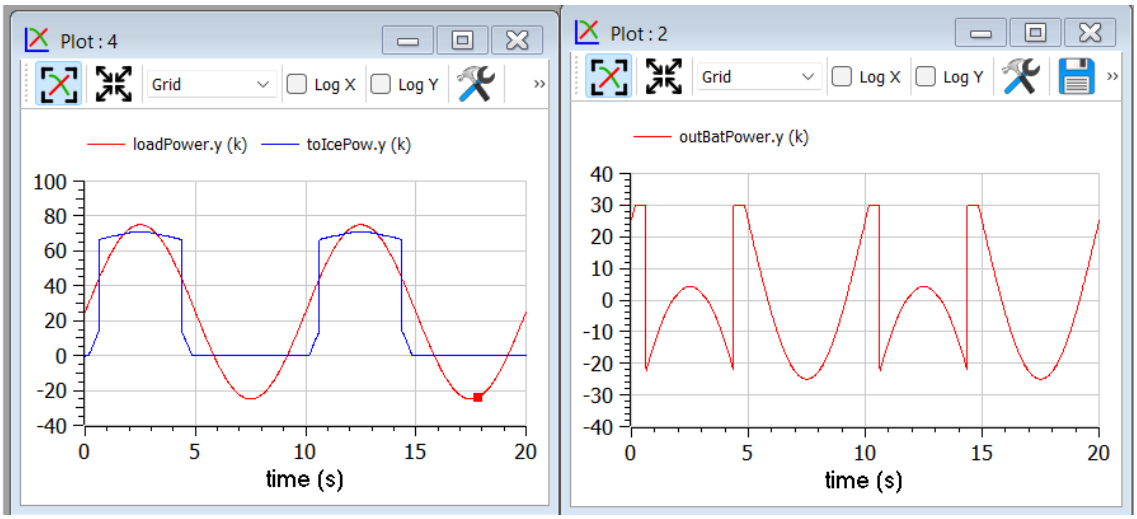
into:

```
input Real outBatPow(min = -maxBatPower, max = maxBatPower);
```

where

```
parameter Modelica.SIunits.Power maxBatPower = 30e3;
```

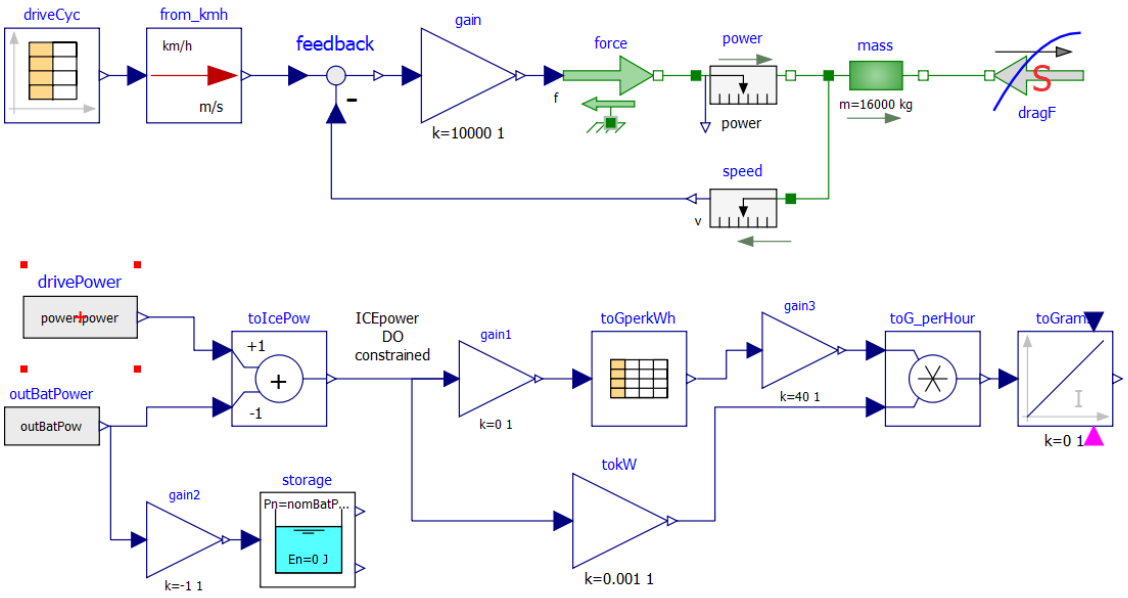
giving rise to the following results (with a much longer computation time than in the previous cases):




## 24.1.9 Example 3: Acausal vehicle

As a last example, we replicate the optimization of Example 2, but the power to be delivered directly deriving from simulation of a vehicle, modelled through its physical elements.

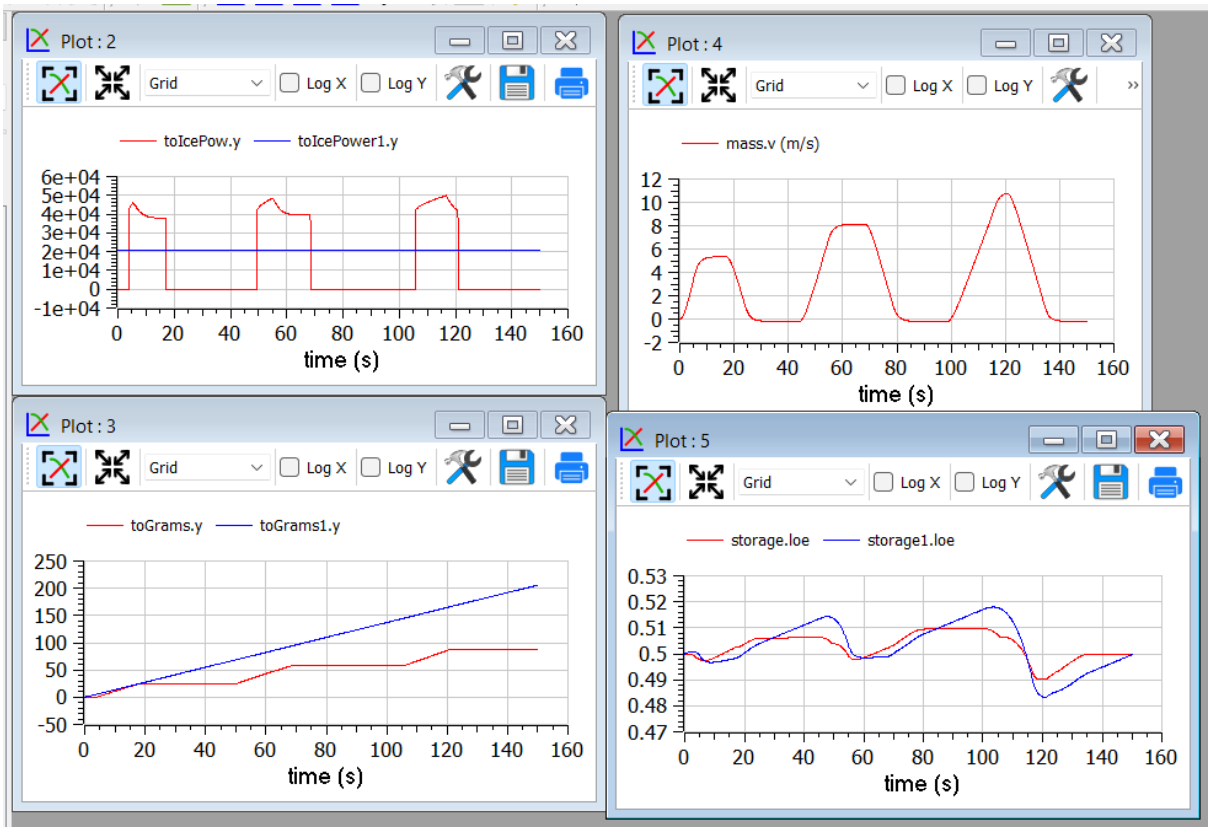
The considered diagram is as follows:




The upper part contains a vehicle model. The model follows a speed profile defined by the drive cycle driveCyc, through a simple proportional controller (simulating the driver). The power is applied to a mass; the drag force dragF sis the force against the movement due to friction (independent on speed) and air resistance (proportional to the square of vehicle speed).

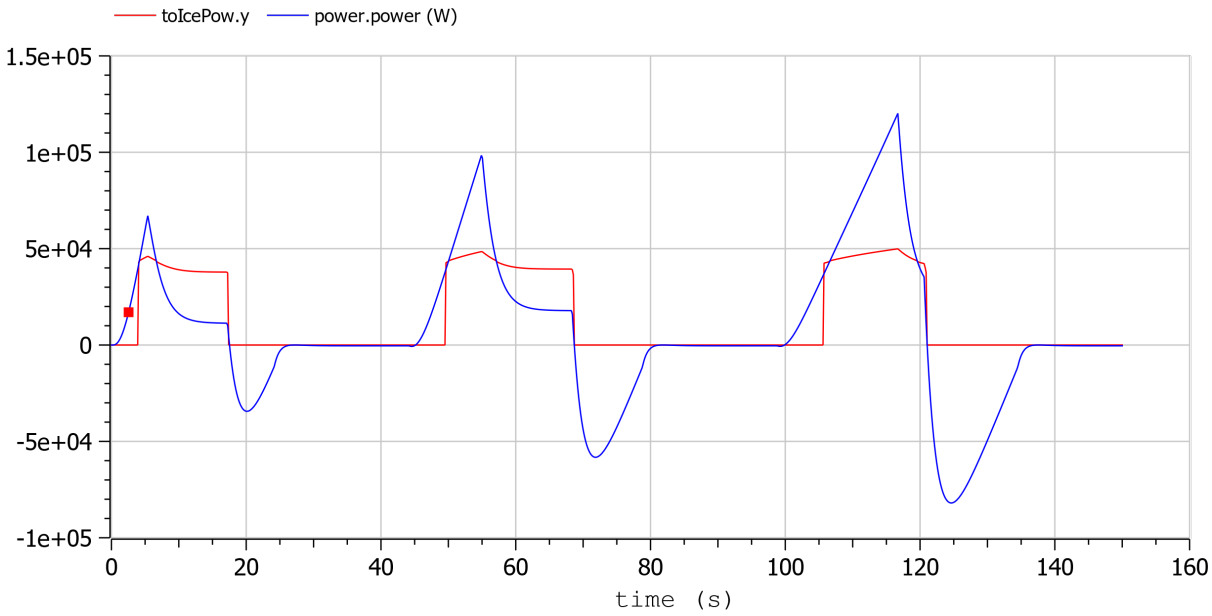
The lower part contains the management of the storage, and the optimization algorithm, already discussed in example 2.

The results are shown in the following picture, where the obtained cost (red curve) is compared to what obtainable in case the ICE is continuously kept ON (blue curve), at a power (blue curve) that allows the battery energy at the end of the simulation to be equal to the one as t=0, as in the case of the optimised solution.



This example shows that the optimizer can find an ON/OFF strategy that more than halves the hybrid vehicle fuel consumption.

The following plot shows the ICE power in comparison with total power needed to cover the given trip profile mass.v. The rest is supplied by the battery.




## 24.2 Built-in Dynamic Optimization using Optimica language extensions

*Note: this is a very short preliminary description which soon will be considerably improved.*

OpenModelica provides builtin dynamic optimization of models by using the powerful symbolic machinery of the OpenModelica compiler for more efficient and automatic solution of dynamic optimization problems.

The builtin dynamic optimization allows users to define optimal control problems (OCP) using the Modelica language for the model and the optimization language extension called Optimica (currently partially supported) for the optimization part of the problem. This is used to solve the underlying dynamic optimization model formulation using collocation methods, using a single execution instead of multiple simulations as in the parameter-sweep optimization described in section *Parameter Sweep Optimization using OMOptim*.

For more detailed information regarding background and methods, see [BOR+12, RBB+14]

### 24.2.1 Compiling the Modelica code

Before starting the optimization the model should be symbolically instantiated by the compiler in order to get a single flat system of equations. The model variables should also be scalarized. The compiler frontend performs this, including syntax checking, semantics and type checking, simplification and constant evaluation etc. are applied. Then the complete flattened model can be used for initialization, simulation and last but not least for model-based dynamic optimization.

The OpenModelica command optimize(ModelName) from OMShell, OMNotebook or MDT runs immediately the optimization. The generated result file can be read in and visualized with OMEdit or within OMNotebook.

### 24.2.2 An Example

In this section, a simple optimal control problem will be solved. When formulating the optimization problems, models are expressed in the Modelica language and optimization specifications. The optimization language specification allows users to formulate dynamic optimization problems to be solved by a numerical algorithm. It includes several constructs including a new specialized class optimization, a constraint section, startTime, finalTime etc. See the optimal control problem for batch reactor model below.

Create a new file named *BatchReactor.mo* and save it in you working directory. Notice that this model contains both the dynamic system to be optimized and the optimization specification.

Once we have formulated the undelying optimal control problems, we can run the optimization by using OMShell, OMNotebook, MDT, OMEdit using command line terminals similar to the options described below:

```
>>> setCommandLineOptions("-g=Optimica");
```

Listing 24.1: BatchReactor.mo

```
model BatchReactor
  Real x1(start =1, fixed=true, min=0, max=1);
  Real x2(start =0, fixed=true, min=0, max=1);
  input Real u(min=0, max=5);
equation
  der(x1) = -(u+u^2/2)*x1;
  der(x2) = u*x1;
end BatchReactor;
```

```
optimization nmpcBatchReactor(objective=-x2)
  extends BatchReactor;
end nmpcBatchReactor;
```

```
>>> optimize(nmpcBatchReactor, numberOfIntervals=16, stopTime=1, tolerance=1e-8)
record SimulationResult
    resultFile = "«DOCHOME»/nmpcBatchReactor_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 1.0, numberOfIntervals = 16,␣
↪tolerance = 1e-8, method = 'optimization', fileNamePrefix = 'nmpcBatchReactor',␣
↪options = '', outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = '
↪'",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.

Optimizer Variables
=========================================================
State[0]:x1(start = 1, nominal = 1, min = 0, max = 1, init = 1)
State[1]:x2(start = 0, nominal = 1, min = 0, max = 1, init = 0)
Input[2]:u(start = 0, nominal = 5, min = 0, max = 5)
---------------------------------------------------------
number of nonlinear constraints: 0
=========================================================

******************************************************************************
This program contains Ipopt, a library for large-scale nonlinear optimization.
 Ipopt is released as open source code under the Eclipse Public License (EPL).
         For more information visit https://github.com/coin-or/Ipopt
******************************************************************************

LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.043830121,
    timeBackend = 0.014745123,
    timeSimCode = 0.0019212580000000001,
    timeTemplates = 0.00483418,
    timeCompile = 0.436183478,
    timeSimulation = 0.017190249,
    timeTotal = 0.518876093
end SimulationResult;
```

The control and state trajectories of the optimization results:

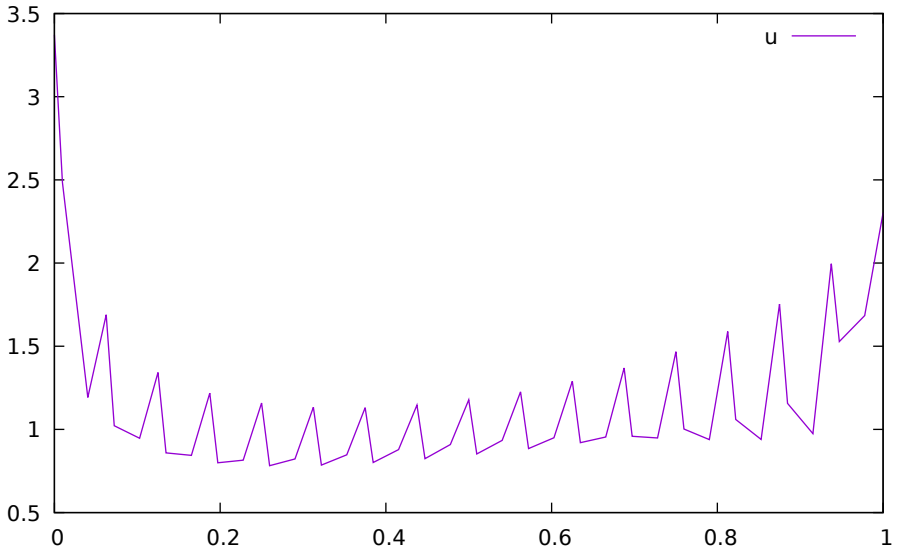



Figure 24.1: Optimization results for Batch Reactor model - input variables.

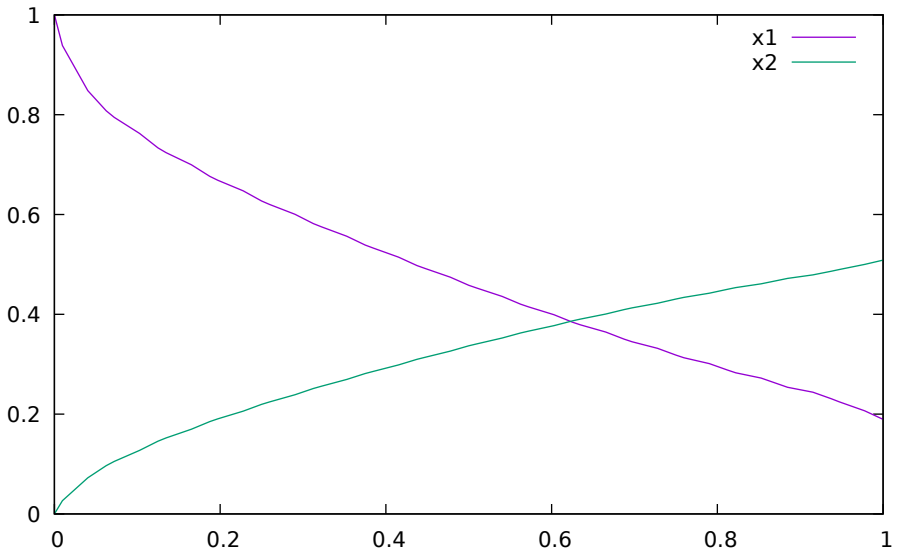



Figure 24.2: Optimization results for Batch Reactor model - state variables.

### 24.2.3 Different Options for the Optimizer IPOPT

Table 24.1: New meanings of the usual simualtion options for Ipopt.

| | | |
|---|---|---|
| numberOfIntervals | | collocation intervals |
| startTime, stopTime | | time horizon |
| tolerance = 1e-8 | e.g. 1e-8 | solver tolerance |
| simflags | all run/debug options | |

Table 24.2: New simulation options for Ipopt.

| | | |
|---|---|---|
| -lv | LOG_IPOPT | console output |
| -ipopt_hesse | CONST,BFGS,NUM | hessian approximation |
| -ipopt_max_iter | number e.g. 10 | maximal number of iteration for ipopt |
| externalInput.csv | | input guess |

## 24.3 Dynamic Optimization with OpenModelica and CasADi

OpenModelica coupling with CasADi supports dynamic optimization of models by OpenModelica exporting the optimization problem to CasADi which performs the optimization. In order to convey the dynamic system model information between Modelica and CasADi, we use an XML-based model exchange format for differential-algebraic equations (DAE). OpenModelica supports export of models written in Modelica and the Optimization language extension using this XML format, while CasADi supports import of models represented in this format. This allows users to define optimal control problems (OCP) using Modelica and Optimization language specifications, and solve the underlying model formulation using a range of optimization methods, including direct collocation and direct multiple shooting.

### 24.3.1 Compiling the Modelica code

Before exporting a model to XML, the model should be symbolically instantiated by the compiler in order to get a single flat system of equations. The model variables should also be scalarized. The compiler frontend performs this, including syntax checking, semantics and type checking, simplification and constant evaluation etc. are applied. Then the complete flattened model is exported to XML code. The exported XML document can then be imported to CasADi for model-based dynamic optimization.

The OpenModelica command translateModelXML(ModelName) from OMShell, OMNotebook or MDT exports the XML. The export XML command is also integrated with OMEdit. Select XML > Export XML the XML document is generated in the current directory of omc. You can use the cd() command to see the current location. After the command execution is complete you will see that a file ModelName.xml has been exported.

Assuming that the model is defined in the modelName.mo, the model can also be exported to an XML code using the following steps from the terminal window:

- Go to the path where your model file found
- Run command omc -g=Optimica --simCodeTarget=XML Model.mo

### 24.3.2 An example

In this section, a simple optimal control problem will be solved. When formulating the optimization problems, models are expressed in the Modelica language and optimization specifications. The optimization language specification allows users to formulate dynamic optimization problems to be solved by a numerical algorithm. It includes several constructs including a new specialized class optimization, a constraint section, startTime, finalTime etc. See the optimal control problem for batch reactor model below.

Create a new file named *BatchReactor.mo* and save it in you working directory. Notice that this model contains both the dynamic system to be optimized and the optimization specification.

```
>>> list(BatchReactor)
model BatchReactor
  Real x1(start = 1, fixed = true, min = 0, max = 1);
  Real x2(start = 0, fixed = true, min = 0, max = 1);
  input Real u(min = 0, max = 5);
equation
  der(x1) = -(u + u^2/2)*x1;
  der(x2) = u*x1;
end BatchReactor;
```

One we have formulated the underlying optimal control problems, we can export the XML by using OMShell, OMNotebook, MDT, OMEdit or command line terminals which are described in Section *XML Import to CasADi via OpenModelica Python Script*.

To export XML, we set the simulation target to XML:

```
>>> translateModelXML(BatchReactor)
"«DOCHOME»/BatchReactor.xml"
```

This will generate an XML file named *BatchReactor.xml* (Listing 24.2) that contains a symbolic representation of the optimal control problem and can be inspected in a standard XML editor.

Listing 24.2: BatchReactor.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<OpenModelicaModelDescription
  xmlns:exp="https://github.com/JModelica/JModelica/tree/master/XML/daeExpressions.xsd
↪"
  xmlns:equ="https://github.com/JModelica/JModelica/tree/master/XML/daeEquations.xsd"
  xmlns:fun="https://github.com/JModelica/JModelica/tree/master/XML/daeFunctions.xsd"
  xmlns:opt="https://github.com/JModelica/JModelica/tree/master/XML/daeOptimization.
↪xsd"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  fmiVersion="1.0"
  modelName="BatchReactor"
  modelIdentifier="BatchReactor"
  guid="{f3e3c2dc-5910-4d93-9b5e-1b18b9bf856c}"
  generationDateAndTime="2026-10-27T12:31:30"
  variableNamingConvention="structured"
  numberOfContinuousStates="2"
  numberOfEventIndicators="0"
  >

  <VendorAnnotations>
    <Tool name="OpenModelica Compiler v1.28.0-dev.1529+gaef66789a3.cmake"> </Tool>
  </VendorAnnotations>


  <ModelVariables>
    <ScalarVariable name="x1"  valueReference="0" variability="continuous" causality=
↪"local" alias="noAlias">
      <Real start="1.0" fixed="true" min="0.0" max="1.0"  />
      <QualifiedName>
        <exp:QualifiedNamePart name="x1"/>
      </QualifiedName>
    <isLinearTimedVariables>
      <TimePoint index="0" isLinear="true"/>
    </isLinearTimedVariables>
      <VariableCategory>state</VariableCategory>
    </ScalarVariable>

    <ScalarVariable name="x2"  valueReference="1" variability="continuous" causality=
↪"local" alias="noAlias">
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```

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</OpenModelicaModelDescription>
```

### 24.3.3 XML Import to CasADi via OpenModelica Python Script

The symbolic optimal control problem representation (or just model description) contained in BatchReactor.xml can be imported into CasADi in the form of the SymbolicOCP class via OpenModelica python script.

The SymbolicOCP class contains symbolic representation of the optimal control problem designed to be general

and allow manipulation. For a more detailed description of this class and its functionalities, we refer to the API documentation of CasADi.

The following step compiles the model to an XML format, imports to CasADi and solves an optimization problem in windows PowerShell:

1. Create a new file named BatchReactor.mo and save it in you working directory.

   E.g. C:\OpenModelica1.9.2\share\casadi\testmodel

2. Perform compilation and generate the XML file

   a. Go to your working directory

   E.g. cd C:\OpenModelica1.9.2\share\casadi\testmodel

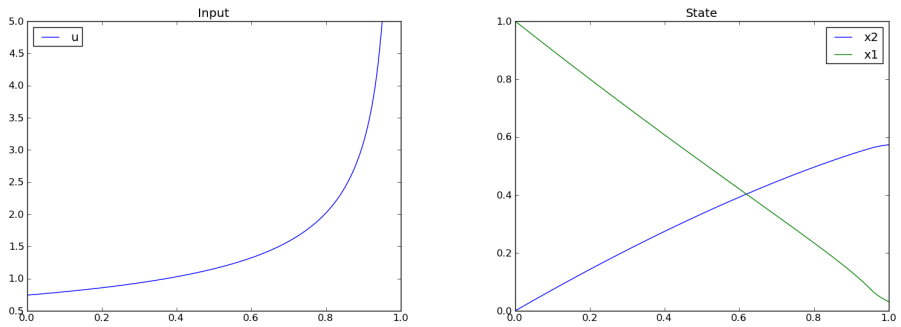
a. Go to omc path from working directory and run the following command

   E.g. ..\..\..\bin\omc +s -g=Optimica --simCodeTarget=XML BatchReactor.mo

3. Run defaultStart.py python script from OpenModelica optimization directory

E.g. Python.exe ..\share\casadi\scripts defaultStart.py BatchReactor.xml

The control and state trajectories of the optimization results are shown below:




## 24.4 Parameter Sweep Optimization using OMOptim

OMOptim is a tool for parameter sweep design optimization of Modelica models. By optimization, one should understand a procedure which minimizes/maximizes one or more objective functions by adjusting one or more parameters. This is done by the optimization algorithm performing a parameter swep, i.e., systematically adjusting values of selected parameters and running a number of simulations for different parameter combinations to find a parameter setting that gives an optimal value of the goal function.

OMOptim 0.9 contains meta-heuristic optimization algorithms which allow optimizing all sorts of models with following functionalities:

- One or several objectives optimized simultaneously
- One or several parameters (integer or real variables)

However, the user must be aware of the large number of simulations an optimization might require.

### 24.4.1 Preparing the Model

Before launching OMOptim, one must prepare the model in order to optimize it.

#### Parameters

An optimization parameter is picked up from all model variables. The choice of parameters can be done using the OMOptim interface.

For all intended parameters, please note that:

- **The corresponding variable is constant during all simulations.**
  The OMOptim optimization in version 0.9 only concerns static parameters' optimization *i.e.* values found for these parameters will be constant during all simulation time.
- **The corresponding variable should play an input role in the model**
  *i.e.* its modification influences model simulation results.

#### Constraints

If some constraints should be respected during optimization, they must be defined in the Modelica model itself.

For instance, if mechanical stress must be less than 5 $N.m^{-2}$, one should write in the model:

```
assert(mechanicalStress < 5, "Mechanical stress too high");
```

If during simulation, the variable *mechanicalStress* exceeds 5 $N.m^{-2}$, the simulation will stop and be considered as a failure.

#### Objectives

As parameters, objectives are picked up from model variables. Objectives' values are considered by the optimizer at the *final time*.

### 24.4.2 Set problem in OMOptim

#### Launch OMOptim

OMOptim can be launched using the executable placed in OpenModelicaInstallationDirectory/bin/ OMOptim/OMOptim.exe. Alternately, choose OpenModelica > OMOptim from the start menu.

#### Create a new project

To create a new project, click on menu File -> New project

Then set a name to the project and save it in a dedicated folder. The created file created has a .min extension. It will contain information regarding model, problems, and results loaded.

#### Load models

First, you need to load the model(s) you want to optimize. To do so, click on *Add .mo* button on main window or select menu *Model -> Load Mo file...*

When selecting a model, the file will be loaded in OpenModelica which runs in the background.

While OpenModelica is loading the model, you could have a frozen interface. This is due to multi-threading limitation but the delay should be short (few seconds).

You can load as many models as you want.

If an error occurs (indicated in log window), this might be because:

- Dependencies have not been loaded before (e.g. modelica library)
- Model use syntax incompatible with OpenModelica.

#### Dependencies

OMOptim should detect dependencies and load corresponding files. However, it some errors occur, please load by yourself dependencies. You can also load Modelica library using Model->Load Modelica library.

When the model correctly loaded, you should see a window similar to Figure 24.3.

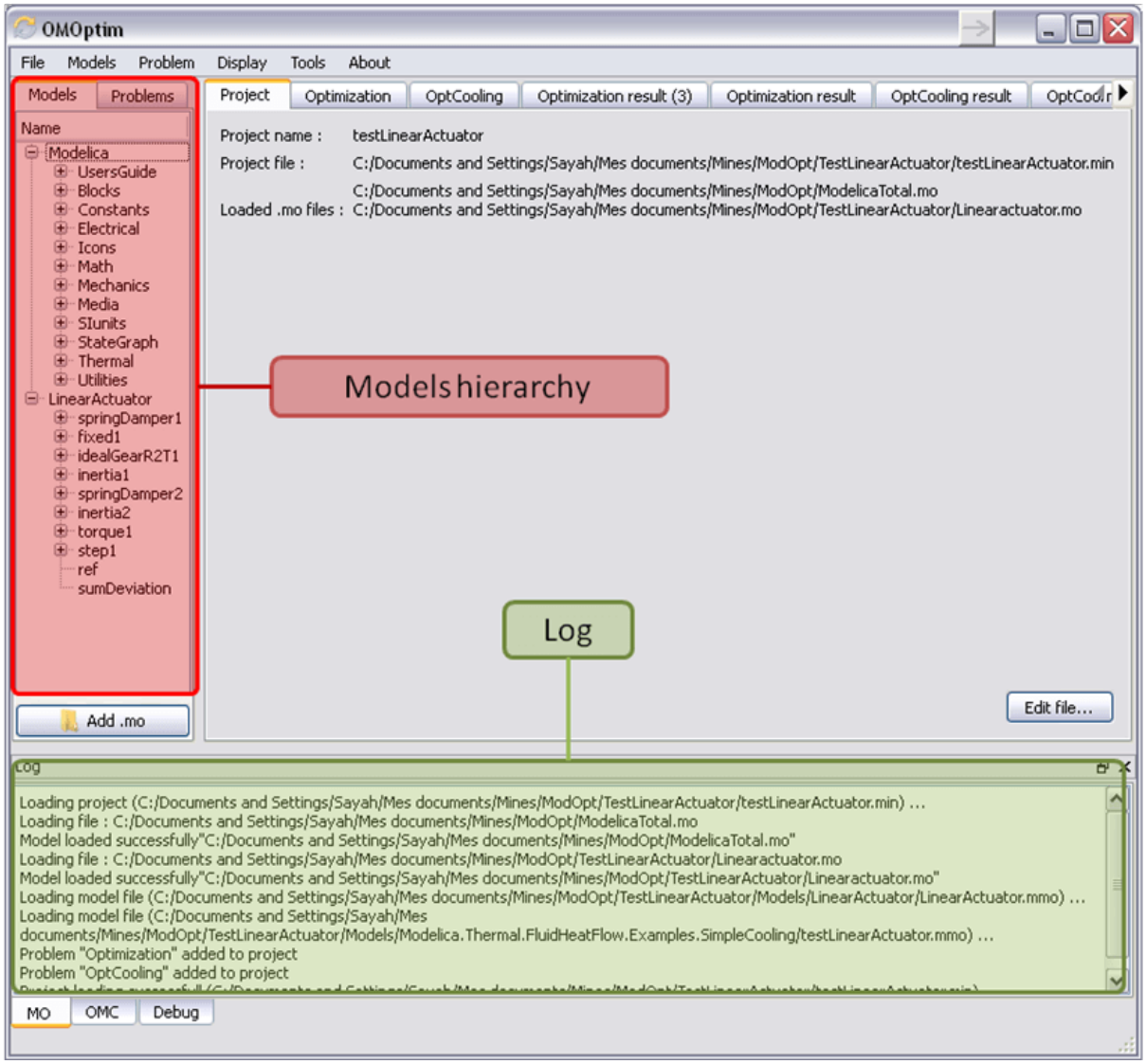



Figure 24.3: OMOptim window after having loaded model.

### Create a new optimization problem

Problem->Add Problem->Optimization

A dialog should appear. Select the model you want to optimize. Only Model can be selected (no Package, Component, Block...).

A new form will be displayed. This form has two tabs. One is called Variables, the other is called Optimization.

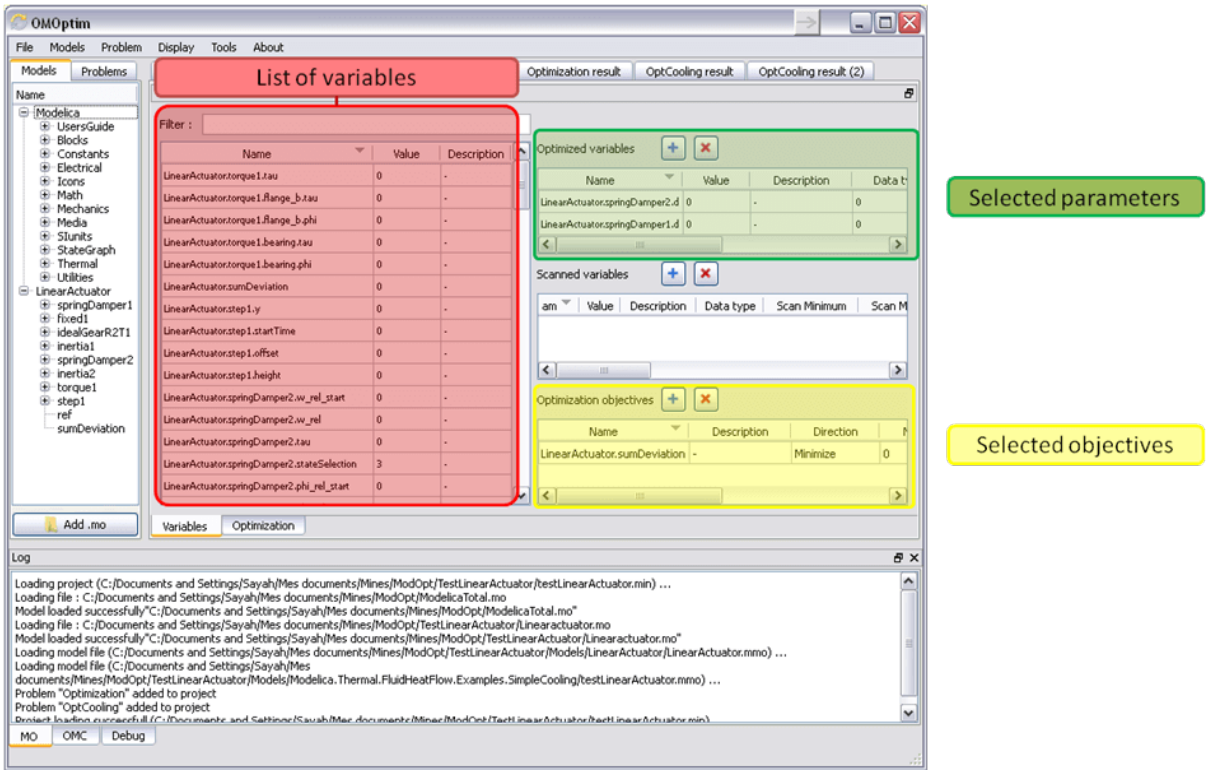



Figure 24.4: Forms for defining a new optimization problem.

### List of Variables is Empty

If variables are not displayed, right click on model name in model hierarchy, and select *Read variables*.

### Select Optimized Variables

To set optimization, we first have to define the variables the optimizer will consider as free *i.e.* those that it should find best values of. To do this, select in the left list, the variables concerned. Then, add them to *Optimized variables* by clicking on corresponding button (✚).

For each variable, you must set minimum and maximum values it can take. This can be done in the *Optimized variables* table.

### Select objectives

Objectives correspond to the final values of chosen variables. To select these last, select in left list variables concerned and click ✚ button of *Optimization objectives* table.

For each objective, you must:

- **Set minimum and maximum values it can take. If a configuration does** not respect these values, this configuration won't be considered. You also can set minimum and maximum equals to "-" : it will then
- Define whether objective should be minimized or maximized.

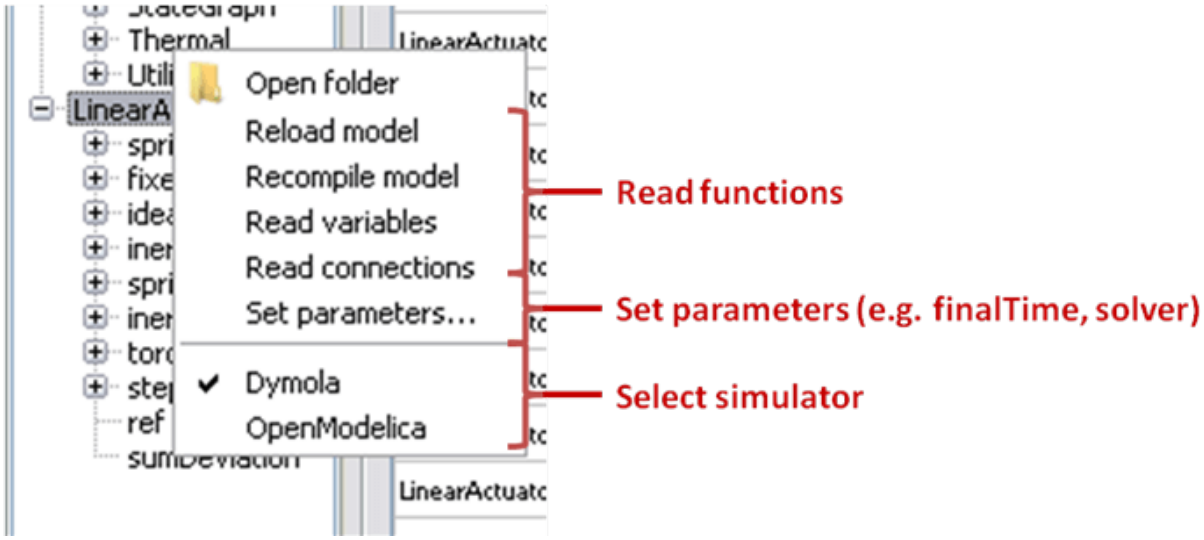



Figure 24.5: Selecting read variables, set parameters, and selecting simulator.

This can be done in the *Optimized variables* table.

### Select and configure algorithm

After having selected variables and objectives, you should now select and configure optimization algorithm. To do this, click on *Optimization* tab.

Here, you can select optimization algorithm you want to use. In version 0.9, OMOptim offers three different genetic algorithms. Let's for example choose SPEA2Adapt which is an auto-adaptative genetic algorithm.

By clicking on *parameters...* button, a dialog is opened allowing defining parameters. These are:

- ***Population size*: this is the number of configurations kept after a**
  generation. If it is set to 50, your final result can't contain more than 50 different points.
- ***Off spring rate*: this is the number of children per adult obtained**
  after combination process. If it is set to 3, each generation will contain 150 individual (considering population size is 50).
- ***Max generations*: this number defines the number of generations**
  after which optimization should stop. In our case, each generation corresponds to 150 simulations. Note that you can still stop optimization while it is running by clicking on *stop* button (which will appear once optimization is launched). Therefore, you can set a really high number and still stop optimization when you want without losing results obtained until there.
- ***Save frequency*: during optimization, best configurations can be**
  regularly saved. It allows to analyze evolution of best configurations but also to restart an optimization from previously obtained results. A Save Frequency parameter set to 3 means that after three generations, a file is automatically created containing best configurations. These files are named iteraion1.sav, iteration2.sav and are store in *Temp* directory, and moved to *SolvedProblems* directory when optimization is finished.
- ***ReinitStdDev*: this is a specific parameter of EAAdapt1. It defines**
  whether standard deviation of variables should be reinitialized. It is used only if you start optimization from previously obtained configurations (using *Use start file* option). Setting it to yes (1) will, in most of cases, lead to a spread research of optimized configurations, forgetting parameters' variations' reduction obtained in previous optimization.

#### Use start file

As indicated before, it is possible to pursue an optimization finished or stopped. To do this, you must enable *Use start file* option and select file from which optimization should be started. This file is an *iteration_.sav* file created in previous optimization. It is stored in corresponding *SolvedProblems* folder (*iteration10.sav* corresponds to the tenth generation of previous optimization).

***Note that this functionality can only work with same variables and objectives*.** However, minimum, maximum of variables and objectives can be changed before pursuing an optimization.

#### Launch

You can now launch Optimization by clicking *Launch* button.

#### Stopping Optimization

Optimization will be stopped when the generation counter will reach the generation number defined in parameters. However, you can still stop the optimization while it is running without loosing obtained results. To do this, click on *Stop* button. Note that this will not immediately stop optimization: it will first finish the current generation.

This stop function is especially useful when optimum points do not vary any more between generations. This can be easily observed since at each generation, the optimum objectives values and corresponding parameters are displayed in log window.

### 24.4.3 Results

The result tab appear when the optimization is finished. It consists of two parts: a table where variables are displayed and a plot region.

#### Obtaining all Variable Values

During optimization, the values of optimized variables and objectives are memorized. The others are not. To get these last, you must recomputed corresponding points. To achieve this, select one or several points in point's list region and click on *recompute*.

For each point, it will simulate model setting input parameters to point corresponding values. All values of this point (including those which are not optimization parameters neither objectives).

#### Window Regions in OMOptim GUI

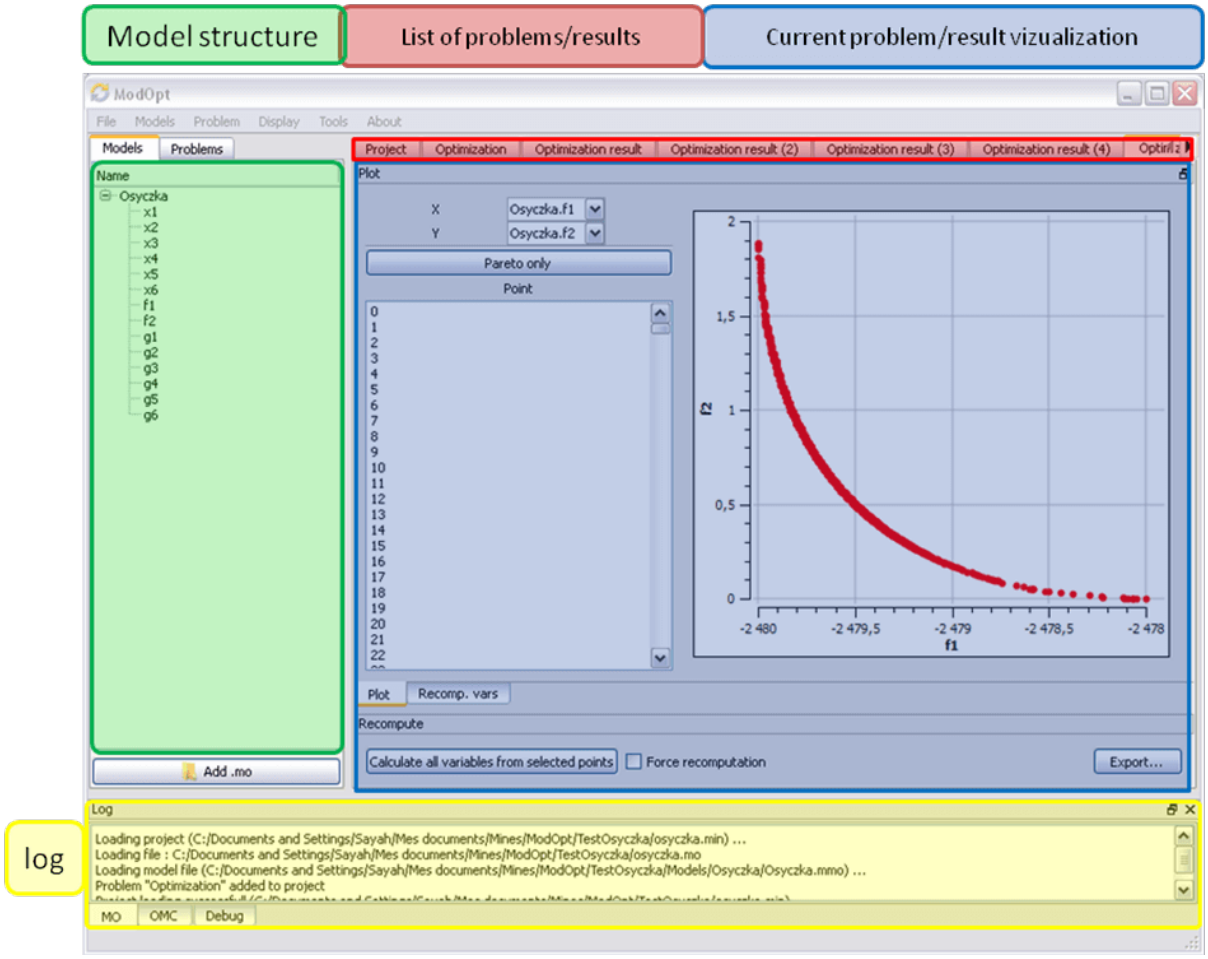



Figure 24.6: Window regions in OMOptim GUI.

CHAPTER

TWENTYFIVE

# PARAMETER SENSITIVITIES WITH OPENMODELICA

This section describes the use of OpenModelica to compute parameter sensitivities using forward sensitivity analysis together with the Sundials/IDA solver.

## 25.1 Single Parameter sensitivities with IDA/Sundials

### 25.1.1 Background

Parameter sensitivity analysis aims at analyzing the behavior of the corresponding model states w.r.t. model parameters.

Formally, consider a Modelica model as a DAE system:

$$F(x, \dot{x}, y, p, t) = 0 \; x(t_0) = x_0(p)$$

where $x(t) \in \mathbf{R}^n$ represent state variables, $\dot{x}(t) \in \mathbf{R}^n$ represent state derivatives, $y(t) \in \mathbf{R}^k$ represent algebraic variables, $p \in \mathbf{R}^m$ model parameters.

For parameter sensitivity analysis the derivatives

$$\frac{\partial x}{\partial p}$$

are required which quantify, according to their mathematical definition, the impact of parameters $p$ on states $x$. In the Sundials/IDA implementation the derivatives are used to evolve the solution over the time by:

$$\dot{s}_i = \frac{\partial x}{\partial p_i}$$

### 25.1.2 An Example

This section demonstrates the usage of the sensitivities analysis in OpenModelica on an example. This module is enabled by the following OpenModelica compiler flag:

```
>>> setCommandLineOptions("--calculateSensitivities")
true
```

Listing 25.1: LotkaVolterra.mo

```
model LotkaVolterra
  Real x(start=5, fixed=true),y(start=3, fixed=true);
  parameter Real mu1=5,mu2=2;
  parameter Real lambda1=3,lambda2=1;
equation
  0 = x*(mu1-lambda1*y) - der(x);
  0 = -y* (mu2 -lambda2*x) - der(y);
end LotkaVolterra;
```

Also for the simulation it is needed to set `IDA` as solver integration method and add a further simulation flag `-idaSensitivity` to calculate the parameter sensitivities during the normal simulation.

```
>>> simulate(LotkaVolterra, method="ida", simflags="-idaSensitivity")
record SimulationResult
    resultFile = "«DOCHOME»/LotkaVolterra_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 1.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'ida', fileNamePrefix = 'LotkaVolterra', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = '-
↪idaSensitivity'",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.002889739,
    timeBackend = 0.005829936,
    timeSimCode = 0.001149165000000002,
    timeTemplates = 0.003399802000000004,
    timeCompile = 0.42981897300000005,
    timeSimulation = 0.013711973,
    timeTotal = 0.45690889
end SimulationResult;
```

Now all calculated sensitivities are stored into the results mat file under the $Sensitivities block, where all currently every **top-level** parameter of the Real type is used to calculate the sensitivities w.r.t. **every state**.

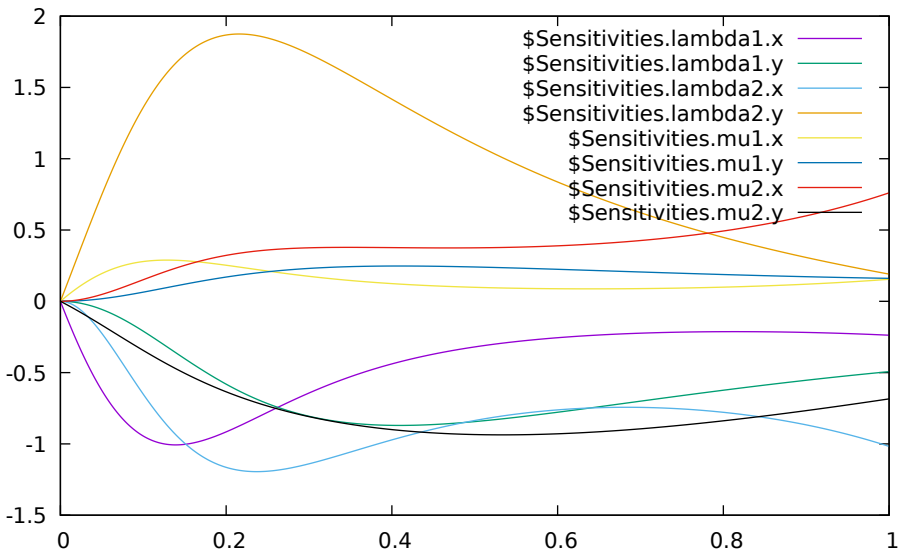



Figure 25.1: Results of the sensitivities calculated by IDA solver.

## 25.2 Single and Multi-parameter sensitivities with OMSens

OMSens is an OpenModelica sensitivity analysis and optimization module.

### 25.2.1 Installation

Follow the install instructions described on the OMSens github page.

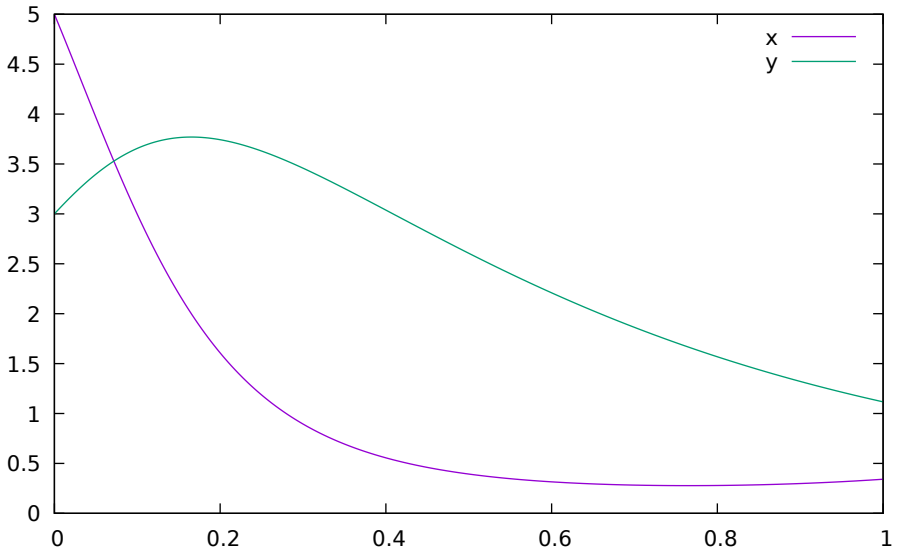



Figure 25.2: Results of the LotkaVolterra equations.

### 25.2.2 Usage

OMSens offers 3 flavors for parameter sensitivity analysis.

- Individual Sensitivity Analysis
  - Used to analyze how a parameter affects a variable when perturbed on its own
- Multi-parameter Sweep
  - Exploratory experimentation that sweeps the space of a set of parameters
- Vectorial Sensitivity Analysis
  - Used to find the combination of parameters that maximizes/minimizes a state variable

As an example, we choose the Lotka-Volterra model that consists of a second-order nonlinear set of ordinary differential equations. The system models the relationship between the populations of predators and preys in a closed ecosystem.

```
model LotkaVolterra "This is the typical equation-oriented model"
  parameter Real alpha=0.1 "Reproduction rate of prey";
  parameter Real beta=0.02 "Mortality rate of predator per prey";
  parameter Real gamma=0.4 "Mortality rate of predator";
  parameter Real delta=0.02 "Reproduction rate of predator per prey";
  parameter Real prey_pop_init=10 "Initial prey population";
  parameter Real pred_pop_init=10 "Initial predator population";
  Real prey_pop(start=prey_pop_init) "Prey population";
  Real pred_pop(start=pred_pop_init) "Predator population";
initial equation
  prey_pop = prey_pop_init;
  pred_pop = pred_pop_init;
equation
  der(prey_pop) = prey_pop*(alpha-beta*pred_pop);
  der(pred_pop) = pred_pop*(delta*prey_pop-gamma);
end LotkaVolterra;
```

Let's say we need to investigate the influence of model parameters on the predator population at 40 units of time. We assume a +/-5% uncertainty on model parameters.

We can use OMSens to study the sensitivity model to each parameter, one at a time.

Open the Lotka-Volterra model using OMEdit.

### Individual Sensitivity Analysis

- Select *Sensitivity Optimization* > *Run Sensitivity Analysis and Optimization* from the menu. A window like the one below should appear. Windows users should use the default python executable that comes with OpenModelica installation i.e., they don't need to change the proposed python executable path. If you want to use some other python installation then make sure that all the python dependencies are installed for that python installation.

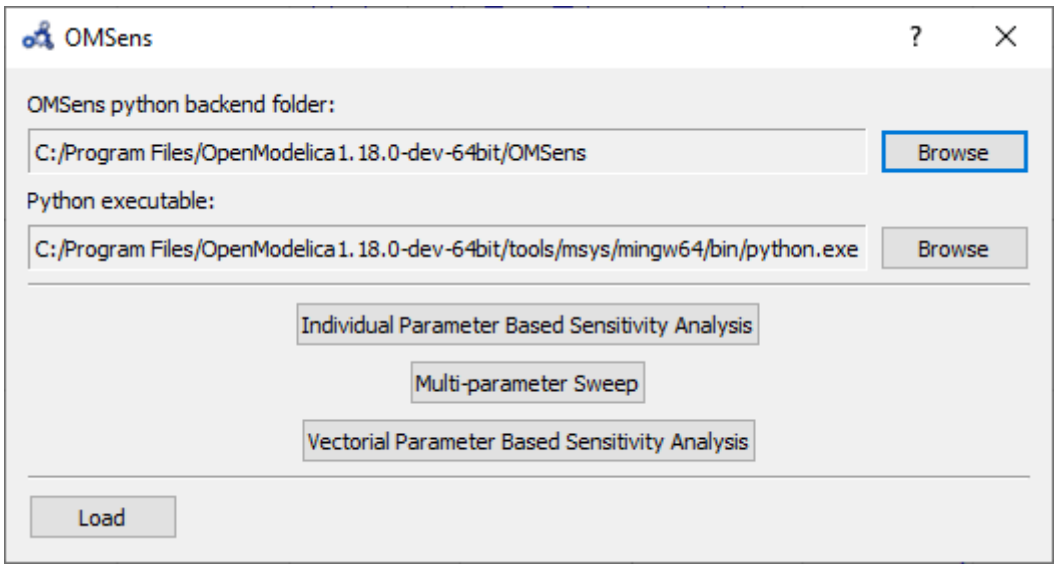



Figure 25.3: OMSens window.

- Choose **Individual Parameter Based Sensitivity Analysis** and set up the simulation settings.

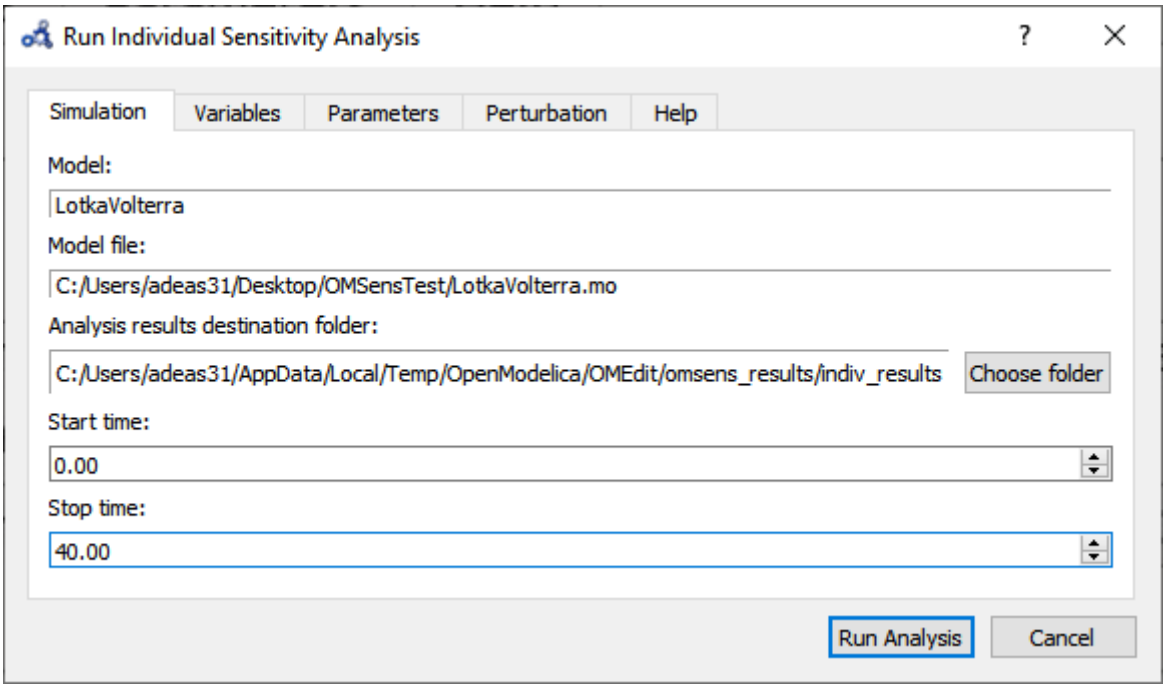



Figure 25.4: Run individual sensitivity analysis.

- Select variables.
- Select parameters.

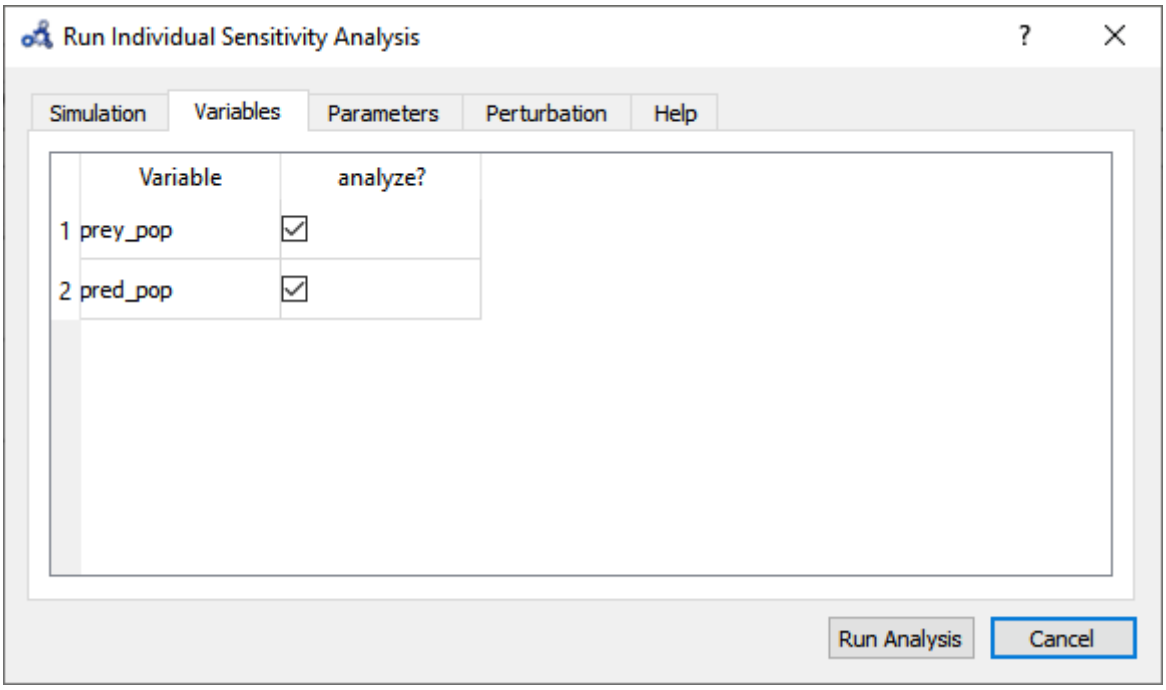



Figure 25.5: Individual sensitivity analysis variables.

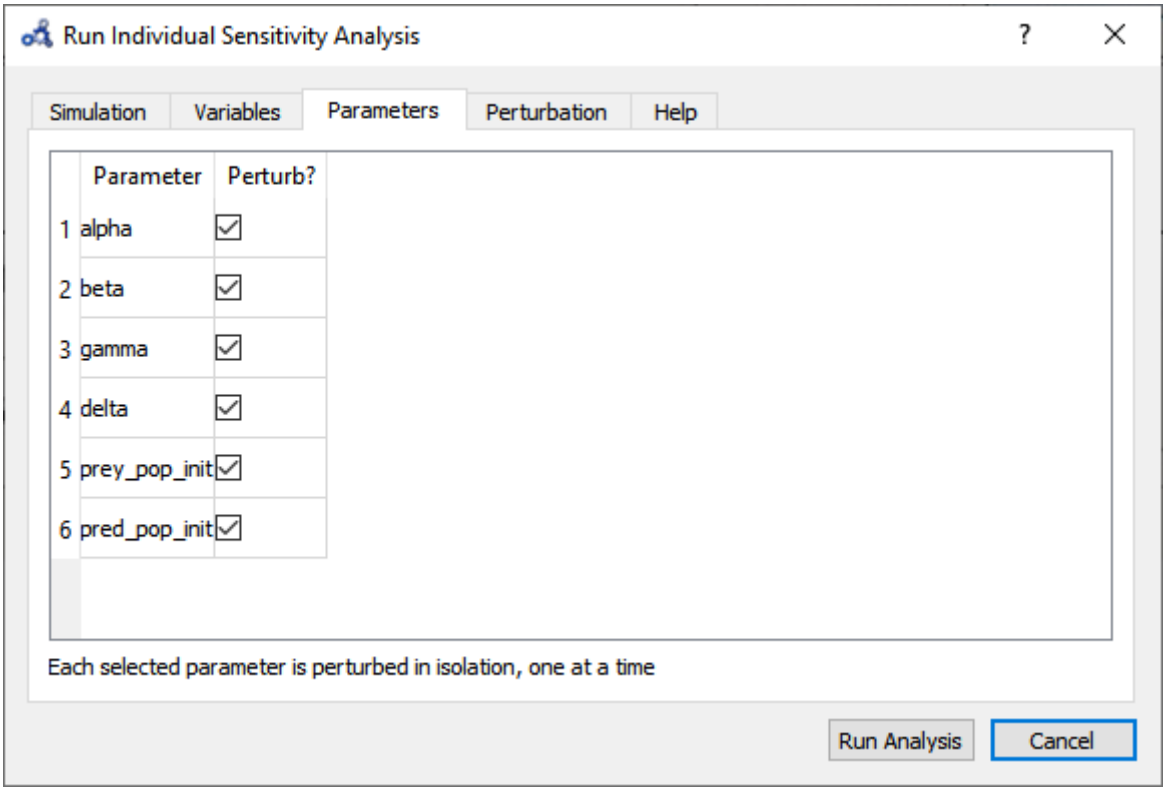



Figure 25.6: Individual sensitivity analysis parameters.

- Choose the perturbation percentage and direction. Run the analysis.

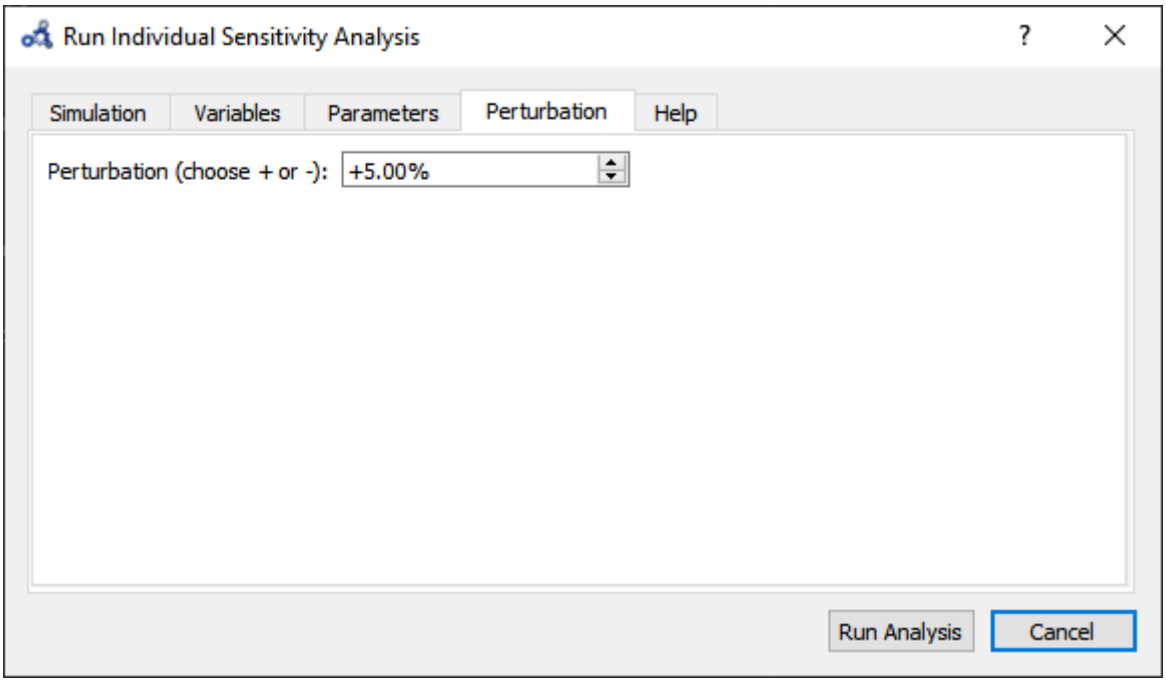



Figure 25.7: Individual sensitivity analysis perturbation.

- After the analysis a dialog with results is shown. Open the heatmap corresponding to the relative sensitivity index.

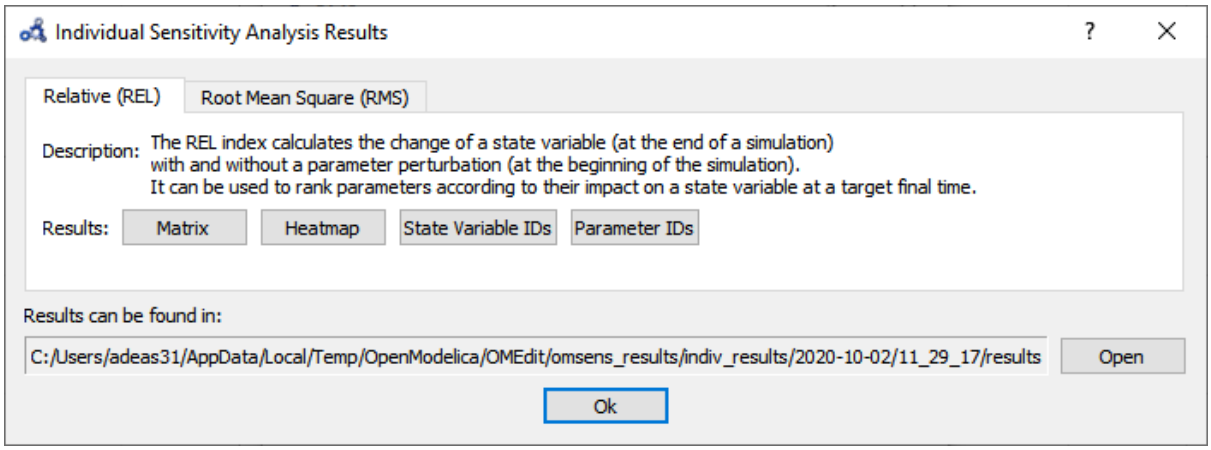



Figure 25.8: Individual sensitivity analysis results.

- The heatmap shows the effect of each parameter on each variable in the form of (parameter,variable) cells. As we can see, pred_pop was affected by the perturbation on every parameter but prey_pop presents a negligible sensitivity to delta (P.3). Recall that this heatmap shows the effect on the variables at time 40 for each perturbation imposed at time 0.

### Multi-parameter Sweep

Now we would like to see what happens to pred_pop when the top 3 most influencing parameters are perturbed at the same time. Repeat the first three steps from *Individual Sensitivity Analysis* but this time select **Multi-parameter Sweep**.

- Choose to sweep alpha, gamma and pred_pop_init in a range of $\pm 5\%$ from its default value and with 3 iterations (#iter) distributed equidistantly within that range. Run the sweep analysis.

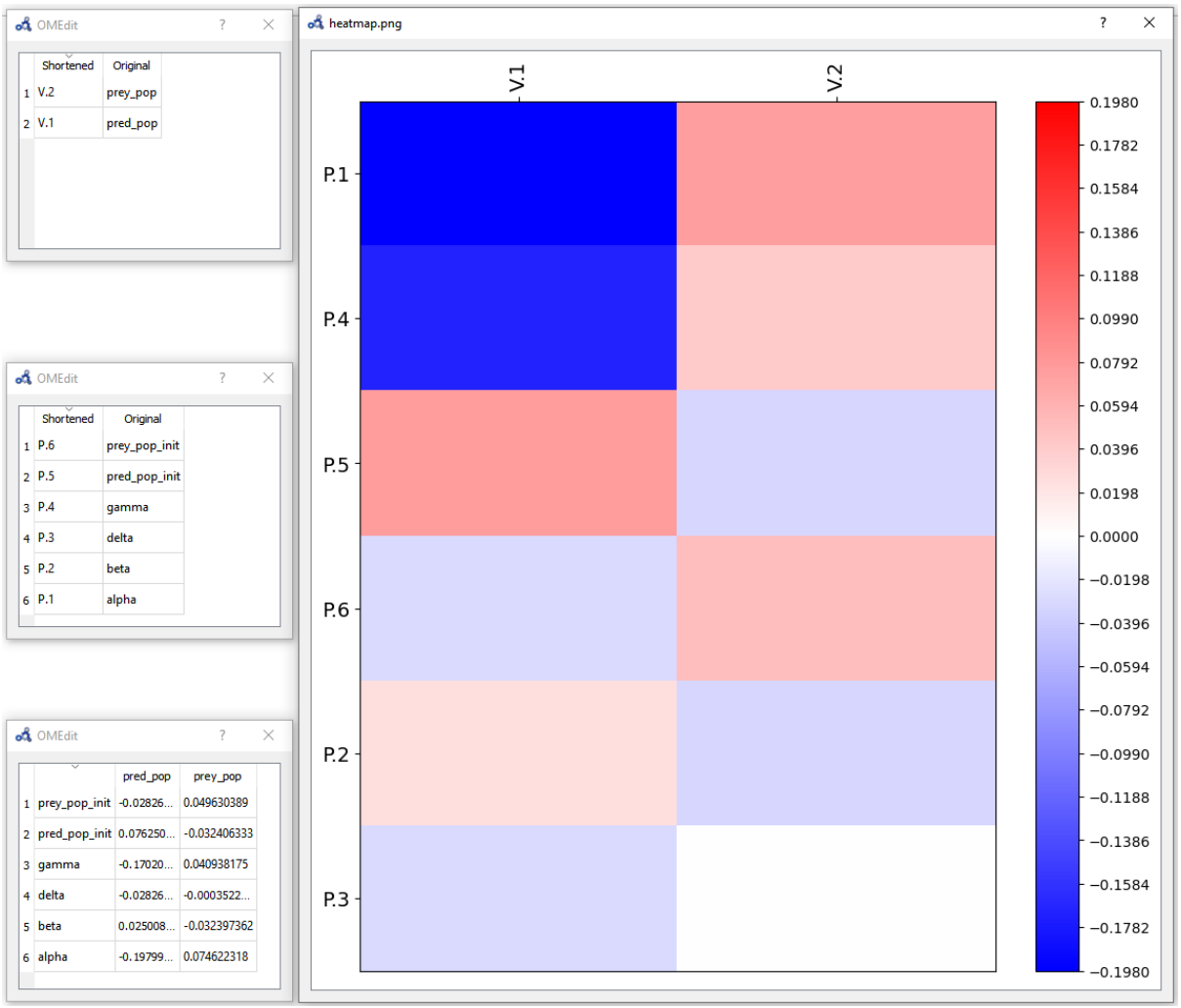



Figure 25.9: Individual sensitivity analysis heatmap.

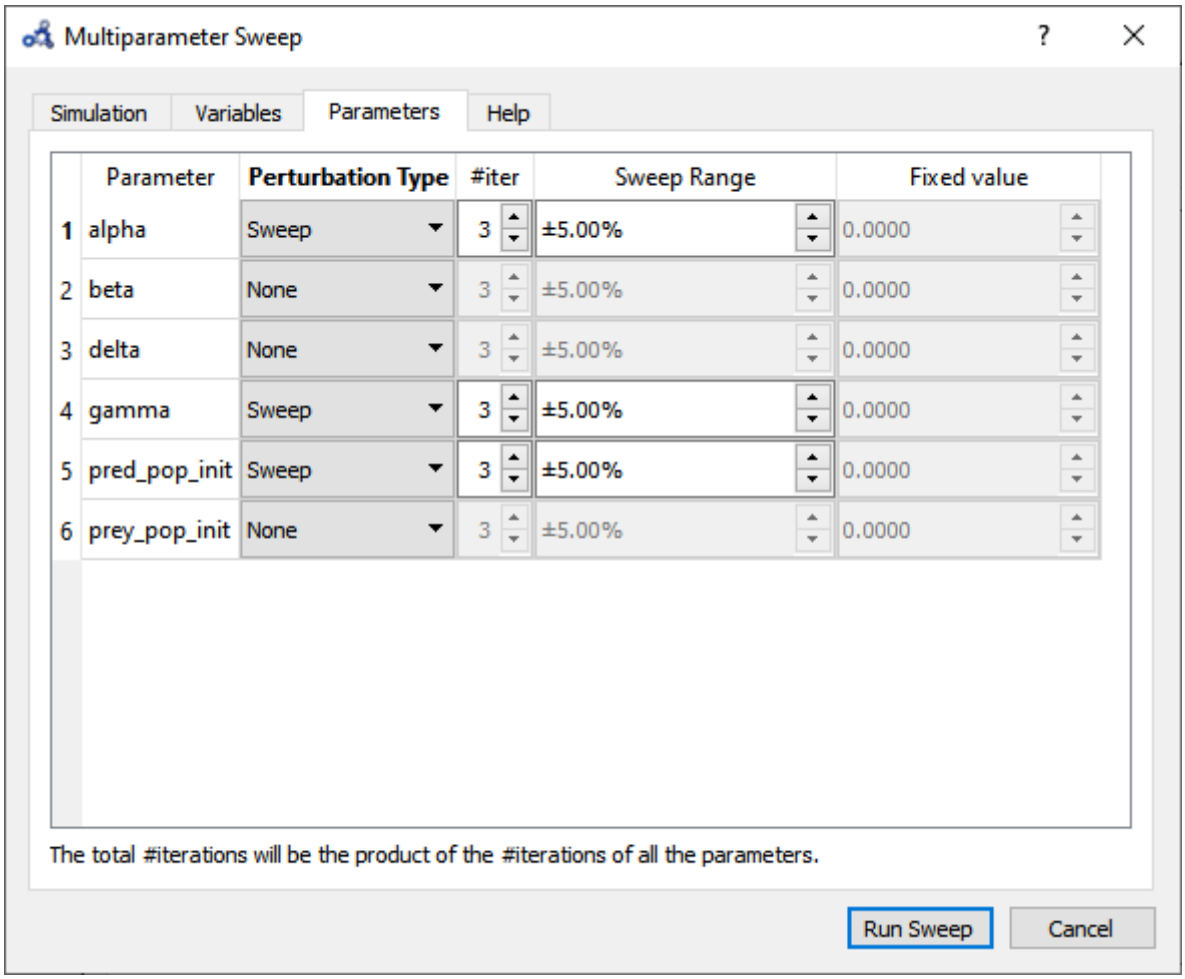



Figure 25.10: Multi-parameter sweep parameters.

- The backend is invoked and when it completes the analysis the following results dialog is shown. Open the plot for pred_pop.

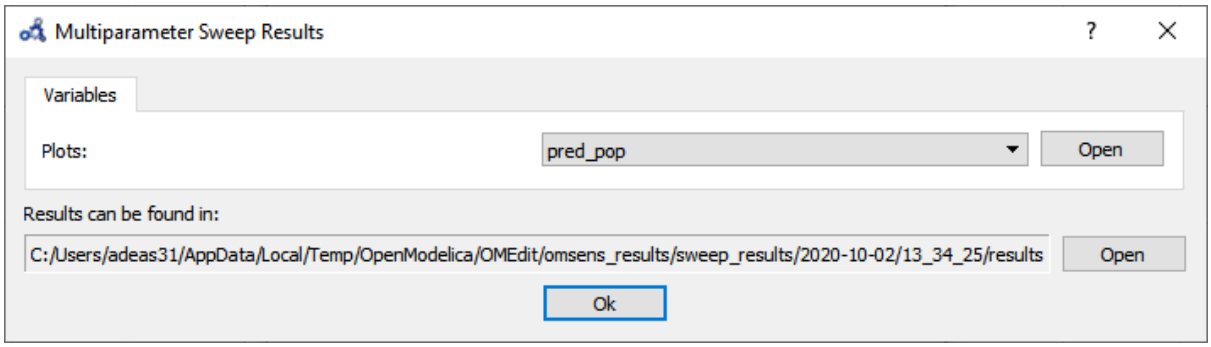



Figure 25.11: Multi-parameter sweep results.

- At time 40 the parameters perturbations with a higher predator population are all blue, but it's not clear which one. We need something more precise.

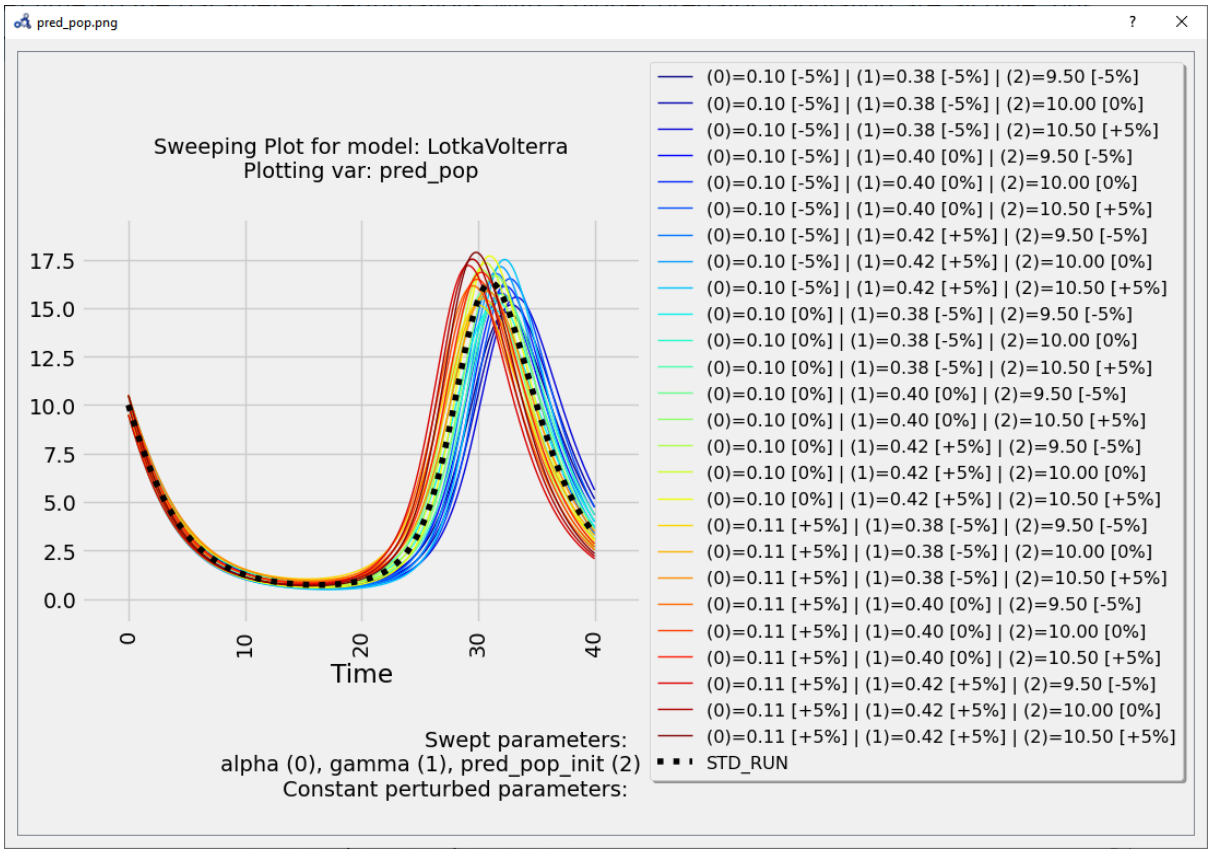



Figure 25.12: Multi-parameter sweep plot.

These results can be very informative but clearly the exhaustive exploration approach doesn't scale for more parameters (#p) and more perturbation values (#v) (#v^#p simulations required).

### Vectorial Sensitivity Analysis

Using the Vectorial optimization-based analysis (see below) we can request OMSens to find a combination of parameters that perturbs the most (i.e. minimize or maximize) the value of the target variable at a desired simulation time.

For **Vectorial Sensitivity Analysis** repeat the first two steps from *Individual Sensitivity Analysis* but choose **Vectorial Parameter Based Sensitivity Analysis**.

- Choose only alpha, delta and pred_pop_init to perturb.

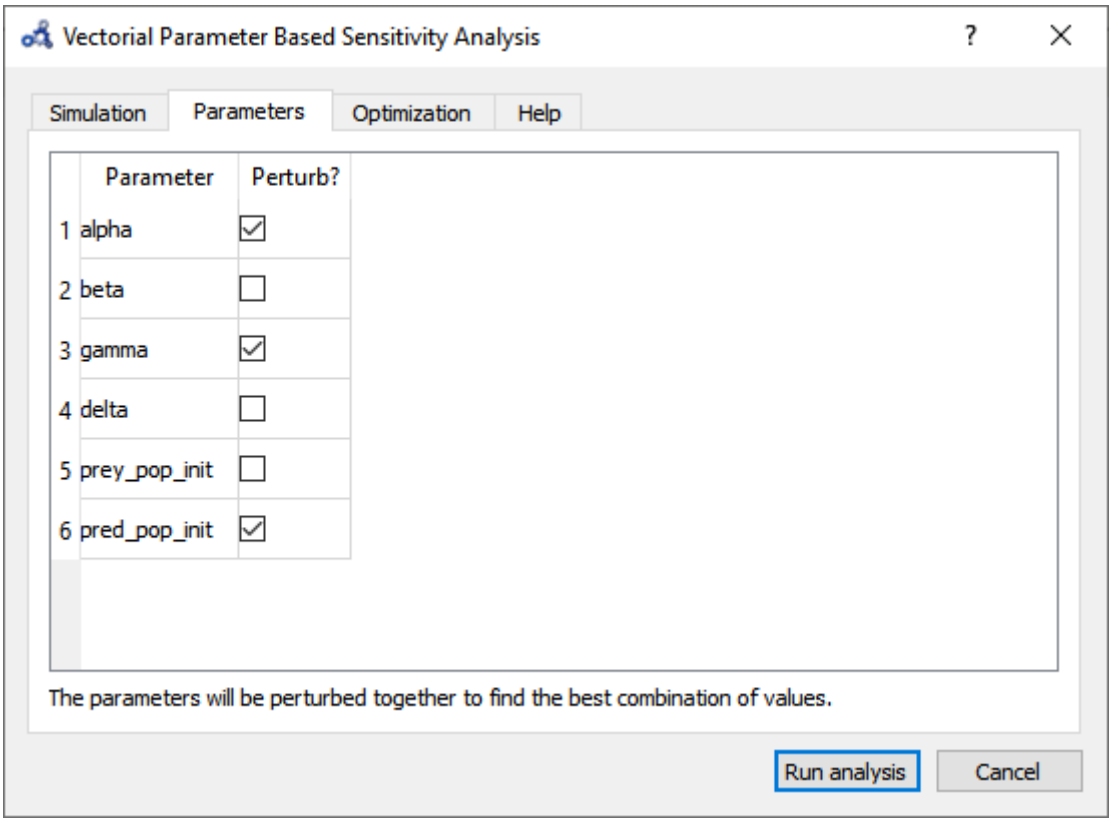



Figure 25.13: Vectorial sensitivity analysis parameters.

- Setup the optimization settings and run the analysis.
- The **Parameters** tab in the results window shows the values found by the optimization routine that maximize pred_pop at t=40 s.
- The **State Variable** tab shows the comparison between the values of the variable in the standard run vs the perturbed run at simulation time 40s.
- If we simulate using the optimum values and compare it to the standard (unperturbed) run, we see that it **delays the bell** described by the variable.
- So far, we have only perturbed the top 3 parameters detected by the **Individual Sensitivity** method. Maybe we can find a greater effect on the variable if we perturb all 6 parameters. Running a Sweep is not an option as perturbing 6 parameters with 3 iterations each results in $3^6$=729 simulations. We run another Vectorial Sensitivity Analysis instead but now choose to perturb all 6 parameters.
- The **parameters tab** shows that the optimum value is found by perturbing all of the parameters to their boundaries.
- The **State Variable** tab shows that pred_pop can be increased by 98% when perturbing the 6 parameters as opposed to 68% when perturbing the top 3 influencing parameters.
- The plot shows again that the parameters found delay the bell-shaped curve, but with a stronger impact than before.

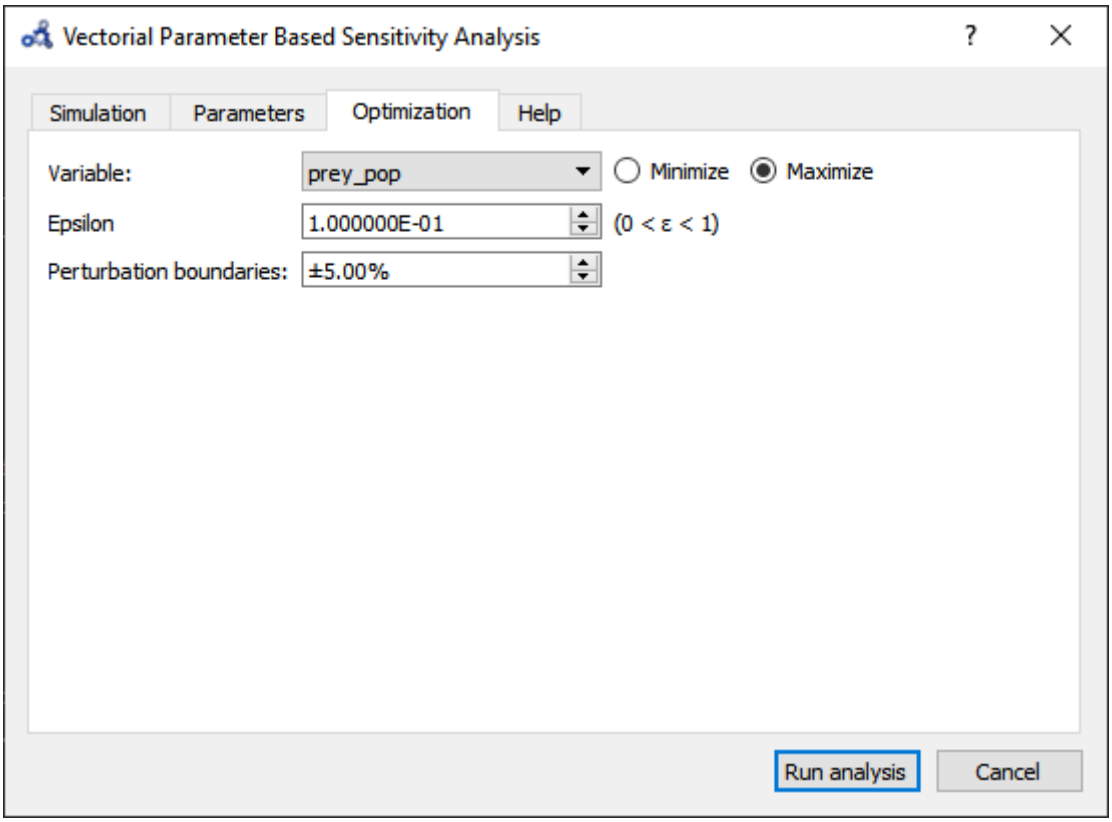



Figure 25.14: Vectorial sensitivity analysis optimization.

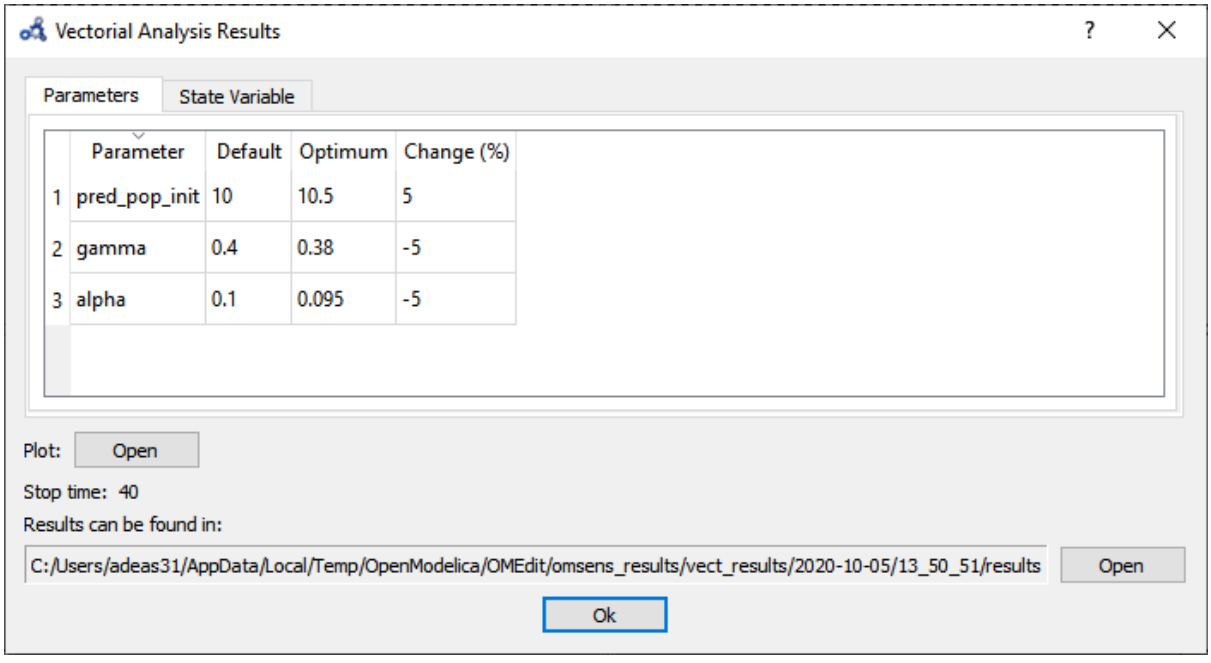



Figure 25.15: Vectorial sensitivity analysis parameters result.

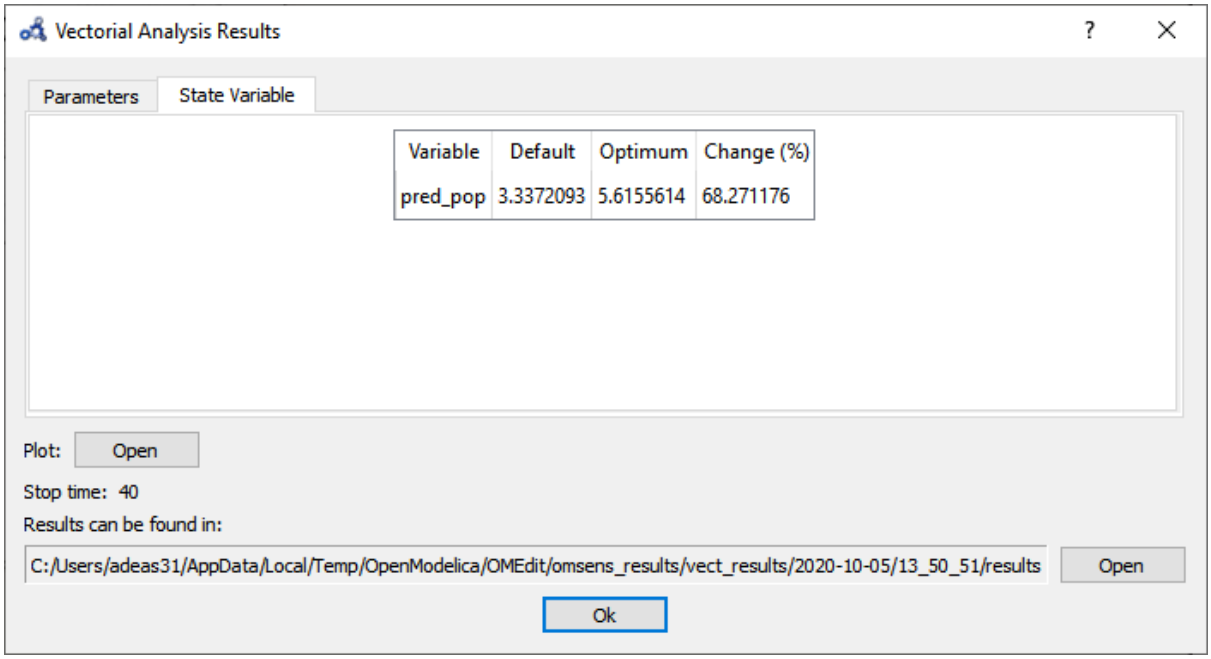



Figure 25.16: Vectorial sensitivity analysis state variables.

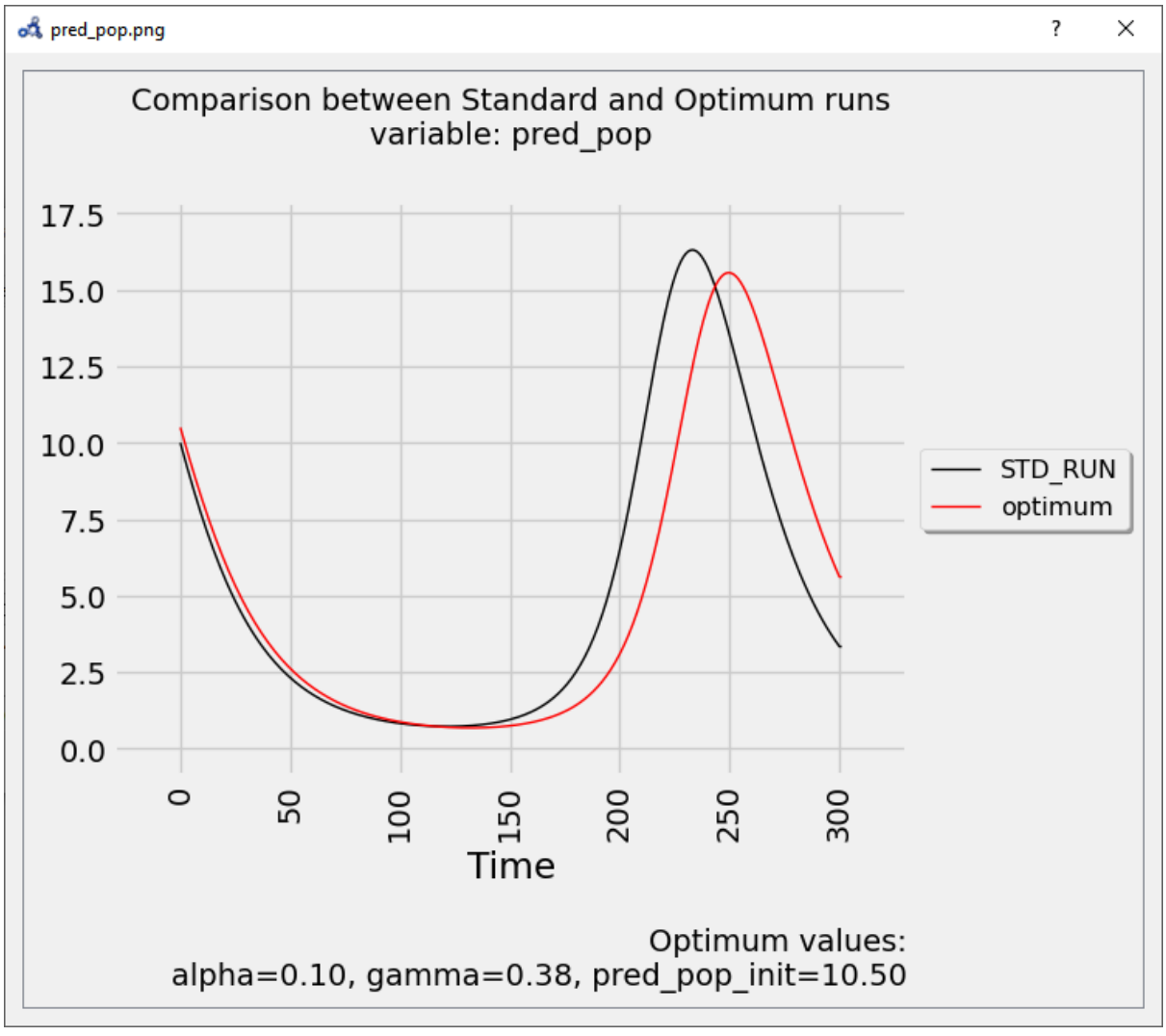



Figure 25.17: Vectorial sensitivity analysis plot.

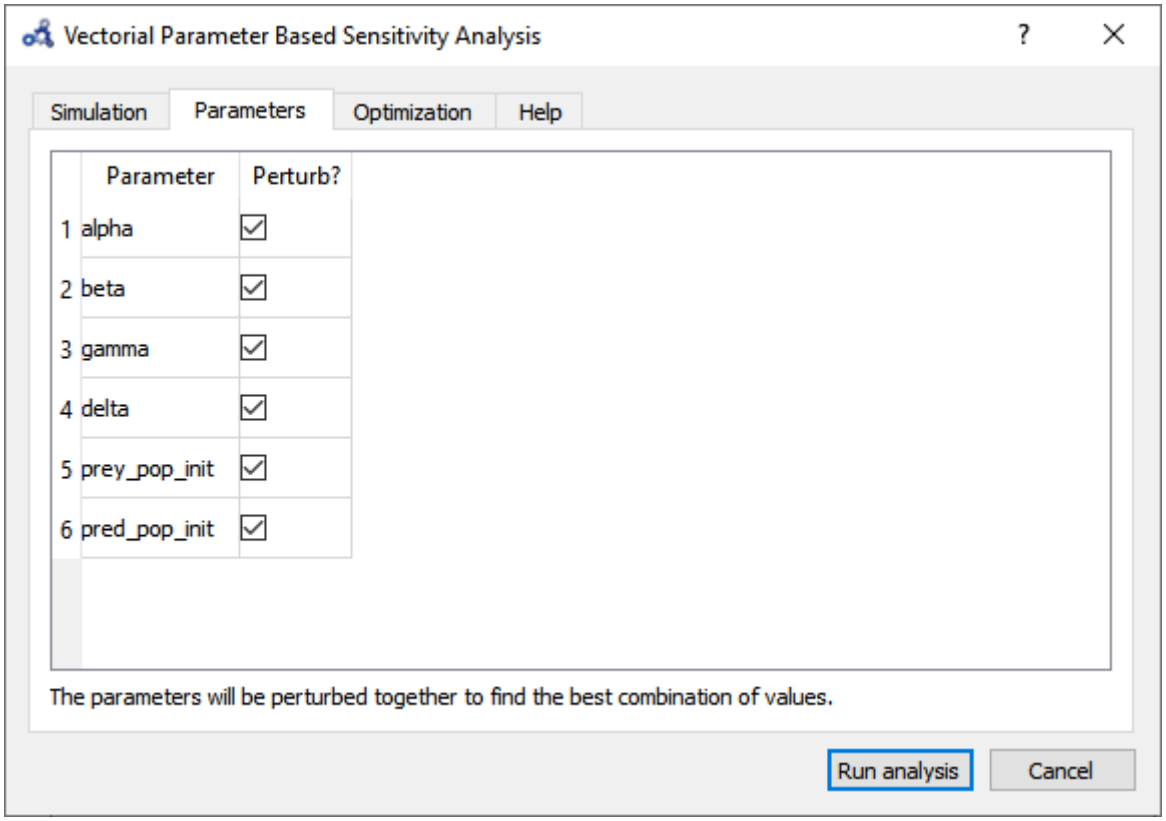



Figure 25.18: Vectorial sensitivity analysis parameters.

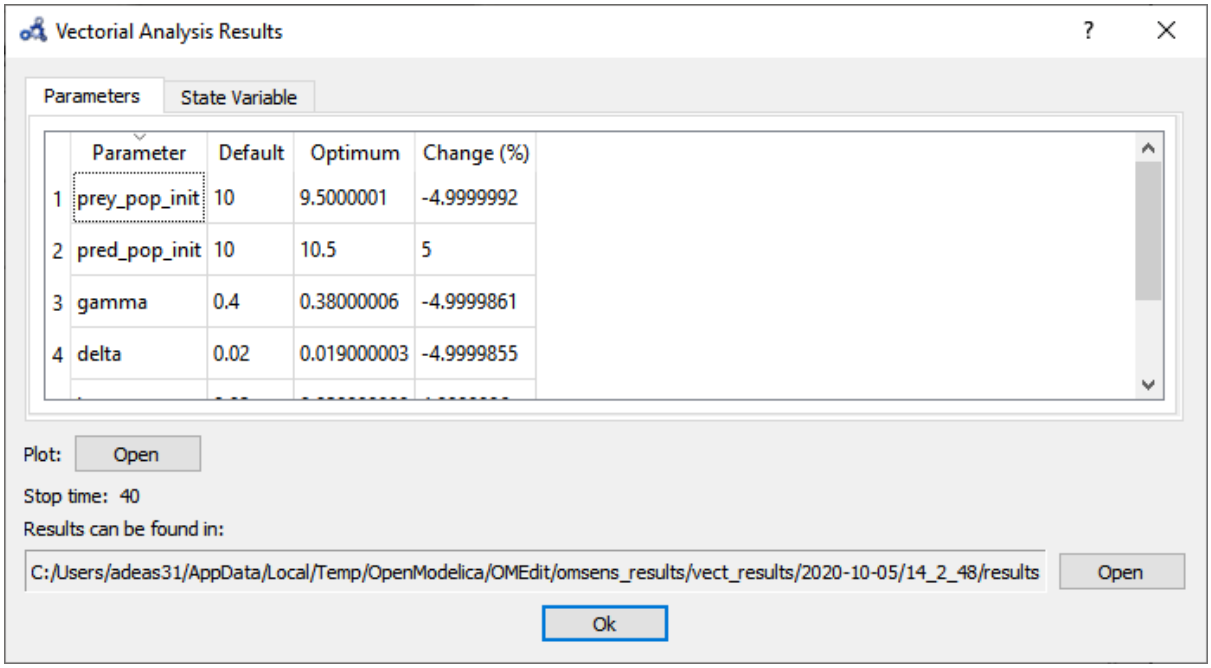



Figure 25.19: Vectorial sensitivity analysis parameters result.

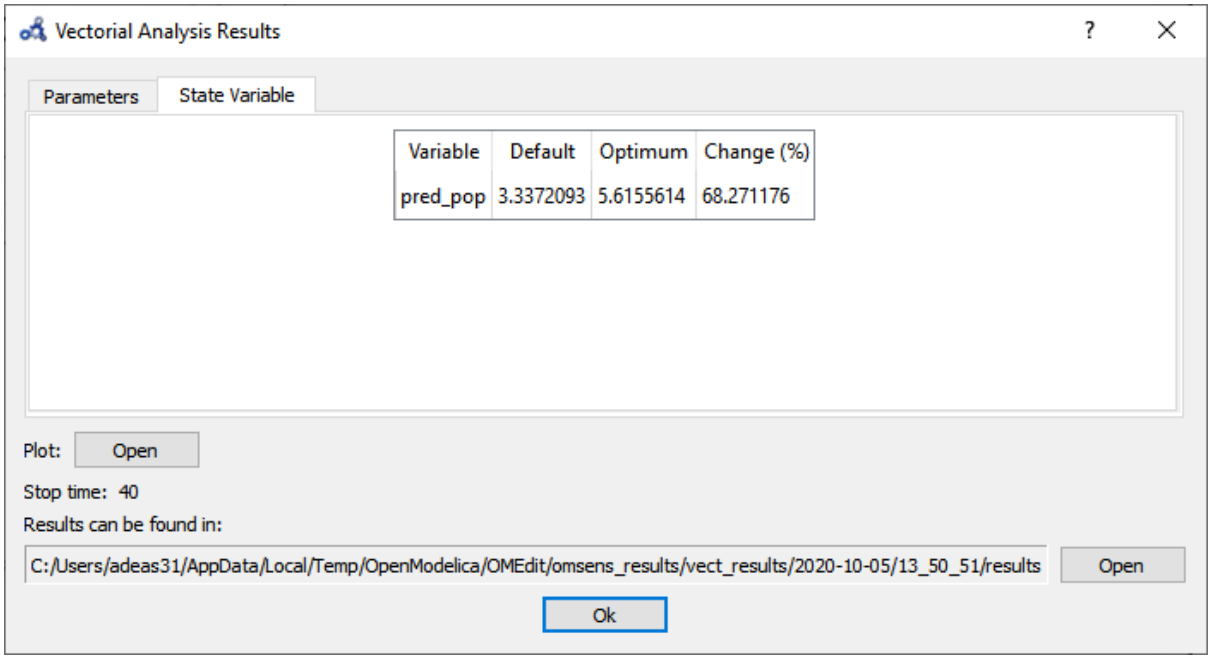



Figure 25.20: Vectorial sensitivity analysis state variables.

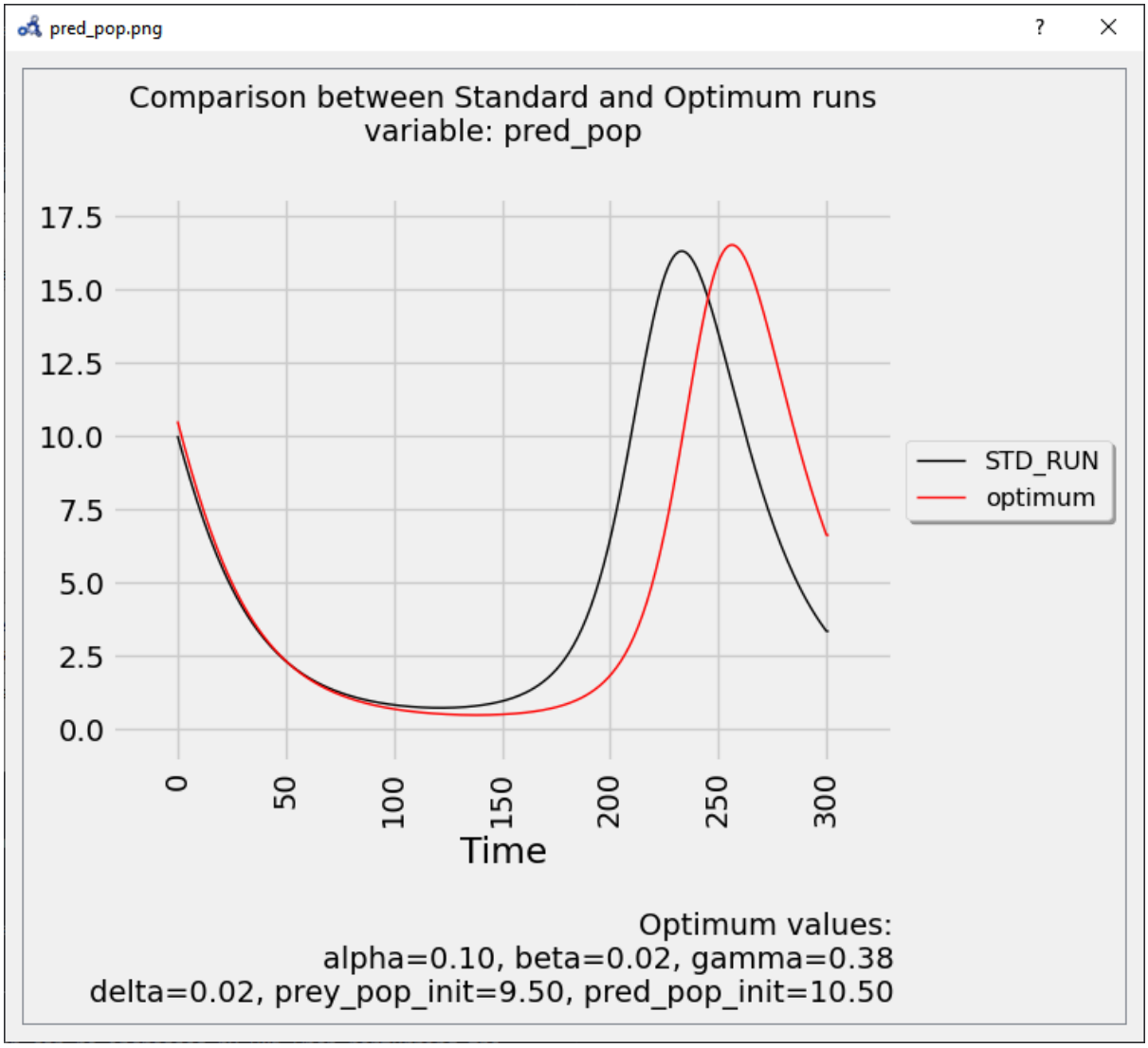



Figure 25.21: Vectorial sensitivity analysis plot.

CHAPTER

# TWENTYSIX

# PDEMODELICA1

PDEModelica1 is nonstandardised experimental Modelica language extension for 1-dimensional partial differential extensions (PDE).

It is enabled using compiler flag `--grammar=PDEModelica`. Compiler flags may be set e.g. in OMEdit (globally in Tools->Options->Simulation->Translation Flags or in Simulation Setup->Translation Flags for specific models) or in an OpenModelica script using `setCommandLineOptions`. Note that PDEModelica does now work yet with the current frontend so you need to also use the flag `-d=-newInst` or check "Enable old frontend for code generation" in OMEdit under Translation Flags.

```
>>> setCommandLineOptions("--grammar=PDEModelica -d=-newInst")
true
```

## 26.1 PDEModelica1 language elements

Let us introduce new PDEModelica1 language elements by an advection equation example model:

```
model Advection "advection equation"
  parameter Real pi = Modelica.Constants.pi;
  parameter DomainLineSegment1D omega(L = 1, N = 100)  "domain";
  field Real u(domain = omega)                         "field";
initial equation
  u = sin(2*pi*omega.x)                                "IC";
equation
  der(u) + pder(u,x) = 0   indomain omega              "PDE";
  u = 0                    indomain omega.left         "BC";
  u = extrapolateField(u)  indomain omega.right        "extrapolation";
end Advection;
```

The domain `omega` represents the geometrical domain where the PDE holds. The domain is defined using the built-in record `DomainLineSegment1D`. This record contains among others `L` - the length of the domain, `N` - the number of grid points, `x` - the coordinate variable and the regions `left`, `right` and `interior`, representing the left and right boundaries and the interior of the domain.

The field variable `u` is defined using a new keyword `field`. The `domain` is a mandatory attribute to specify the domain of the field.

The `indomain` operator specifies where the equation containing the field variable holds. It is utilised in the initial conditions (IC) of the fields, in the PDE and in the boundary conditions (BC). The syntax is

```
anEquation indomain aDomain.aRegion;
```

If the region is omitted, `interior` is the default (e.g. the PDE in the example above).

The IC of the field variable u is written using an expression containing the coordinate variable `omega.x`.

The PDE contains a partial space derivative written using the `pder` operator. Also the second derivative is allowed (not in this example), the syntax is e.g. `pder(u,x,x)`. It is not necessary to specify the domain of coordinate in pder (to write e.g. `pder(u,omega.x)`, even though `x` is a member of `omega`.

## 26.2 Limitations

BCs may be written only in terms of variables that are spatially differentiated currently.

All fields that are spatially differentiated must have either BC or extrapolation at each boundary. This extrapolation should be done automatically by the compiler, but this has not been implemented yet. The current workaround is the usage of the `extrapolateField()` operator directly in the model.

If-equations are not spported yet, if-expressions must be used instead.

## 26.3 Viewing results

During translation field variables are replaced with arrays. These arrays may be plotted using *Array Plot* or even better using *Array Parametric Plot* (to plot x-coordinate versus a field).

CHAPTER

TWENTYSEVEN

# MDT - THE OPENMODELICA DEVELOPMENT TOOLING ECLIPSE PLUGIN

## 27.1 Introduction

The Modelica Development Tooling (MDT) Eclipse Plugin as part of OMDev - The OpenModelica Development Environment integrates the OpenModelica compiler with Eclipse. MDT, together with the OpenModelica compiler, provides an environment for working with Modelica and MetaModelica development projects. This plugin is primarily intended for tool developers rather than application Modelica modelers.

The following features are available:

- Browsing support for Modelica projects, packages, and classes
- Wizards for creating Modelica projects, packages, and classes
- Syntax color highlighting
- Syntax checking
- Browsing of the Modelica Standard Library or other libraries
- Code completion for class names and function argument lists
- Goto definition for classes, types, and functions
- Displaying type information when hovering the mouse over an identifier.

## 27.2 Installation

The installation of MDT is accomplished by following the below installation instructions. These instructions assume that you have successfully downloaded and installed Eclipse (http://www.eclipse.org).

The latest installation instructions are available through the OpenModelica Trac.

1. Start Eclipse
2. Select Help->Software Updates->Find and Install... from the menu
3. Select 'Search for new features to install' and click 'Next'
4. Select 'New Remote Site...'
5. Enter 'MDT' as name and http://www.ida.liu.se/labs/pelab/modelica/OpenModelica/MDT as URL and click 'OK'
6. Make sure 'MDT' is selected and click 'Finish'
7. In the updates dialog select the 'MDT' feature and click 'Next'
8. Read through the license agreement, select 'I accept...' and click 'Next'
9. Click 'Finish' to install MDT

## 27.3 Getting Started

### 27.3.1 Configuring the OpenModelica Compiler

MDT needs to be able to locate the binary of the compiler. It uses the environment variable OPENMODELICAHOME to do so.

If you have problems using MDT, make sure that OPENMODELICAHOME is pointing to the folder where the OpenModelica Compiler is installed. In other words, OPENMODELICAHOME must point to the folder that contains the Open Modelica Compiler (OMC) binary. On the Windows platform it's called omc.exe and on Unix platforms it's called omc.

### 27.3.2 Using the Modelica Perspective

The most convenient way to work with Modelica projects is to use to the Modelica perspective. To switch to the Modelica perspective, choose the Window menu item, pick Open Perspective followed by Other**...** Select the Modelica option from the dialog presented and click OK..

### 27.3.3 Selecting a Workspace Folder

Eclipse stores your projects in a folder called a workspace. You need to choose a workspace folder for this session, see Figure 27.1.

### 27.3.4 Creating one or more Modelica Projects

To start a new project, use the New Modelica Project Wizard. It is accessible through File->New-> Modelica Project or by right-clicking in the Modelica Projects view and selecting New->Modelica Project.

You need to disable automatic build for the project(s) (Figure 27.3).

Repeat the procedure for all the projects you need, e.g. for the exercises described in the MetaModelica users guide: 01_experiment, 02a_exp1, 02b_exp2, 03_assignment, 04a_assigntwotype, etc.

NOTE: Leave open only the projects you are working on! Close all the others!

### 27.3.5 Building and Running a Project

After having created a project, you eventually need to build the project (Figure 27.4).

The build options are the same as the make targets: you can build, build from scratch (clean), or run simulations depending on how the project is setup. See Figure 27.5 for an example of how omc can be compiled (`make omc` builds OMC).

### 27.3.6 Switching to Another Perspective

If you need, you can (temporarily) switch to another perspective, e.g. to the Java perspective for working with an OpenModelica Java client as in Figure 27.7.

### 27.3.7 Creating a Package

To create a new package inside a Modelica project, select File->New->Modelica Package**.** Enter the desired name of the package and a description of what it contains. Note: for the exercises we already have existing packages.

### 27.3.8 Creating a Class

To create a new Modelica class, select where in the hierarchy that you want to add your new class and select File->New->Modelica Class. When creating a Modelica class you can add different restrictions on what the class can contain. These can for example be model, connector, block, record, or function. When you have selected your desired class type, you can select modifiers that add code blocks to the generated code. 'Include initial code block' will for example add the line 'initial equation' to the class.

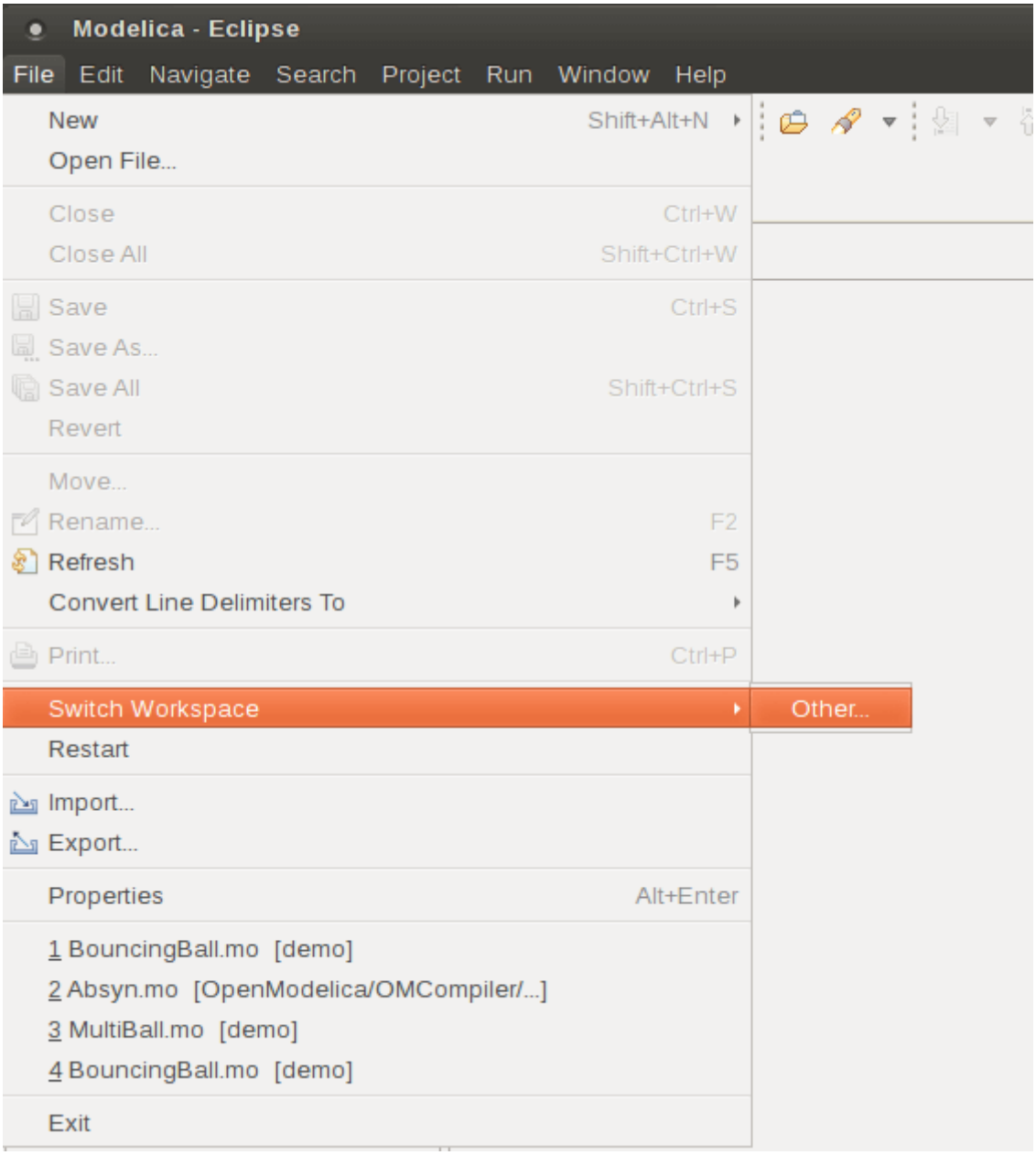



Figure 27.1: Eclipse Setup - Switching Workspace.

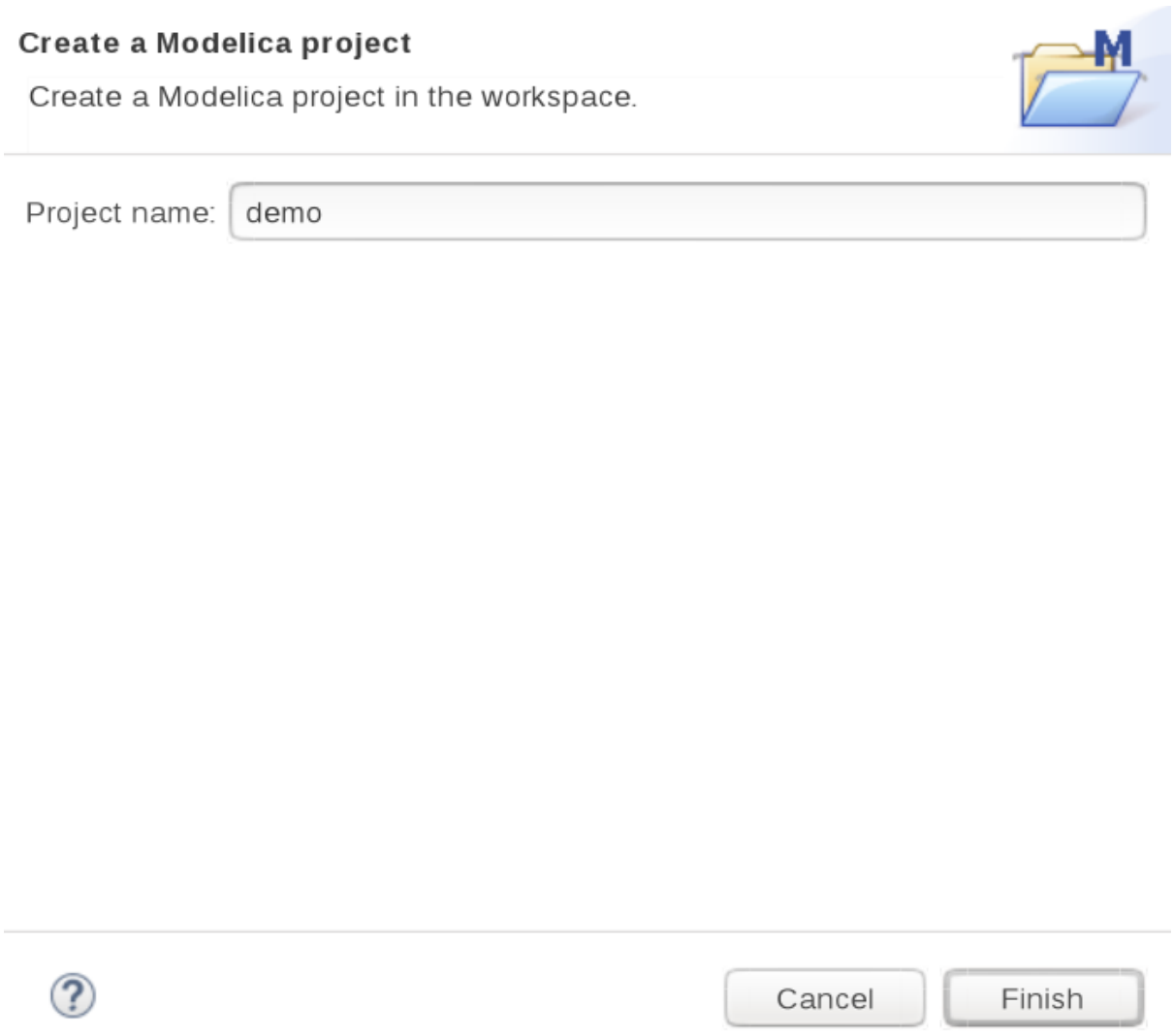



Figure 27.2: Eclipse Setup - creating a Modelica project in the workspace.

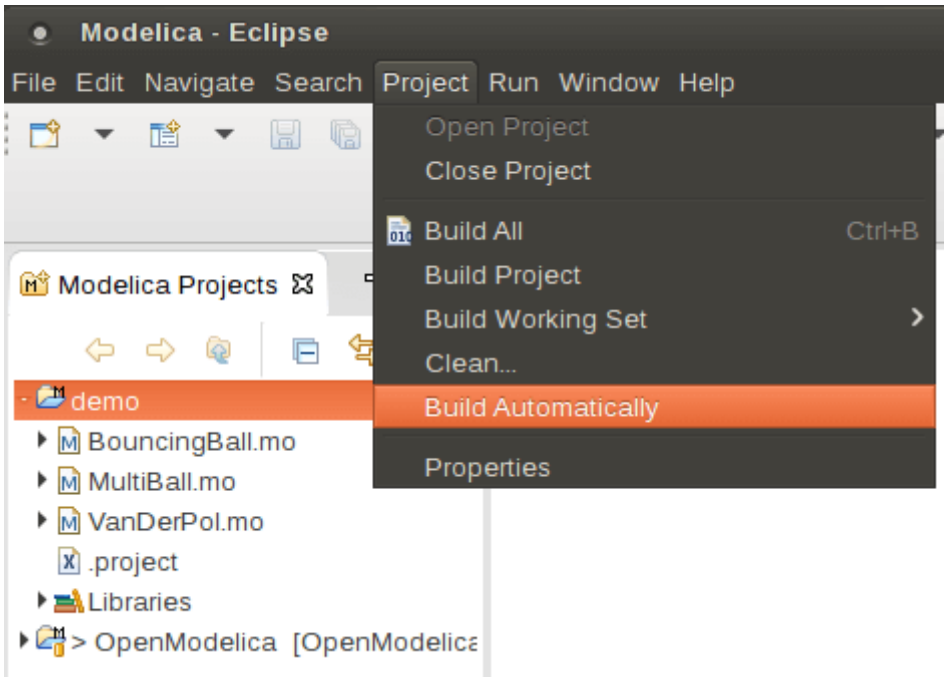



Figure 27.3: Eclipse Setup - disable automatic build for the projects.

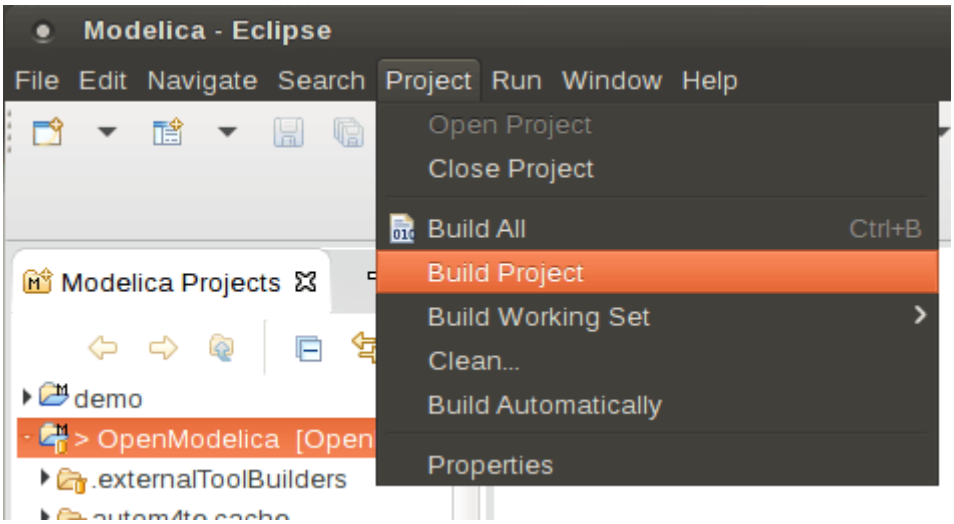



Figure 27.4: Eclipse MDT - Building a project.

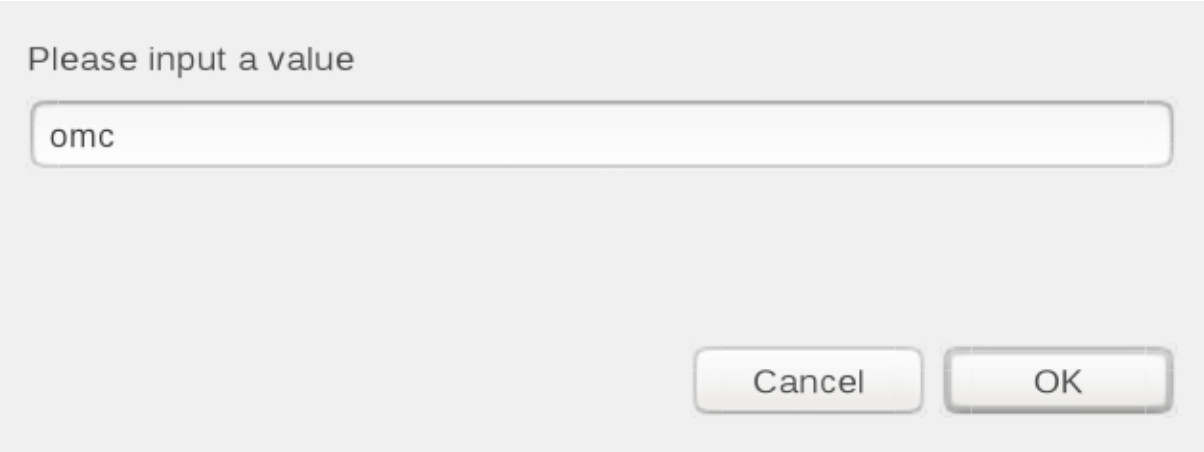



Figure 27.5: Eclipse - building a project.

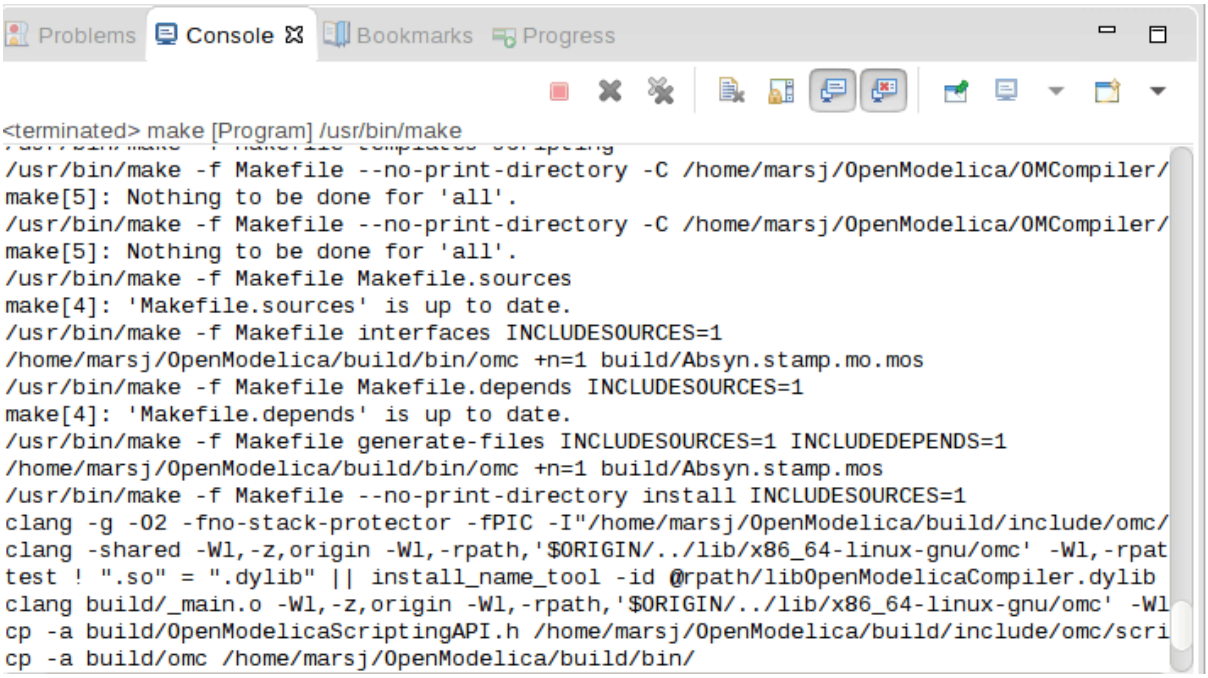



Figure 27.6: Eclipse - building a project, resulting log.

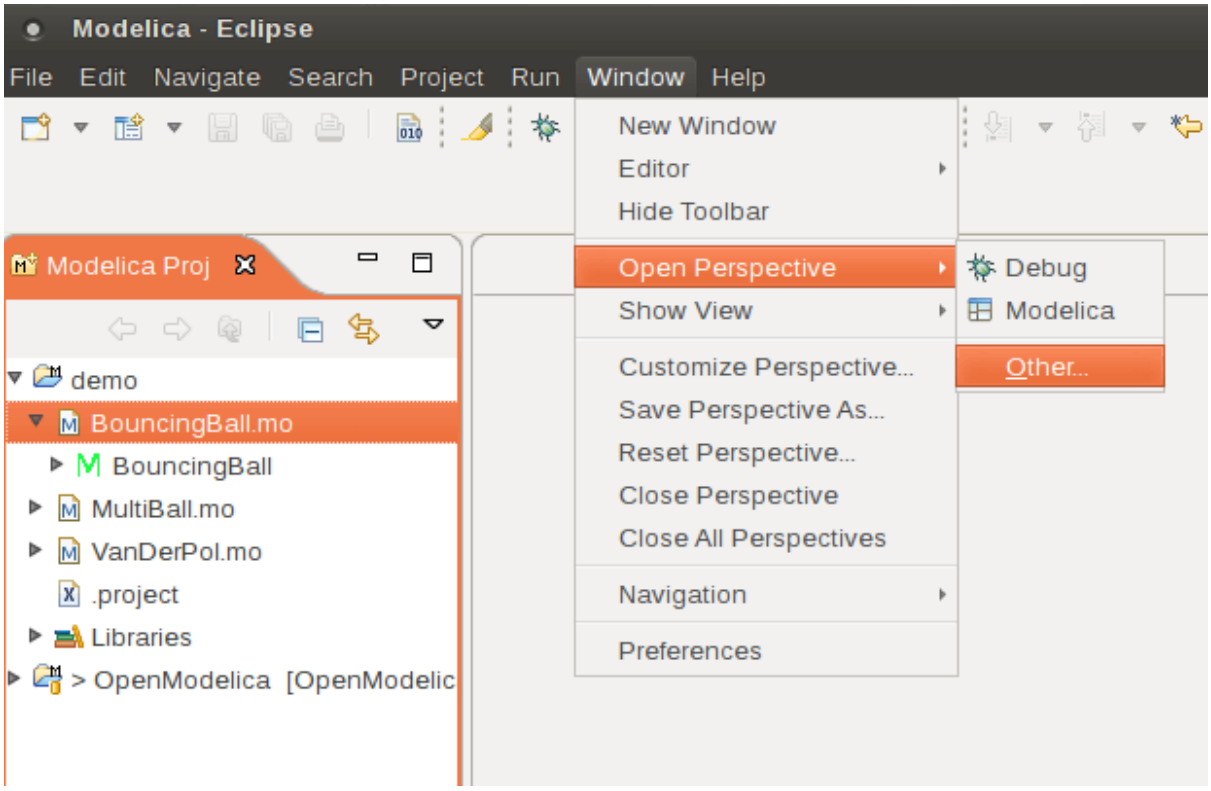



Figure 27.7: Eclipse - Switching to another perspective - e.g. the Java Perspective.

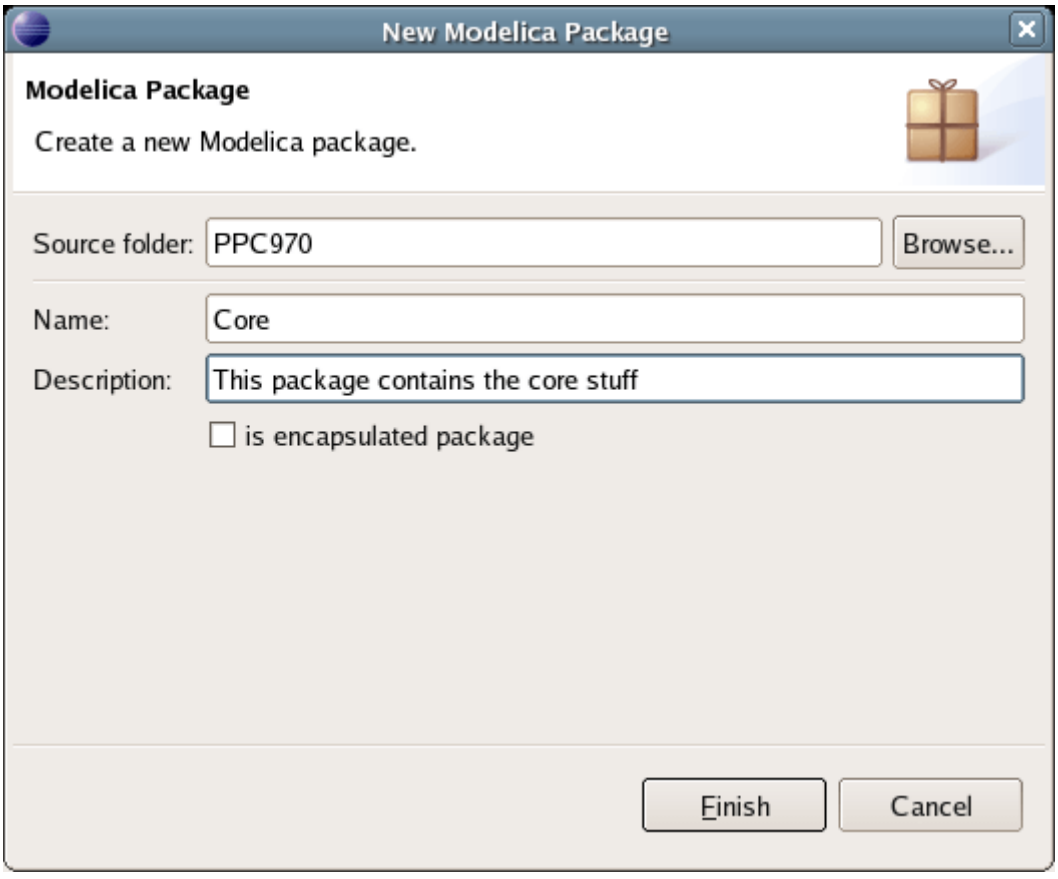



Figure 27.8: Creating a new Modelica package.

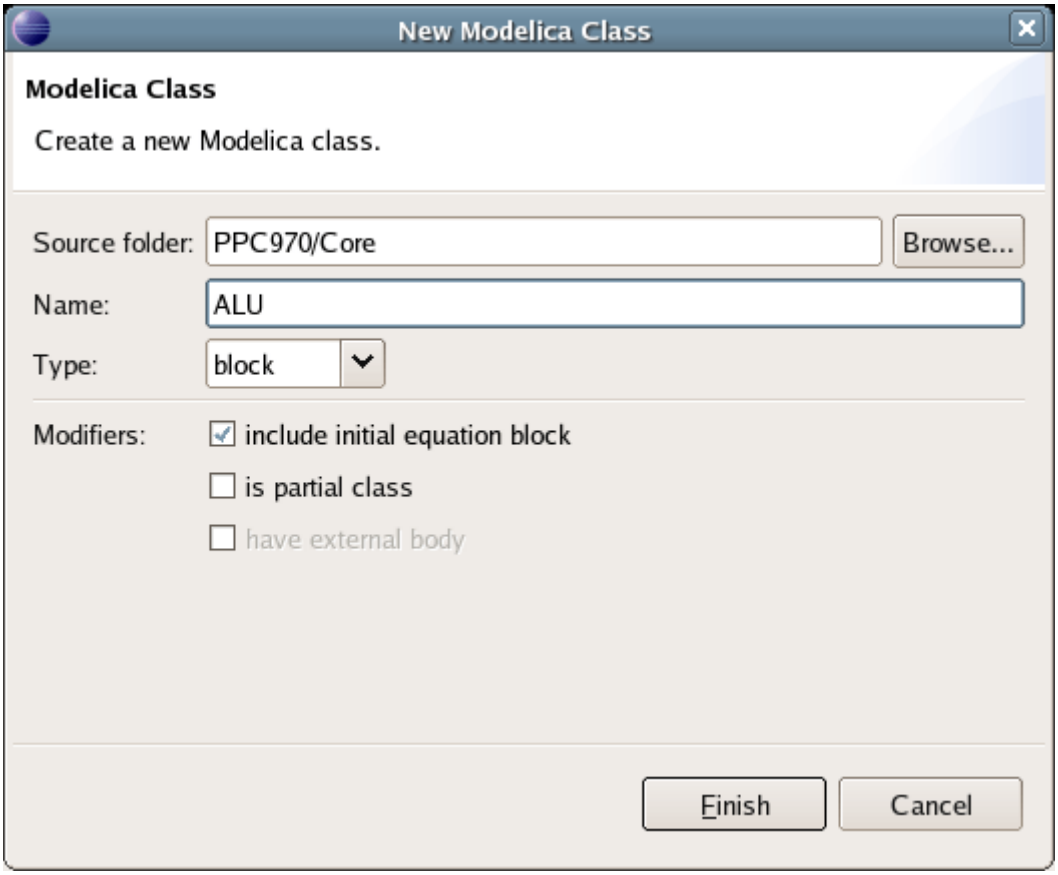



Figure 27.9: Creating a new Modelica class.

### 27.3.9 Syntax Checking

Whenever a build command is given to the MDT environment, modified and saved Modelica (.mo) files are checked for syntactical errors. Any errors that are found are added to the Problems view and also marked in the source code editor. Errors are marked in the editor as a red circle with a white cross, a squiggly red line under the problematic construct, and as a red marker in the right-hand side of the editor. If you want to reach the problem, you can either click the item in the Problems view or select the red box in the right-hand side of the editor.

### 27.3.10 Automatic Indentation Support

MDT currently has support for automatic indentation. When typing the Return (Enter) key, the next line is indented correctly. You can also correct indentation of the current line or a range selection using CTRL+I or "Correct Indentation" action on the toolbar or in the Edit menu.

### 27.3.11 Code Completion

MDT supports Code Completion in two variants. The first variant, code completion when typing a dot after a class (package) name, shows alternatives in a menu. Besides the alternatives, Modelica documentation from comments is shown if is available. This makes the selection easyer.

The second variant is useful when typing a call to a function. It shows the function signature (formal parameter names and types) in a popup when typing the parenthesis after the function name, here the signature Real sin(SI.Angle u) of the sin function:

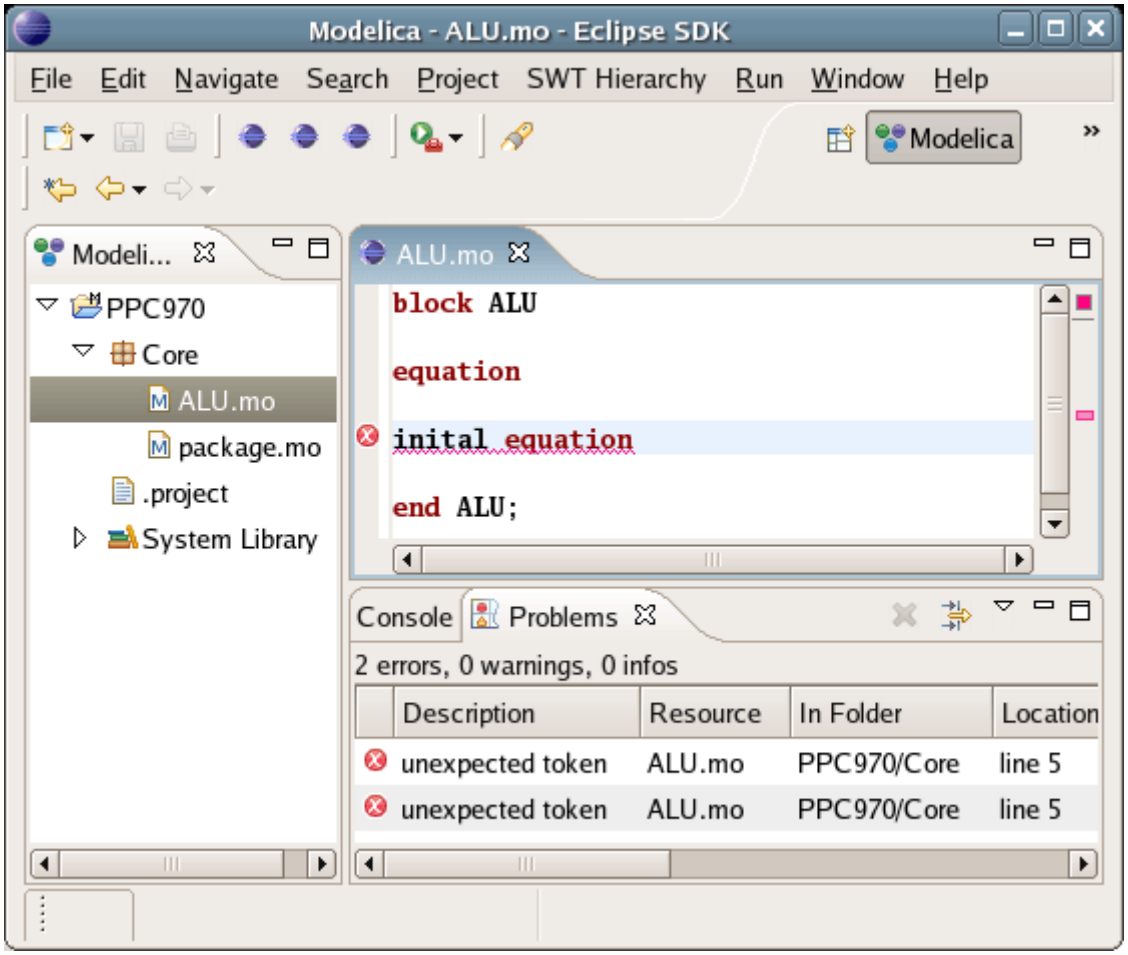



Figure 27.10: Syntax checking.

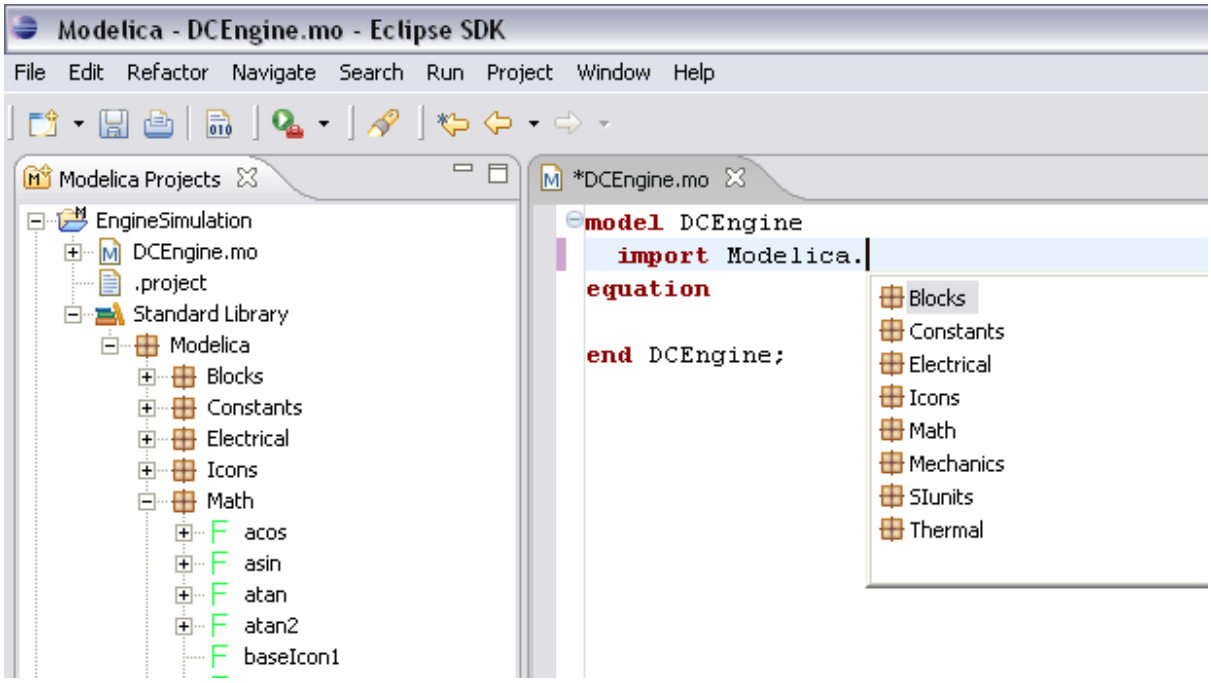



Figure 27.11: Code completion when typing a dot.

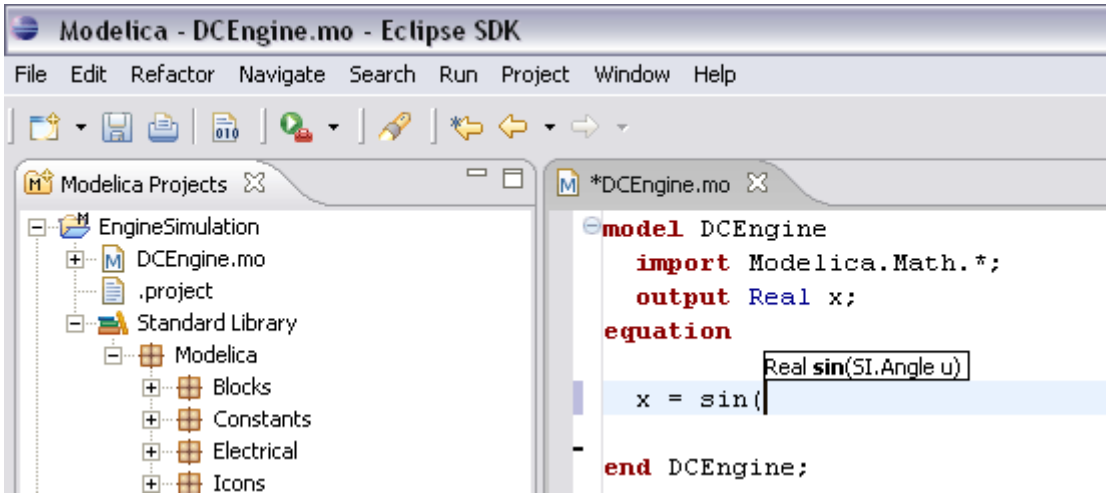



Figure 27.12: Code completion at a function call when typing left parenthesis.

### 27.3.12 Code Assistance on Identifiers when Hovering

When hovering with the mouse over an identifier a popup with information about the identifier is displayed. If the text is too long, the user can press F2 to focus the popup dialog and scroll up and down to examine all the text. As one can see the information in the popup dialog is syntax-highlighted.

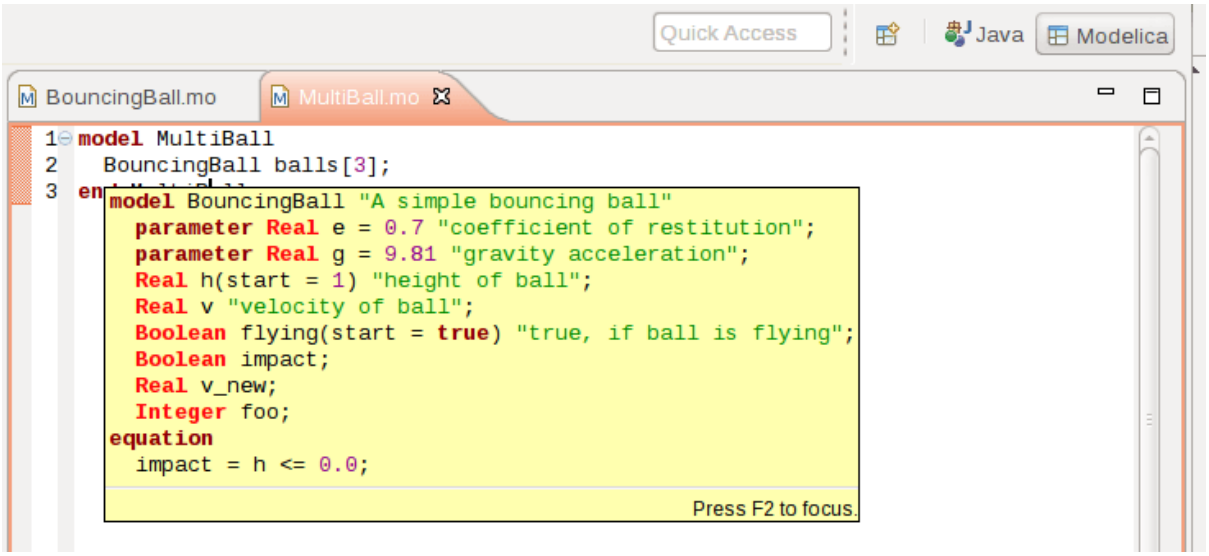



Figure 27.13: Displaying information for identifiers on hovering.

### 27.3.13 Go to Definition Support

Besides hovering information the user can press CTRL+click to go to the definition of the identifier. When pressing CTRL the identifier will be presented as a link and when pressing mouse click the editor will go to the definition of the identifier.

### 27.3.14 Code Assistance on Writing Records

When writing records, the same functionality as for function calls is used. This is useful especially in MetaModelica when writing cases in match constructs.

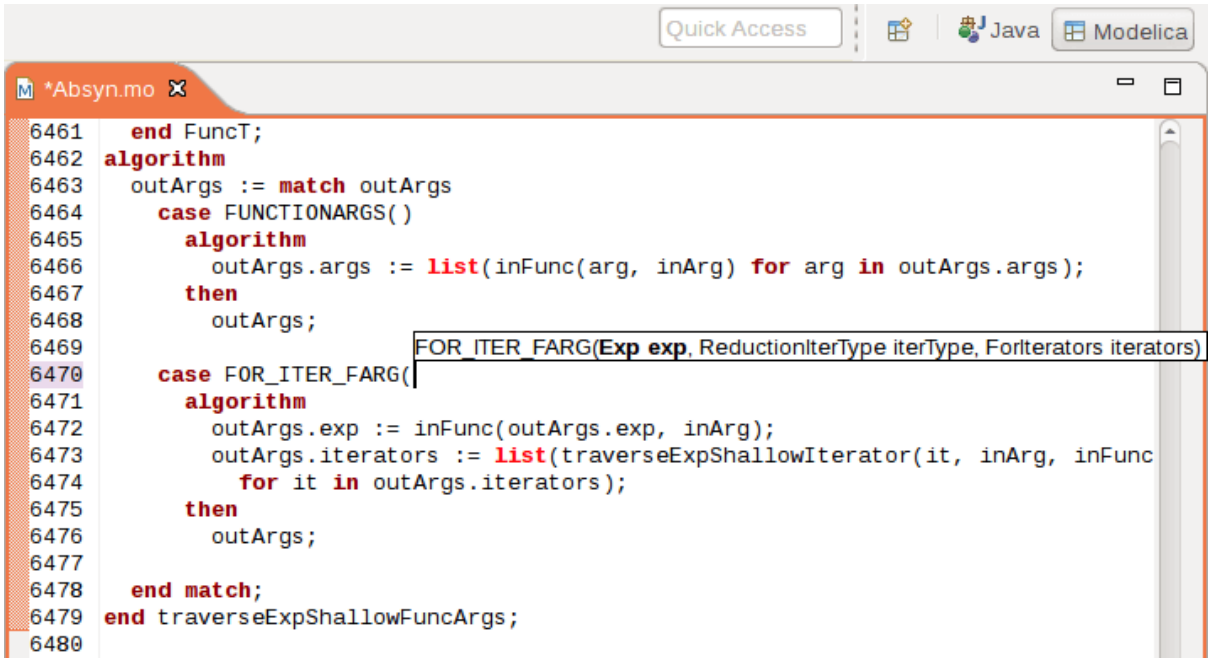



Figure 27.14: Code assistance when writing cases with records in MetaModelica.

### 27.3.15 Using the MDT Console for Plotting

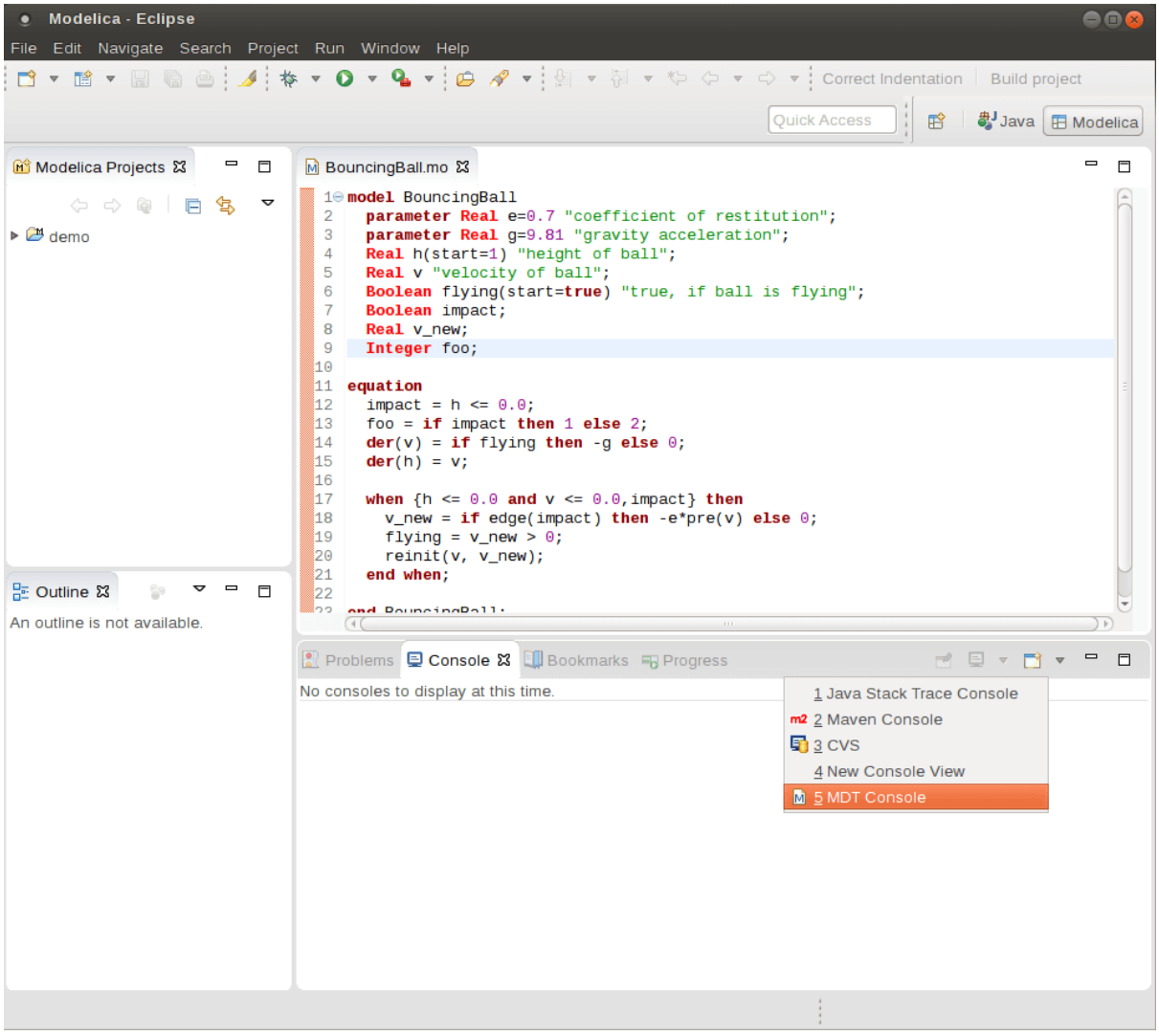



Figure 27.15: Activate the MDT Console.

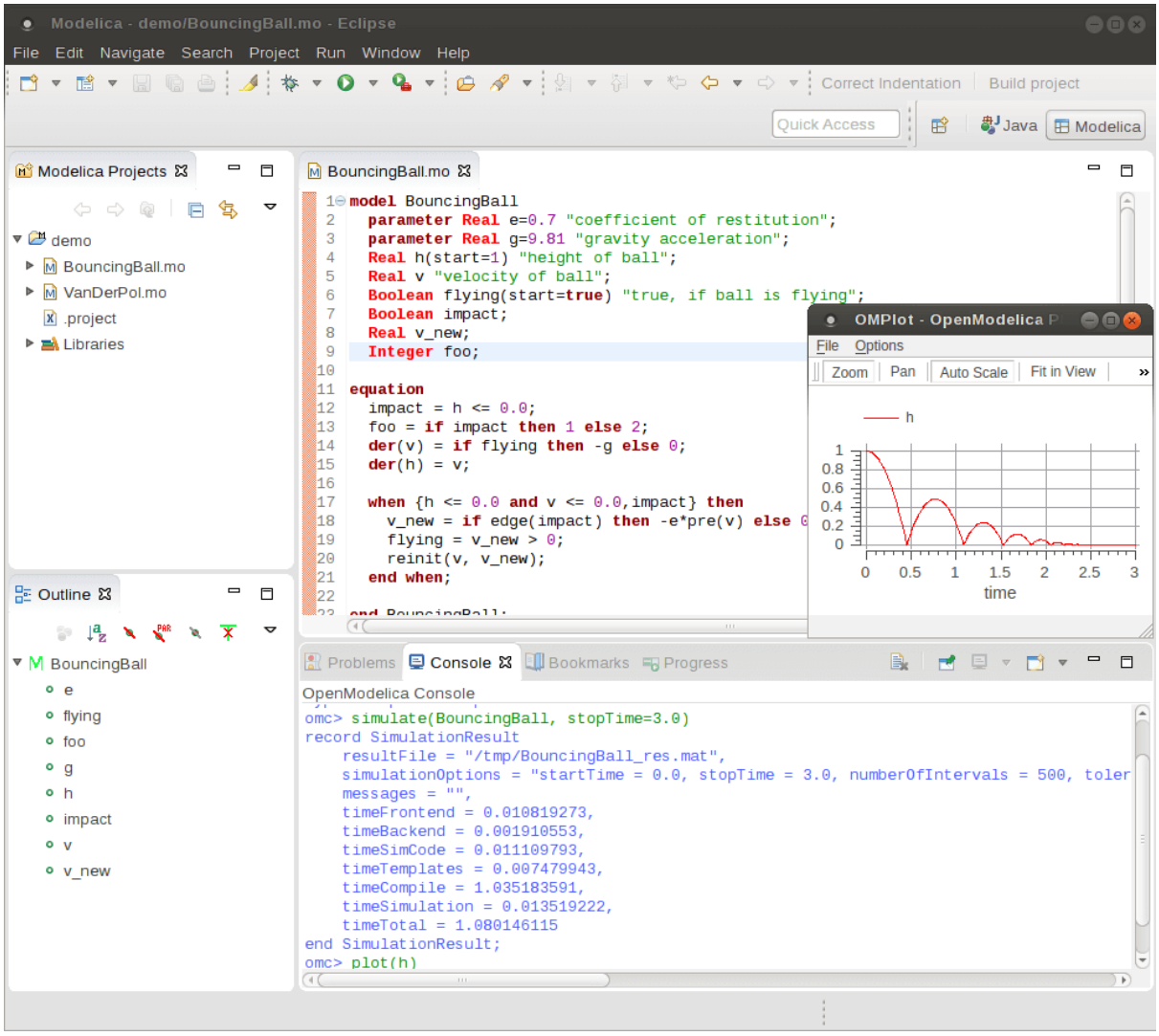



Figure 27.16: Simulation from MDT Console.

CHAPTER

# TWENTYEIGHT

# MDT DEBUGGER FOR ALGORITHMIC MODELICA

The algorithmic code debugger, used for the algorithmic subset of the Modelica language as well as the MetaModelica language is described in Section *The Eclipse-based Debugger for Algorithmic Modelica*. Using this debugger replaces debugging of algorithmic code by primitive means such as print statements or asserts which is complex, time-consuming and error- prone. The usual debugging functionality found in debuggers for procedural or traditional object-oriented languages is supported, such as setting and removing breakpoints, stepping, inspecting variables, etc. The debugger is integrated with Eclipse.

## 28.1 The Eclipse-based Debugger for Algorithmic Modelica

The debugging framework for the algorithmic subset of Modelica and MetaModelica is based on the Eclipse environment and is implemented as a set of plugins which are available from Modelica Development Tooling (MDT) environment. Some of the debugger functionality is presented below. In the right part a variable value is explored. In the top-left part the stack trace is presented. In the middle-left part the execution point is presented.

The debugger provides the following general functionalities:

- Adding/Removing breakpoints.
- Step Over - moves to the next line, skipping the function calls.
- Step In - takes the user into the function call.
- **Step Return - complete the execution of the function and takes the** user back to the point from where the function is called.
- Suspend - interrupts the running program.

### 28.1.1 Starting the Modelica Debugging Perspective

To be able to run in debug mode, one has to go through the following steps:

- create a mos file
- setting the debug configuration
- setting breakpoints
- running the debug configuration

All these steps are presented below using images.

#### Create mos file

In order to debug Modelica code we need to load the Modelica files into the OpenModelica Compiler. For this we can write a small script file like this:

```
function HelloWorld
  input Real r;
  output Real o;
algorithm
```

(continues on next page)

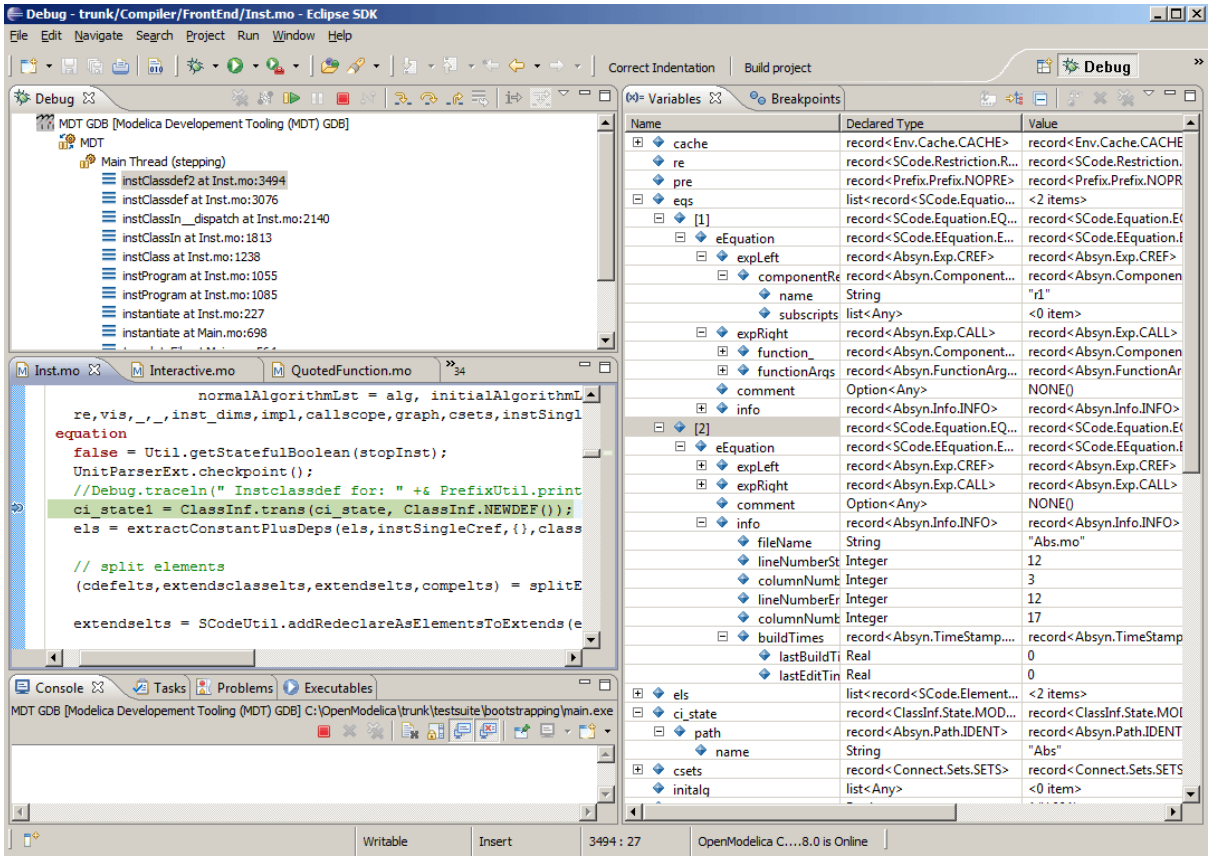



Figure 28.1: Debugging functionality.

(continued from previous page)

```
  o := 2 * r;
end HelloWorld;
```

```
>>> setCommandLineOptions({"-d=rml,noevalfunc","-g=MetaModelica"})
{true, true}
>>> setCFlags(getCFlags() + " -g")
true
>>> HelloWorld(120.0)
```

So lets say that we want to debug HelloWorld.mo. For that we must load it into the compiler using the script file. Put all the Modelica files there in the script file to be loaded. We should also initiate the debugger by calling the starting function, in the above code `HelloWorld(120.0)`;

### Setting the debug configuration

While the Modelica perspective is activated the user should click on the bug icon on the toolbar and select Debug in order to access the dialog for building debug configurations.

To create the debug configuration, right click on the classification Modelica Development Tooling (MDT) GDB and select New as in figure below. Then give a name to the configuration, select the debugging executable to be executed and give it command line parameters. There are several tabs in which the user can select additional debug configuration settings like the environment in which the executable should be run.

Note that we require Gnu Debugger (GDB) for debugging session. We must specify the GDB location, also we must pass our script file as an argument to OMC.

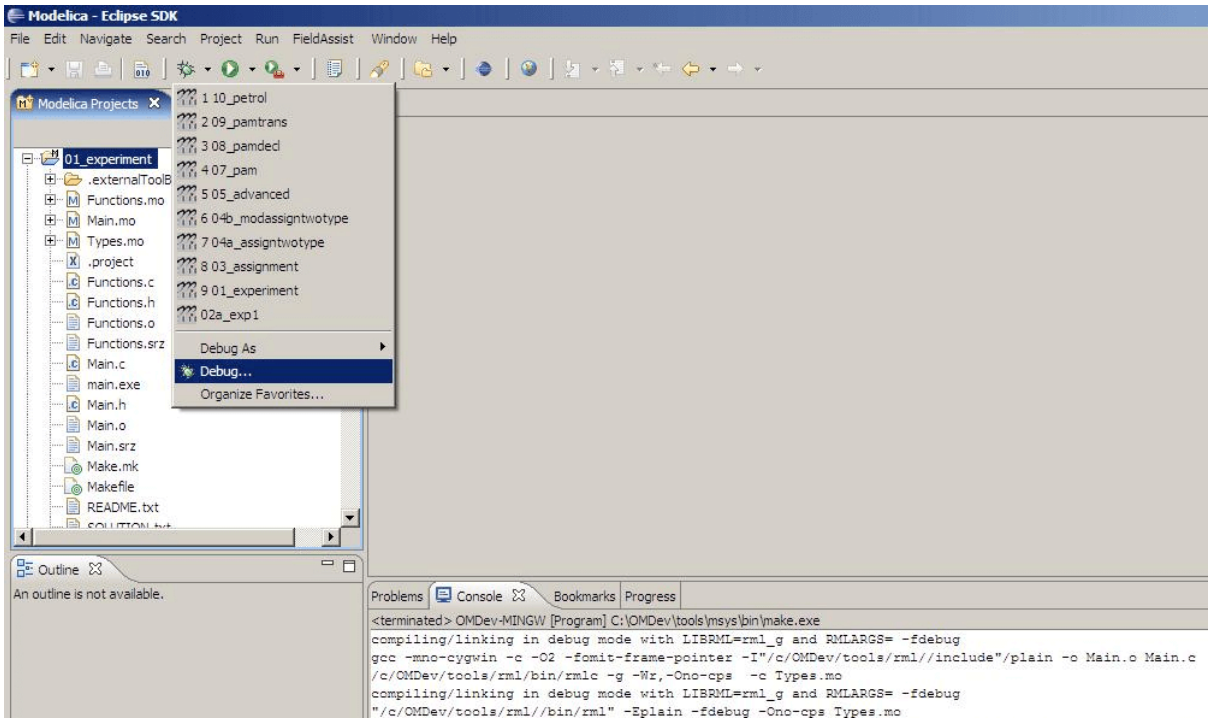



Figure 28.2: Accessing the debug configuration dialog.

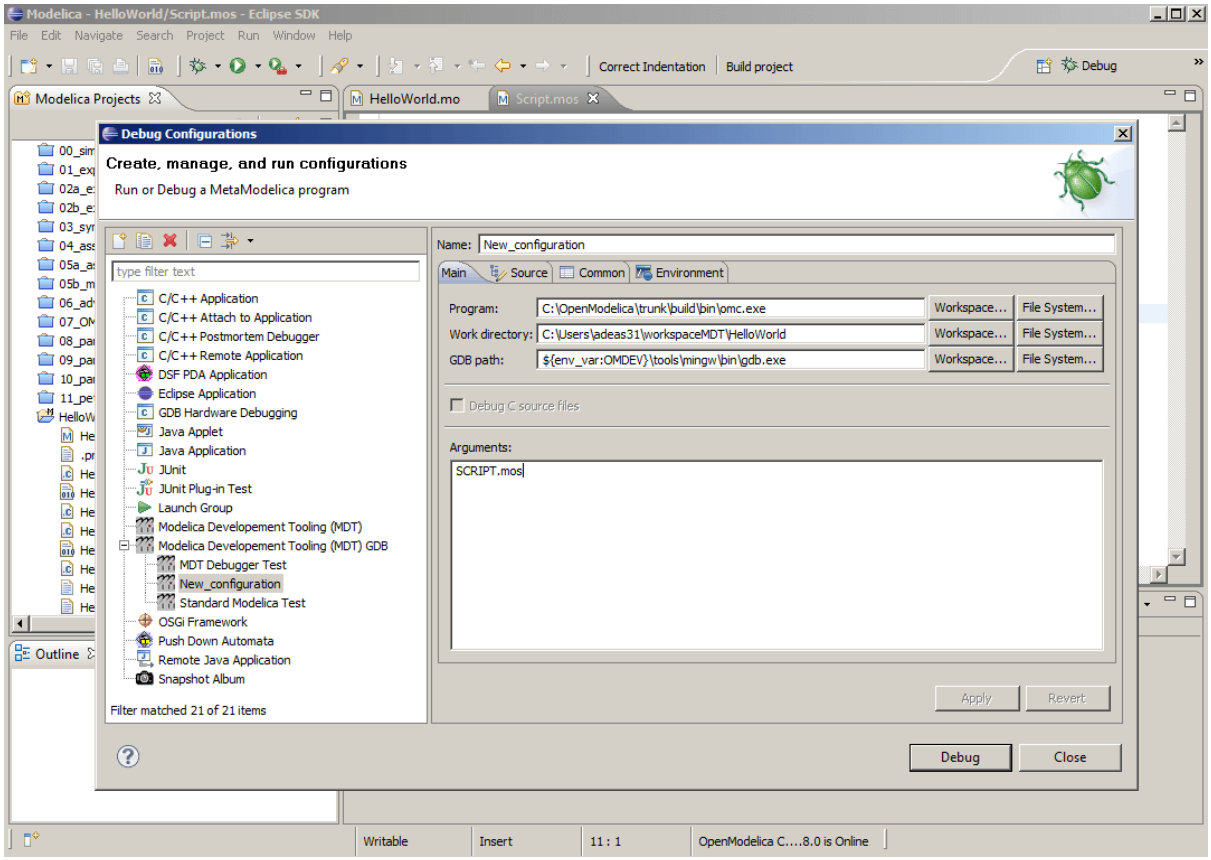



Figure 28.3: Creating the Debug Configuration.

### Setting/Deleting Breakpoints

The Eclipse interface allows to add/remove breakpoints. At the moment only line number based breakpoints are supported. Other alternative to set the breakpoints is; function breakpoints.

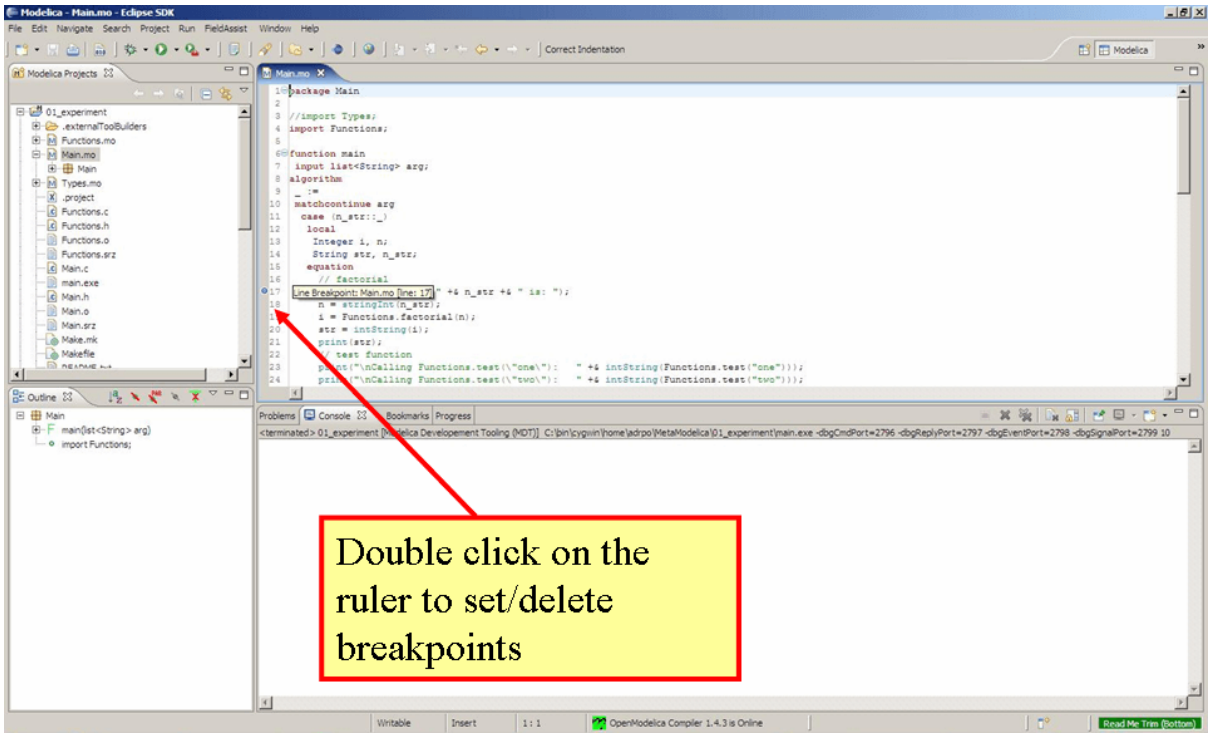



Figure 28.4: Setting/deleting breakpoints.

### Starting the debugging session and enabling the debug perspective

## 28.1.2 The Debugging Perspective

The debug view primarily consists of two main views:

- Stack Frames View
- Variables View

The stack frame view, shown in the figure below, shows a list of frames that indicates how the flow had moved from one function to another or from one file to another. This allows backtracing of the code. It is very much possible to select the previous frame in the stack and inspect the values of the variables in that frame. However, it is not possible to select any of the previous frame and start debugging from there. Each frame is shown as <function_name at file_name:line_number>.

The Variables view shows the list of variables at a certain point in the program, containing four colums:

- Name - the variable name.
- Declared Type - the Modelica type of the variable.
- Value - the variable value.
- Actual Type - the mapped C type.

By preserving the stack frames and variables it is possible to keep track of the variables values. If the value of any variable is changed while stepping then that variable will be highlighted yellow (the standard Eclipse way of showing the change).

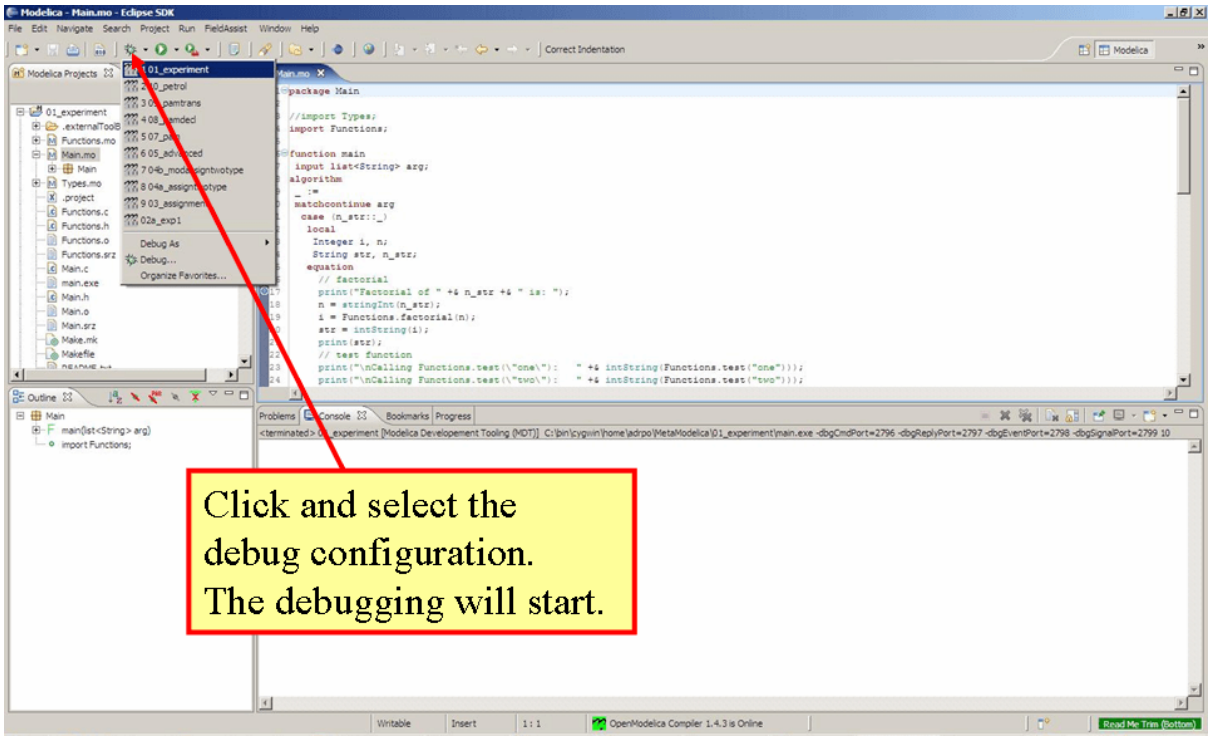



Figure 28.5: Starting the debugging session.

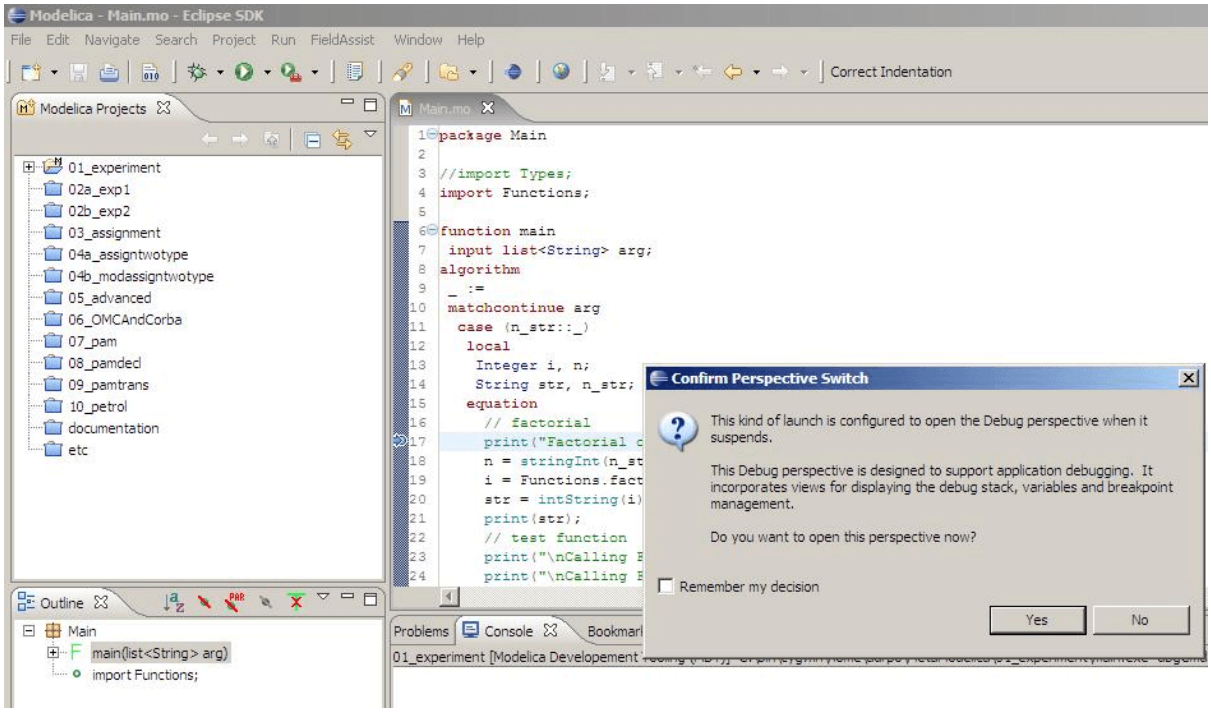



Figure 28.6: Eclipse will ask if the user wants to switch to the debugging perspective.

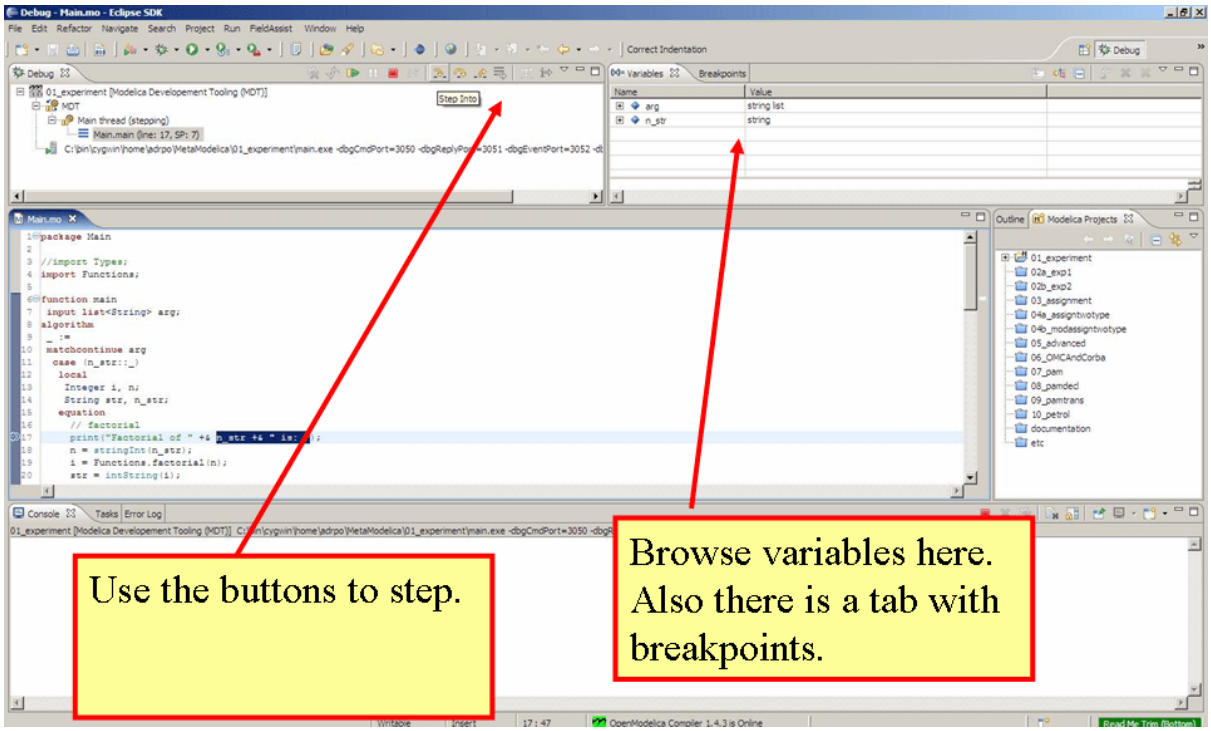



Figure 28.7: The debugging perspective.

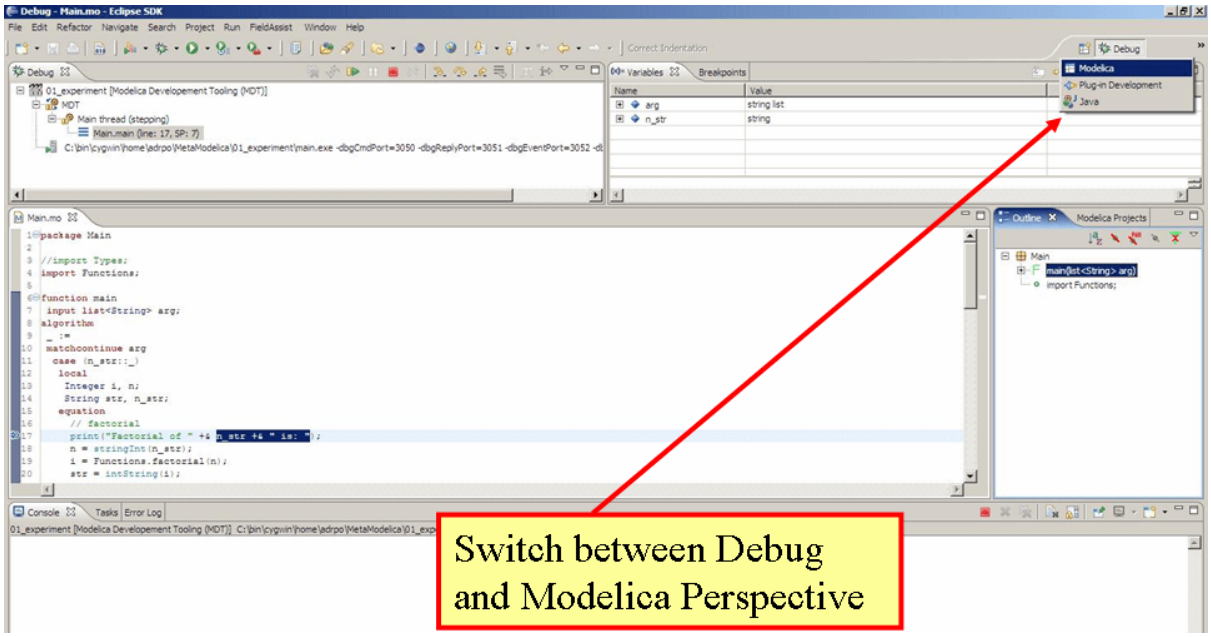



Figure 28.8: Switching between perspectives.

CHAPTER

# TWENTYNINE

# MODELICA PERFORMANCE ANALYZER

A common problem when simulating models in an equation-based language like Modelica is that the model may contain non-linear equation systems. These are solved in each time-step by extrapolating an initial guess and running a non-linear system solver. If the simulation takes too long to simulate, it is useful to run the performance analysis tool. The tool has around 5~25% overhead, which is very low compared to instruction-level profilers (30x-100x overhead). Due to being based on a single simulation run, the report may contain spikes in the charts.

When running a simulation for performance analysis, execution times of user-defined functions as well as linear, non-linear and mixed equation systems are recorded.

To start a simulation in this mode, turn on profiling with the following command line flag >>> setCommandLineOptions("--profiling=all")

The generated report is in HTML format (with images in the SVG format), stored in a file modelname_prof.html, but the XML database and measured times that generated the report and graphs are also available if you want to customize the report for comparison with other tools.

Below we use the performance profiler on the simple model A:

```
model ProfilingTest
  function f
    input Real r;
    output Real o = sin(r);
  end f;
  String s = "abc";
  Real x = f(x) "This is x";
  Real y(start=1);
  Real z1 = cos(z2);
  Real z2 = sin(z1);
equation
  der(y) = time;
end ProfilingTest;
```

We simulate as usual, after setting the profiling flag:

```
>>> setCommandLineOptions("--profiling=blocks+html")
true
>>> simulate(ProfilingTest)
record SimulationResult
    resultFile = "«DOCHOME»/ProfilingTest_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 1.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'ProfilingTest', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
Warning: empty y range [1:1], adjusting to [0.99:1.01]
Warning: empty y range [1:1], adjusting to [0.99:1.01]
```

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```
Warning: empty y range [1:1], adjusting to [0.99:1.01]
Warning: empty y range [1:1], adjusting to [0.99:1.01]
Warning: empty y range [1:1], adjusting to [0.99:1.01]
Warning: empty y range [1:1], adjusting to [0.99:1.01]
LOG_STDOUT        | info    | Time measurements are stored in ProfilingTest_prof.html␣
↪(human-readable) and ProfilingTest_prof.xml (for XSL transforms or more details)
",
    timeFrontend = 0.002424772,
    timeBackend = 0.019030335000000002,
    timeSimCode = 0.0030149620000000004,
    timeTemplates = 0.0041011120000000005,
    timeCompile = 0.452521526,
    timeSimulation = 0.05359384299999992,
    timeTotal = 0.53476893
end SimulationResult;
"Warning: There are nonlinear iteration variables with default zero start attribute␣
↪found in NLSJac0. For more information set -d=initialization. In OMEdit Tools->
↪Options->Simulation->Show additional information from the initialization process,␣
↪in OMNotebook call setCommandLineOptions("-d=initialization").
Warning: The initial conditions are not fully specified. For more information set -
↪d=initialization. In OMEdit Tools->Options->Simulation->Show additional information␣
↪from the initialization process, in OMNotebook call setCommandLineOptions("-
↪d=initialization")."
```

## 29.1 Profiling information for ProfilingTest

### 29.1.1 Information

All times are measured using a real-time wall clock. This means context switching produces bad worst-case execution times (max times) for blocks. If you want better results, use a CPU-time clock or run the command using real-time priviliges (avoiding context switches).

Note that for blocks where the individual execution time is close to the accuracy of the real-time clock, the maximum measured time may deviate a lot from the average.

For more details, see ProfilingTest_prof.xml.

### 29.1.2 Settings

| Name | Value |
|---|---|
| Integration method | dassl |
| Output format | mat |
| Output name | ProfilingTest_res.mat |
| Output size | 24.0 kB |
| Profiling data | ProfilingTest_prof.data |
| Profiling size | 0 B |

### 29.1.3 Summary

| Task | Time | Fraction |
|---|---|---|
| Pre-Initialization | 0.000090 | 2.73% |
| Initialization | 0.000367 | 11.13% |
| Event-handling | 0.000019 | 0.58% |
| Creating output file | 0.000472 | 14.31% |
| Linearization | | NaN% |
| Time steps | 0.001957 | 59.34% |
| Overhead | 0.000182 | 5.52% |
| Unknown | NaN | NaN% |
| Total simulation time | 0.003298 | 100.00% |

### 29.1.4 Global Steps

| | Steps | Total Time | F rac- tion | Average Time | Max Time | De via- tion |
|---|---|---|---|---|---|---|
| **\|Graph th umbnail 999\|** | 499 | 0 .001957 | 59.34% | 3.9218 4368737 475e- 06 | 0.00 0054087 | 12.79x |

### 29.1.5 Measured Function Calls

| | Name | Calls | Time | F rac- tion | Max Time | De via- tion |
|---|---|---|---|---|---|---|
| **\|Graph th umbnail f unc- tion fun0\|** \|Graph th umbnail count f unction fun0\| | ` Profili ngTest. f <#lin e=0>`__ | 506 | 0.00 0003736 | 0.11% | 0.00 0000213 | 27.85x |

### 29.1.6 Measured Blocks

| | Name | Calls | Time | F raction | Max Time | De via- tion |
|---|---|---|---|---|---|---|
| **\|Graph th umbnail eq0\|** \|Graph th umbnail count eq0\| | ` <# eq0>`__ | 8 | 0.00 0085730 | 2.60% | 0.00 0085891 | 7.02x |
| **\|Graph th umbnail eq11\|** \|Graph th umbnail count eq11\| | ` <#e q11>`__ | 2 | 0.00 0002051 | 0.06% | 0.00 0002074 | 1.02x |
| **\|Graph th umbnail eq19\|** \|Graph th umbnail count eq19\| | ` <#e q19>`__ | 504 | 0.00 0698401 | 21.18% | 0.00 0033672 | 23.30x |
| **\|Graph th umbnail eq21\|** \|Graph th umbnail count eq21\| | ` <#e q21>`__ | 504 | 0.00 0686649 | 20.82% | 0.00 0055176 | 39.50x |

### Equations

| Name | Variables |
|---|---|
| eq0 | |
| eq1 | *y* |
| eq2 | *s* |
| eq3 | *z1* |
| eq4 | |
| eq5 | ` <#var0>`__ |
| eq6 | ` <#var0>`__ |
| eq7 | ` <#var0>`__ |
| eq8 | ` <#var0>`__ |
| eq9 | *z2* |
| eq10 | |
| eq11 | *x* |
| eq12 | |
| eq13 | *z2* |
| eq14 | |
| eq15 | ` <#var0>`__ |
| eq16 | ` <#var0>`__ |
| eq17 | ` <#var0>`__ |
| eq18 | ` <#var0>`__ |
| eq19 | *z1* |
| eq20 | |
| eq21 | *x* |
| eq22 | *der(y)* |
| eq23 | |

### Variables

| Name | Comment |
|---|---|
| *y* | |
| *der(y)* | |
| *x* | This is x |
| *z1* | |
| *z2* | |
| *s* | |

---

This report was generated by OpenModelica on 2026-10-27 12:31:33.

## 29.2 Genenerated JSON for the Example

Listing 29.1: ProfilingTest_prof.json

```
{
"name":"ProfilingTest",
"prefix":"ProfilingTest",
"date":"2026-10-27 12:31:33",
"method":"dassl",
"outputFormat":"mat",
"outputFilename":"ProfilingTest_res.mat",
"outputFilesize":24581,
```

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```
"overheadTime":0.000182461,
"preinitTime":8.9969e-05,
"initTime":0.000366901,
"eventTime":1.8579e-05,
"outputTime":0.000471686,
"jacobianTime":1.1521e-05,
"totalTime":0.00329832,
"totalStepsTime":3.44e-06,
"totalTimeProfileBlocks":0.00147283,
"numStep":499,
"maxTime":5.4087e-05,
"functions":[
{"name":"ProfilingTest.f","ncall":506,"time":0.000003736,"maxTime":0.000000213}
],
"profileBlocks":[
{"id":0,"ncall":8,"time":0.000085730,"maxTime":0.000085891},
{"id":11,"ncall":2,"time":0.000002051,"maxTime":0.000002074},
{"id":19,"ncall":504,"time":0.000698401,"maxTime":0.000033672},
{"id":21,"ncall":504,"time":0.000686649,"maxTime":0.000055176}
]
}
```


## 29.3 Using the Profiler from OMEdit

When running a simulation from OMEdit, it is possible to enable profiling information, which can be combined with the *transformations browser*.

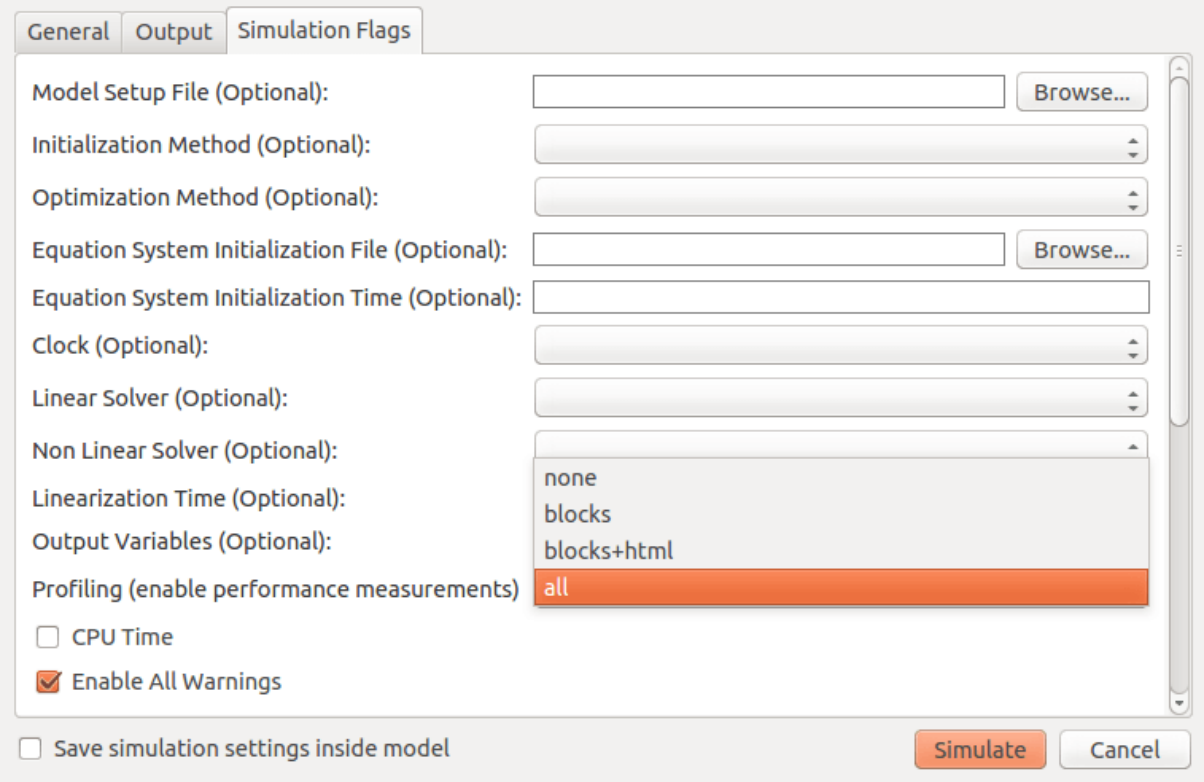



Figure 29.1: Setting up the profiler from OMEdit.

When profiling the DoublePendulum example from MSL, the following output in Figure 29.2 is a typical result. This information clearly shows which system takes longest to simulate (a linear system, where most of the time

overhead probably comes from initializing LAPACK over and over).

Equations Browser

| Index | Type | Equation | Executions | Max time | Time | Fraction |
|---|---|---|---|---|---|---|
| + 876 | regular | linear, size 2 | 4602 | 0.000199 | 0.0582 | 86.2% |
| 836 | regular | (assignment) revolute2.R_rel.T[2,2] = cos(revolute2.phi) | 1534 | 8.25e-05 | 0.000491 | 0.728% |
| 837 | regular | (assignment) revolute2.R_rel.T[2,1] = -sin(revolute2.phi) | 1534 | 7.29e-05 | 0.000422 | 0.625% |
| 841 | regular | (assignment) boxBody1.frame_...[2,1] = -sin(damper.phi_rel) | 1534 | 7.1e-05 | 0.000395 | 0.585% |
| 840 | regular | (assignment) boxBody1.frame_...T[2,2] = cos(damper.phi_rel) | 1534 | 7.08e-05 | 0.000361 | 0.535% |
| 839 | regular | (assignment) revolute2.R_rel.T[1,1] = cos(revolute2.phi) | 1534 | 7.33e-05 | 0.000303 | 0.449% |
| 842 | regular | (assignment) boxBody1.frame_b.R.T[1,2] = sin(damper.phi_rel) | 1534 | 7.45e-05 | 0.000303 | 0.449% |
| 838 | regular | (assignment) revolute2.R_rel.T[1,2] = sin(revolute2.phi) | 1534 | 7.11e-05 | 0.0003 | 0.444% |
| 849 | regular | (assignment) boxBody1.frame_...T[1,1] = cos(damper.phi_rel) | 1534 | 7.29e-05 | 0.000286 | 0.424% |
| 827 | regular | (assignment) revolute1.tau = (-damper.d) * revolute1.w | 1534 | 6.84e-05 | 0.000274 | 0.406% |

Defines

| Variable |
|---|
| damper.a_rel |
| revolute2.frame_b.f[2] |

Figure 29.2: Profiling results of the Modelica standard library DoublePendulum example, sorted by execution time.

CHAPTER

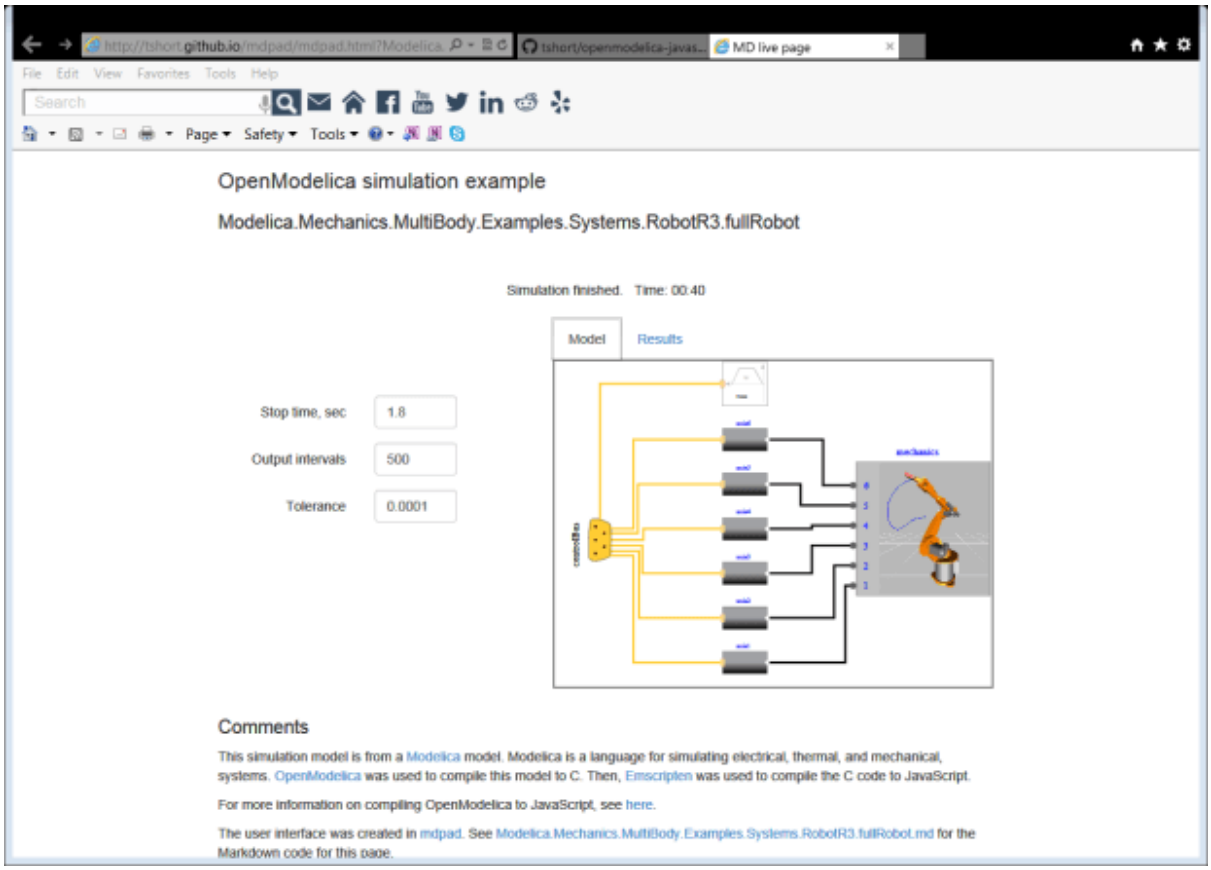
THIRTY

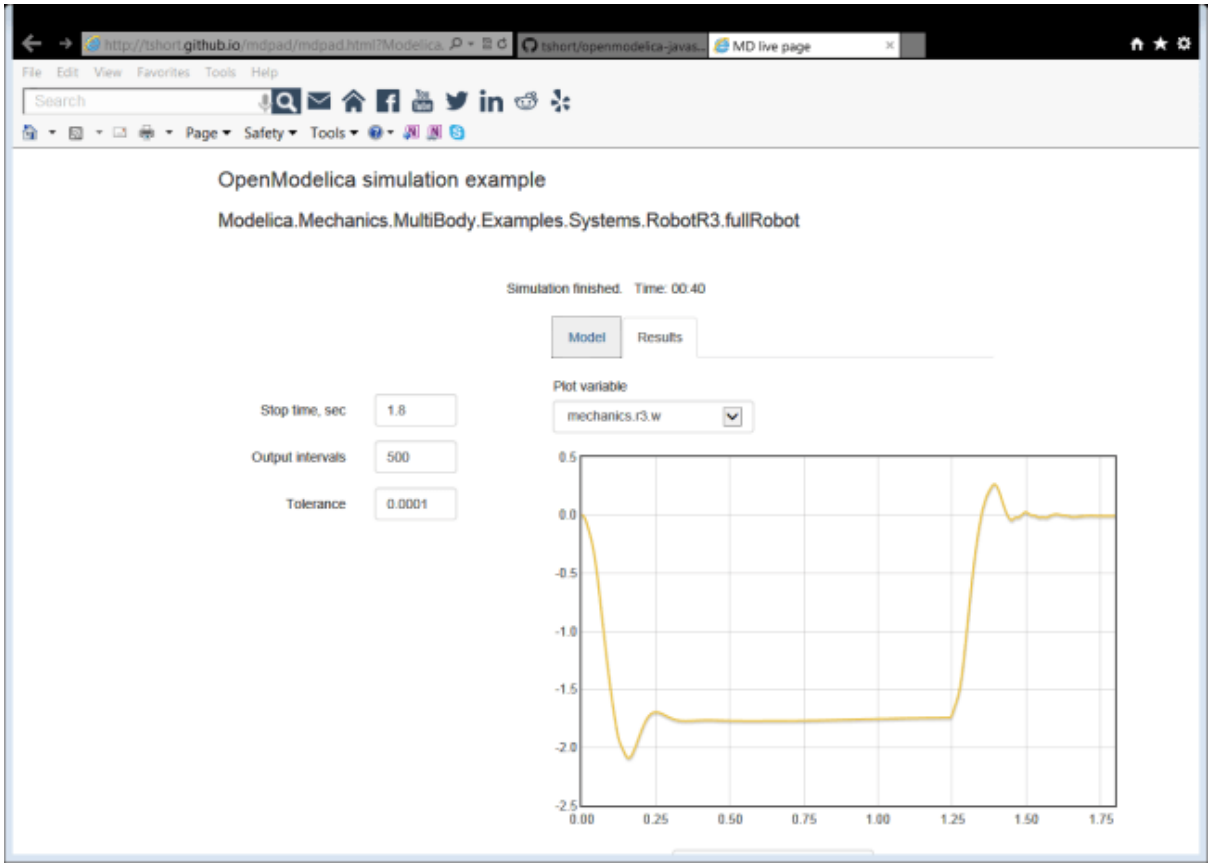
# SIMULATION IN WEB BROWSER

OpenModelica can simulate in a web browser on a client computer by model code being compiled to efficient Javacript code.

For more information, see https://github.com/tshort/openmodelica-javascript

Below used on the MSL MultiBody RobotR3.fullRobot example model.




MD live page
File Edit View Favorites Tools Help
Search
Page Safety Tools
OpenModelica simulation example
Modelica.Mechanics.MultiBody.Examples.Systems.RobotR3.fullRobot
Simulation finished. Time: 00:40
Model
Results
Stop time, sec
1.8
Output intervals
500
Tolerance
0.0001
Plot variable
mechanics.r3.w
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75

CHAPTER

# THIRTYONE

# INTEROPERABILITY - C AND PYTHON

Below is information and examples about the OpenModelica external C interfaces, as well as examples of Python interoperability.

## 31.1 Calling External C functions

The following is a small example (ExternalLibraries.mo) to show the use of external C functions:

```
model ExternalLibraries

  function ExternalFunc1
    input Real x;
    output Real y;
  external y=ExternalFunc1_ext(x) annotation(Library="ExternalFunc1.o",␣
↪LibraryDirectory="modelica://ExternalLibraries", Include="#include \"ExternalFunc1.
↪h\"");
  end ExternalFunc1;

  function ExternalFunc2
    input Real x;
    output Real y;
  external "C" annotation(Library="ExternalFunc2", LibraryDirectory="modelica://
↪ExternalLibraries");
  end ExternalFunc2;

  Real x(start=1.0, fixed=true), y(start=2.0, fixed=true);
equation
  der(x)=-ExternalFunc1(x);
  der(y)=-ExternalFunc2(y);
end ExternalLibraries;
```

These C (.c) files and header files (.h) are needed (note that the headers are not needed since OpenModelica will generate the correct definition if it is not present; using the headers it is possible to write C-code directly in the Modelica source code or declare non-standard calling conventions):

Listing 31.1: ExternalFunc1.c

```
double ExternalFunc1_ext(double x)
{
  double res;
  res = x+2.0*x*x;
  return res;
}
```

Listing 31.2: ExternalFunc1.h

```
double ExternalFunc1_ext(double);
```

Listing 31.3: ExternalFunc2.c

```
double ExternalFunc2(double x)
{
  double res;
  res = (x-1.0)*(x+2.0);
  return res;
}
```

The following script file ExternalLibraries.mos will perform everything that is needed, provided you have gcc installed in your path:

```
>>> system(getCompiler() + " -c -o ExternalFunc1.o ExternalFunc1.c")
0
>>> system(getCompiler() + " -c -o ExternalFunc2.o ExternalFunc2.c")
0
>>> system("ar rcs libExternalFunc2.a ExternalFunc2.o")
0
>>> simulate(ExternalLibraries)
record SimulationResult
    resultFile = "«DOCHOME»/ExternalLibraries_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 1.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'ExternalLibraries', options =
↪'', outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.002138736,
    timeBackend = 0.004730878,
    timeSimCode = 0.003680253,
    timeTemplates = 0.0032693210000000004,
    timeCompile = 0.440149075,
    timeSimulation = 0.01364502,
    timeTotal = 0.4676886229999999
end SimulationResult;
```

**Note**

Notification: Model statistics after passing the front-end and creating the data structures used by the back-end:

* Number of equations: 2

* Number of variables: 2

Notification: Model statistics after passing the back-end for initialization:

* Number of independent subsystems: 2

* Number of states: 0 ()

* Number of discrete variables: 0 ()

* Number of discrete states: 0 ()

* Number of clocked states: 0 ()

* Top-level inputs: 0

Notification: Strong component statistics for initialization (4):

* Single equations (assignments): 4

* Array equations: 0

* Algorithm blocks: 0

* Record equations: 0

* When equations: 0

* If-equations: 0

* Equation systems (not torn): 0

* Torn equation systems: 0

* Mixed (continuous/discrete) equation systems: 0

Notification: Model statistics after passing the back-end for simulation:

* Number of independent subsystems: 2

* Number of states: 2 (y,x)

* Number of discrete variables: 0 ()

* Number of discrete states: 0 ()

* Number of clocked states: 0 ()

* Top-level inputs: 0

Notification: Strong component statistics for simulation (2):

* Single equations (assignments): 2

* Array equations: 0

* Algorithm blocks: 0

* Record equations: 0

* When equations: 0

* If-equations: 0

* Equation systems (not torn): 0

* Torn equation systems: 0

* Mixed (continuous/discrete) equation systems: 0

And plot the results:

## 31.2 Calling external Python Code from a Modelica model

The following calls external Python code through a very simplistic external function (no data is retrieved from the Python code). By making it a dynamically linked library, you might get the code to work without changing the linker settings.

```
function pyRunString
  input String s;
external "C" annotation(Include="
#include <Python.h>
```

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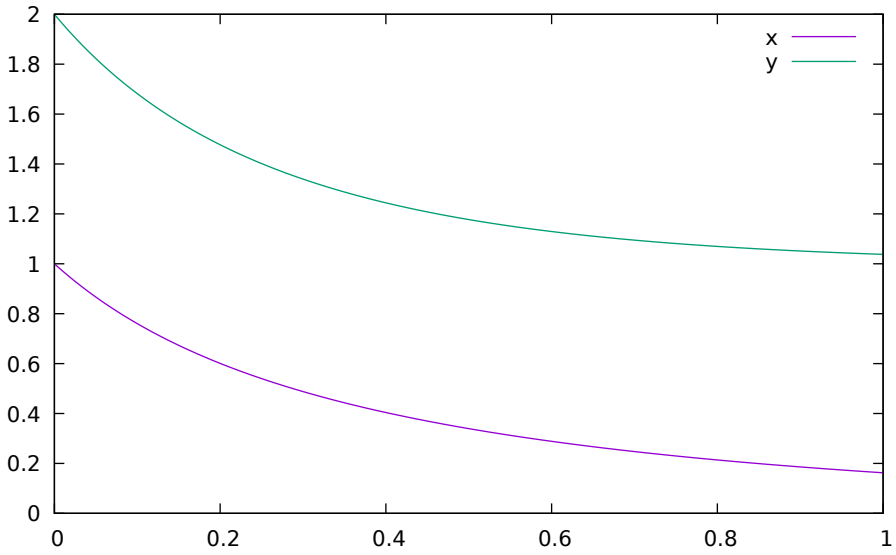



Figure 31.1: Plot generated by OpenModelica+gnuplot

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```
void pyRunString(const char *str)
{
  Py_Initialize();
  PyRun_SimpleString(str);
  Py_Finalize();
}
");
end pyRunString;

model CallExternalPython
algorithm
  pyRunString("
print('Python says: simulation time',"+String(time)+")
");
end CallExternalPython;
```

```
>>> system("python3-config --cflags > pycflags")
0
>>> system("python3-config --ldflags --embed > pyldflags")
0
>>> pycflags := stringReplace(readFile("pycflags"),"\n","");
>>> pyldflags := stringReplace(readFile("pyldflags"),"\n","");
>>> setCFlags(getCFlags()+pycflags)
true
>>> setLinkerFlags(getLinkerFlags()+pyldflags)
true
>>> simulate(CallExternalPython, stopTime=2)
record SimulationResult
    resultFile = "«DOCHOME»/CallExternalPython_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 2.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'CallExternalPython', options␣
↪= '', outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "Python says: simulation time 0
```

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```
Python says: simulation time 0
LOG_SUCCESS       | info    | The initialization finished successfully without␣
↪homotopy method.
Python says: simulation time 2
LOG_SUCCESS       | info    | The simulation finished successfully.
",
    timeFrontend = 0.0018346060000000001,
    timeBackend = 0.010090186000000001,
    timeSimCode = 0.0015971070000000002,
    timeTtemplates = 0.0029092140000000002,
    timeCompile = 0.5163529609999999,
    timeSimulation = 0.044366213,
    timeTotal = 0.577223684
end SimulationResult;
```

**Note**

Notification: Model statistics after passing the front-end and creating the data structures used by the back-end:

* Number of equations: 0

* Number of variables: 0

Notification: Model statistics after passing the back-end for initialization:

* Number of independent subsystems: 1

* Number of states: 0 ()

* Number of discrete variables: 0 ()

* Number of discrete states: 0 ()

* Number of clocked states: 0 ()

* Top-level inputs: 0

Notification: Strong component statistics for initialization (0):

* Single equations (assignments): 0

* Array equations: 0

* Algorithm blocks: 0

* Record equations: 0

* When equations: 0

* If-equations: 0

* Equation systems (not torn): 0

* Torn equation systems: 0

* Mixed (continuous/discrete) equation systems: 0

Notification: Model statistics after passing the back-end for simulation:

* Number of independent subsystems: 1

* Number of states: 0 ()

* Number of discrete variables: 0 ()

* Number of discrete states: 0 ()

```
* Number of clocked states: 0 ()
* Top-level inputs: 0
Notification: Strong component statistics for simulation (0):
* Single equations (assignments): 0
* Array equations: 0
* Algorithm blocks: 0
* Record equations: 0
* When equations: 0
* If-equations: 0
* Equation systems (not torn): 0
* Torn equation systems: 0
* Mixed (continuous/discrete) equation systems: 0
```

## 31.3 Calling OpenModelica from Python Code

This section describes a simple-minded approach to calling Python code from OpenModelica. For a description of Python scripting with OpenModelica, see *OMPython - OpenModelica Python Interface*.

The interaction with Python can be perfomed in four different ways whereas one is illustrated below. Assume that we have the following Modelica code:

Listing 31.4: CalledbyPython.mo

```
model CalledbyPython
  Real x(start=1.0), y(start=2.0);
  parameter Real b = 2.0;
equation
  der(x) = -b*y;
  der(y) = x;
end CalledbyPython;
```

In the following Python (.py) files the above Modelica model is simulated via the OpenModelica scripting interface:

Listing 31.5: PythonCaller.py

```
#!/usr/bin/env python3
import os

newb = 0.5
exec(open('CreateMosFile.py').read())
os.popen(r"omc CalledbyPython.mos").read()
exec(open('RetrResult.py').read())
```

Listing 31.6: CreateMosFile.py

```
#!/usr/bin/env python3
mos_file = open('CalledbyPython.mos','w', 1)
mos_file.write('loadFile("CalledbyPython.mo");\n')
mos_file.write('setComponentModifierValue(CalledbyPython,b,$Code(="+str(newb)+"));\n')
mos_file.write('simulate(CalledbyPython,stopTime=10);\n')
mos_file.close()
```

Listing 31.7: RetrResult.py

```
#!/usr/bin/env python3
def zeros(n):
  return [0.0] * int(n)
res_file = open("CalledbyPython_res.plt",'r',1)
line = res_file.readline()
size = int(res_file.readline().split('=')[1])
time = zeros(size)
y = zeros(size)
while line != ['DataSet: time\\n']:
  line = res_file.readline().split(',')[0:1]
for j in range(int(size)):
  time[j]=float(res_file.readline().split(',')[0])
while line != ['DataSet: y\\n']:
  line=res_file.readline().split(',')[0:1]
for j in range(int(size)):
  y[j]=float(res_file.readline().split(',')[1])
res_file.close()
```

A second option of simulating the above Modelica model is to use the command buildModel instead of the simulate command and setting the parameter value in the initial parameter file, CalledbyPython_init.txt instead of using the command setComponentModifierValue. Then the file CalledbyPython.exe is just executed.

The third option is to use the ZeroMQ interface for invoking the compiler and then just use the scripting interface to send commands to the compiler via this interface.

The fourth variant is to use external function calls to directly communicate with the executing simulation process.

CHAPTER

THIRTYTWO

# OMPYTHON - OPENMODELICA PYTHON INTERFACE

OMPython - OpenModelica Python API is a free, open source, highly portable Python based interactive session handler for Modelica scripting. It provides the modeler with components for creating a complete Modelica modeling, compilation and simulation environment based on the latest OpenModelica tools standard available. OMPython is architectured to combine both the solving strategy and model building. So domain experts (people writing the models) and computational engineers (people writing the solver code) can work on one unified tool that is industrially viable for optimization of Modelica models, while offering a flexible platform for algorithm development and research.

OMPython is implemented in Python and depends on ZeroMQ - high performance asynchronous messaging library.

To install OMPython follow the instructions at https://github.com/OpenModelica/OMPython

## 32.1 Features of OMPython

OMPython provides user friendly features like:

- Interactive session handling, parsing, interpretation of commands and Modelica expressions for evaluation, simulation, plotting, etc.
- Optimized parser results that give control over every element of the output.
- Helper functions to allow manipulation on Nested dictionaries.
- Easy access to the library and testing of OpenModelica commands.
- Possibility to run DoEs (design of experiments) based on parameter variation of an existing model.
- Run models in different environments like Linux, Windows, docker or WSL.
- Run compiled models without any dependency on OMC / ZMQ.

The classes which talk to OMC depend on an OpenModelica installation, because they start or connect to an OMC server. The classes which only run already compiled models - `OMSessionRunner`, `ModelicaSystemRunner` and `OMPython.model_execution` - do not, and are therefore usable on machines without OpenModelica.

- **OMPython.om_session_*** - the session classes, see *Session Classes*.
- **OMPython.modelica_system_*** - the modelica system classes, see *Modelica System Classes*.
- **OMPython.modelica_doe_*** - design of experiments (DOE), see *Design of Experiments*

Besides these main parts, additional helper functionality exists:

- **OMPython.OMParser** and **OMPython.OMTypedParser** - parser for OpenModelica return data, see *Parsers - Parsing OMC Return Data*
- **OMPython.model_execution** - execute compiled models, see *Execute Compiled Models*

Each of the main sections listed above is differentiated in

- **OMPython.*_abc** - abstract base classes holding the basic functionality which is shared by the two available implementations
- **OMPython.*_omc** - run OpenModelica based on an OMC server

- **OMPython.*_runner** - run simulations using pre-compiled binaries

The two available implementations mentioned above are **OMPython.*_omc**, which drives a full OpenModelica installation by sending commands to an OMC server, and **OMPython.*_runner**, which only executes a previously compiled model executable and therefore runs without OMC / ZeroMQ.

The following documentation is based on current OMPython version, which contains a compatibility layer supporting the main interface of OMPython v4.0.0. During a transition period, both options are available. The main differences between both interfaces as well as the limitations of the compatibility layer are described in *Compatibility with OMPython v4.0.0*.

## 32.2 Session Classes

OMPython provides a set of classes named `OMCSession*`. All of them use ZeroMQ to communicate with the OpenModelica Compiler (OMC) and they all offer the same interface, see *Session API*. The following options exist:

- `OMCSessionLocal(timeout=None, omhome=None)` - the default; it starts an `omc` server as a child process of the current Python process. `omhome` is the OpenModelica installation directory, i.e. the directory which contains `bin/omc`. If it is not given, the installation is looked up in the `OPENMODELICAHOME` environment variable, and then via the `omc` command in `PATH`.

```
import OMPython
# the installation is looked up in $OPENMODELICAHOME and then in $PATH
omc = OMPython.OMCSessionLocal()
# or select the installation explicitly; a longer timeout for slow operations
omc = OMPython.OMCSessionLocal(omhome="/opt/openmodelica", timeout=600)
```

- `OMCSessionPort(omc_port, timeout=None)` - connects to an already running OMC server. `omc_port` is the connection string which the server reports, for example `tcp://127.0.0.1:41613`.

```
import OMPython
# start the server separately, e.g. in another terminal:
#   omc --interactive=zmq
#   port   ->  "tcp://127.0.0.1:41613"
omc = OMPython.OMCSessionPort(omc_port="tcp://127.0.0.1:41613")
print(omc.get_port())
print(omc.sendExpression("getVersion()"))
```

- `OMCSessionDocker(timeout=None, docker=None, dockerExtraArgs=None, dockerOpenModelicaPath="omc", dockerNetwork=None, port=None)` - runs the OMC server in a Docker container. `docker` is the image to use, `dockerOpenModelicaPath` the path of `omc` within the image and `port` the port to connect to. The container is started by OMPython and removed again when the session ends. This is the recommended way to get a reproducible compiler environment, independent of the Python installation.

```
import OMPython
omc = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-
↪ompython")
print(omc.sendExpression("getVersion()"))
print(omc.get_docker_container_id())
```

- `OMCSessionDockerContainer(timeout=None, dockerContainer=None, dockerExtraArgs=None, dockerOpenModelicaPath="omc", dockerNetwork=None, port=None)` - runs the OMC server in an already existing Docker container which is identified by `dockerContainer`, i.e. by its container ID. In contrast to `OMCSessionDocker`, the container is not removed when the session is closed.

```
import OMPython
# a long living container, e.g. started via "docker run -d <image> sleep infinity
↪"
container_id = "b1e4e6a0f7c2"

omc = OMPython.OMCSessionDockerContainer(dockerContainer=container_id)
print(omc.sendExpression("getVersion()"))
print(omc.get_docker_container_id())

# alternatively, reuse the container of an OMCSessionDocker instance
omc_docker = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-
↪ompython")
omc_inner = OMPython.OMCSessionDockerContainer(dockerContainer=omc_docker.get_
↪docker_container_id())
print(omc_inner.sendExpression("getVersion()"))
```

Each session starts its own `omc` server inside the given container, so several sessions can work with the same container without interfering. The container survives the session, which makes this the session of choice for repeated runs against a fixed compiler environment.

- `OMCSessionWSL(timeout=None, wsl_omc="omc", wsl_distribution=None, wsl_user=None)` - runs the OMC server within the Windows Subsystem for Linux. The distribution and the user can be selected; `wsl_omc` is the path of `omc` within the WSL environment.

```
import OMPython
omc = OMPython.OMCSessionWSL()
print(omc.sendExpression("getVersion()"))
```

- `OMSessionRunner(ompath_runner=OMPathRunnerLocal, timeout=None, version="1.27.0", cmd_prefix=None, model_execution_local=True)` - the runner session described in *Running a pre-compiled model*; it runs a pre-compiled model executable directly, without using OMC at all. `ompath_runner` selects how the paths are resolved, either locally (`OMPathRunnerLocal`) or via a remote shell (`OMPathRunnerBash`), and `cmd_prefix` is the command prefix needed to enter that environment.

```
import OMPython

# a model executable which runs on the local machine
runner = OMPython.OMSessionRunner(version="1.27.0")
mod = OMPython.ModelicaSystemRunner(session=runner, work_directory="/path/to/
↪build_dir")
mod.setup(model_name="BouncingBall")
mod.simulate()

# a model executable which runs inside a Docker container; the command prefix is␣
↪taken
# from the Docker session which built the model
docker_omc = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-
↪ompython")
runner = OMPython.OMSessionRunner(
    version=docker_omc.get_version(),
    cmd_prefix=docker_omc.model_execution_prefix(cwd="/path/to/build_dir"),
    ompath_runner=OMPython.OMPathRunnerBash,
    model_execution_local=False,
)
mod = OMPython.ModelicaSystemRunner(session=runner, work_directory="/path/to/
↪build_dir")
```

Since no compiler is involved, the version passed to the constructor is only reported by `get_version()`; it does not have to match any real OMC server.

All sessions accept a `timeout` argument; see *Session API*.

The handling of any paths within the communication is covered by the `OMCPath` class. It is an implementation based on `pathlib` which uses OMC to run the different filesystem related commands. Therefore, it can be used also for remote / separated systems like docker or WSL. Because all paths are resolved by OMC and not by the local Python process, a path created via `omc.omcpath(...)` always refers to the file system seen by OMC, which is not necessarily the file system of the Python process. See *File and directory access* for details.

To test the command outputs, simply create an `OMCSessionLocal` object by importing from the OMPython library within the Python interpreter. The module allows you to interactively send commands to the OMC server and display their output.

To get started, create an `OMCSessionLocal` object:

```
>>> import OMPython
>>> omc = OMPython.OMCSessionLocal()
```

```
>>> omc.sendExpression("getVersion()")
v1.28.0-dev.1529+gaef66789a3.cmake
>>> omc.sendExpression("cd()")
«DOCHOME»
>>> omc.sendExpression("loadModel(Modelica)")
True
>>> omc.sendExpression("loadFile(getInstallationDirectoryPath() + \"/share/doc/omc/
↪testmodels/BouncingBall.mo\")")
True
>>> omc.sendExpression("instantiateModel(BouncingBall)")
class BouncingBall
  parameter Real e = 0.7 "coefficient of restitution";
  parameter Real g = 9.81 "gravity acceleration";
  Real h(start = 1.0, fixed = true) "height of ball";
  Real v(fixed = true) "velocity of ball";
  Boolean flying(start = true, fixed = true) "true, if ball is flying";
  Boolean impact;
  Real v_new(fixed = true);
  Integer foo;
equation
  impact = h <= 0.0;
  foo = if impact then 1 else 2;
  der(v) = if flying then -g else 0.0;
  der(h) = v;
  when {h <= 0.0 and v <= 0.0, impact} then
    v_new = if edge(impact) then -e * pre(v) else 0.0;
    flying = v_new > 0.0;
    reinit(v, v_new);
  end when;
end BouncingBall;
```

We get the name and other properties of a class:

```
>>> omc.sendExpression("getClassNames()")
('BouncingBall', 'ModelicaServices', 'Complex', 'Modelica')
>>> omc.sendExpression("isPartial(BouncingBall)")
False
>>> omc.sendExpression("isPackage(BouncingBall)")
False
>>> omc.sendExpression("isModel(BouncingBall)")
True
>>> omc.sendExpression("checkModel(BouncingBall)")
```

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```
Check of BouncingBall completed successfully.
Class BouncingBall has 6 equation(s) and 6 variable(s).
1 of these are trivial equation(s).
>>> omc.sendExpression("getClassRestriction(BouncingBall)")
model
>>> omc.sendExpression("getClassInformation(BouncingBall)")
('model', '', False, False, False, '/var/lib/jenkins/ws/OpenModelica/build/share/doc/
↪omc/testmodels/BouncingBall.mo', False, 1, 1, 24, 17, (), False, False, '', '',␣
↪False, '', '', '', '', '')
>>> omc.sendExpression("getConnectionCount(BouncingBall)")
0
>>> omc.sendExpression("getInheritanceCount(BouncingBall)")
0
>>> omc.sendExpression("getComponentModifierValue(BouncingBall,e)")
0.7
>>> omc.sendExpression("checkSettings()")
{'OPENMODELICAHOME': '«OPENMODELICAHOME»', 'OPENMODELICALIBRARY': '«OPENMODELICAHOME»/
↪lib/omlibrary', 'OMC_PATH': '«OPENMODELICAHOME»/bin/omc', 'SYSTEM_PATH': '/var/lib/
↪jenkins/ws/OpenModelica/build/bin:/var/lib/jenkins/ws/OpenModelica/build/bin:/usr/
↪local/cargo/bin:/opt/venv/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/
↪sbin:/bin', 'OMDEV_PATH': '', 'OMC_FOUND': True, 'MODELICAUSERCFLAGS': '', 'WORKING_
↪DIRECTORY': '«DOCHOME»', 'CREATE_FILE_WORKS': True, 'REMOVE_FILE_WORKS': True, 'OS
↪': 'linux', 'SYSTEM_INFO': 'Linux 3a997dbbec2b 6.8.0-142-generic #142-Ubuntu SMP␣
↪PREEMPT_DYNAMIC Wed Sep  2 14:24:27 UTC 2026 x86_64 x86_64 x86_64 GNU/Linux\n',
↪'RTLIBS': ' -lOpenModelicaRuntimeC -llapack -lblas -lm -lpthread -rdynamic --
↪coverage ', 'C_COMPILER': 'cc', 'C_COMPILER_VERSION': 'cc (Ubuntu 13.3.0-6ubuntu2~
↪24.04.1) 13.3.0\nCopyright (C) 2023 Free Software Foundation, Inc.\nThis is free␣
↪software; see the source for copying conditions.  There is NO\nwarranty; not even␣
↪for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.\n\n', 'C_COMPILER_
↪RESPONDING': True, 'CONFIGURE_CMDLINE': 'Configured  using arguments: '}
```

The common combination of a simulation followed by getting a value and doing a plot:

```
>>> omc.sendExpression("simulate(BouncingBall, stopTime=3.0)")
{'resultFile': '«DOCHOME»/BouncingBall_res.mat', 'simulationOptions': "startTime = 0.
↪0, stopTime = 3.0, numberOfIntervals = 500, tolerance = 1e-6, method = 'dassl',␣
↪fileNamePrefix = 'BouncingBall', options = '', outputFormat = 'mat', variableFilter␣
↪= '.*', cflags = '', simflags = ''", 'messages': 'LOG_SUCCESS       | info    | The␣
↪initialization finished successfully without homotopy method.\nLOG_SUCCESS       |␣
↪info    | The simulation finished successfully.\n', 'timeFrontend': 0.
↪0028207700000000002, 'timeBackend': 0.009283941, 'timeSimCode': 0.002595427,
↪'timeTemplates': 0.004688859, 'timeCompile': 0.46641441, 'timeSimulation': 0.
↪017014529, 'timeTotal': 0.502967445}
>>> omc.sendExpression("val(h , 2.0)")
0.04239430772884106
```

### 32.2.1 Import As Library

To use the module from within another python program, simply import the selected `OMCSession*` class from within the selected program.

For example:

```
# test.py
import OMPython
omc = OMPython.OMCSessionLocal()
cmds = [
```

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```
  'loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/BouncingBall.
↪mo")',
  "simulate(BouncingBall)",
  "plot(h)",
  ]
for cmd in cmds:
  answer = omc.sendExpression(cmd)
  print("\n{}:\n{}".format(cmd, answer))
```

### 32.2.2 Session API

All `OMCSession*` classes derive from `OMCSessionABC` and share the same interface. The following methods are available on every OMC based session.

`sendExpression(expr, parsed=True, raise_on_error=True)` is the central method. It sends `expr` to the OMC server and returns the result, converted into a Python object by the parser described in *Parsers - Parsing OMC Return Data*. Some typical usages are:

```
omc.sendExpression("getVersion()")
omc.sendExpression("getClassNames()")
```

The `parsed` argument controls whether the returned string is run through the parser. Set it to `False` whenever you need the exact string that OMC produced, for example when you want to post-process the output yourself. The two calls which return free text which cannot be parsed, `getErrorString()` and `getMessagesStringInternal()`, always return the raw string and log a warning if `parsed=True` was requested. `quit()` closes the connection and returns `None`; it is called automatically when the session object is deleted.

By default, `sendExpression()` raises an `OMSessionException` if OMC emitted an `error`-level diagnostic during the call. Some OMC API calls, notably `buildModel`, can emit error-level diagnostics which are recoverable and do not actually prevent the call from succeeding. If your code has its own, more precise way of verifying success - for example by checking that the expected files were created - pass `raise_on_error=False` to log those messages instead of raising an exception:

```
try:
  omc.sendExpression("loadModel(Modelica)")
except OMPython.OMSessionException as ex:
  print("Modelica could not be loaded:", ex)
```

The remaining session methods are:

- `get_version()` returns the version of the connected OMC server as a string.
- `set_timeout(timeout=None)` sets the timeout which is used when waiting for an answer of the OMC server or for the model executable, and returns the timeout which was in effect before the call. The value of zero or less raises an `OMSessionException`. Passing `None` changes nothing, which makes `set_timeout()` a getter.
- `set_workdir(workdir)` changes the working directory of the OMC server, i.e. the directory subsequent relative paths are resolved against. It is a no-op for `OMSessionRunner`.
- `omcpath(*path)` creates an `OMCPath` object, see *File and directory access*.
- `omcpath_tempdir(tempdir_base=None)` creates a uniquely named temporary directory as `OMCPath`. If `tempdir_base` is given, the directory is created inside that directory. This is how `ModelicaSystem` obtains its private build directory.
- `get_cmd_prefix()` returns the command prefix needed to run commands in the environment which is defined by the session.
- `escape_str(value)` escapes a string so that it can be embedded into an OMC expression: all backslashes and double quotes are escaped. Use it whenever you interpolate user data into a command.

In addition, the OMC based sessions provide `get_port()` which returns the ZeroMQ address of the OMC server and `get_log()` which returns the content of the OMC server log file, and the Docker based sessions provide `get_server_address()` and `get_docker_container_id()`. `OMSessionRunner` provides none of them, and its `sendExpression()` always raises an `OMSessionException`.

### 32.2.3 File and directory access

The `OMCPath` class gives you a `pathlib`-like interface to the file system which OMC sees. This is important when OMC does not run on the local machine, e.g. inside a Docker container or in WSL - in that case the Python process and OMC do not share a file system, and a plain `pathlib.Path` would silently operate on the wrong files.

Paths are always created via the session they belong to, so that the correct backend is used:

```
import OMPython
omc = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-ompython")
mo_file = omc.omcpath("/work") / "BouncingBall.mo"
mo_file.write_text('model BouncingBall end BouncingBall;')
print(mo_file.is_file())
print(mo_file.read_text())
print(mo_file.size())
```

The following methods are available. They all have the same names and semantics as their `pathlib.Path` counterparts:

- `is_file()` and `is_dir()` check the type of the path.
- `exists()` is a shorthand for `is_file() or is_dir()`.
- `is_absolute()` checks whether the path is absolute. Windows and POSIX conventions are distinguished based on the environment defined by the session.
- `read_text()` and `write_text(data)` read and write the file content. Both are always UTF-8 encoded; the other arguments of the `pathlib` methods are ignored.
- `mkdir()` creates a directory. An existing directory raises a `FileExistsError` unless `exist_ok=True` is given.
- `unlink()` deletes the file or the empty directory. A path which does not exist raises a `FileNotFoundError` unless `missing_ok=True` is given.
- `resolve()` and `absolute()` convert a relative path into an absolute one. The path has to exist, because OMC can only resolve existing paths.
- `cwd()` returns the current working directory of OMC.
- `size()` returns the file size in bytes. It raises an `OMSessionException` if the path is not a file.
- `get_session()` returns the session this path belongs to.

The path arithmetic of `pathlib` - the `/` operator, `.parent`, `.name`, `.stem`, `.suffix` and `.as_posix()` - is inherited unchanged and needs no OMC call.

## 32.3 Modelica System Classes

The ModelicaSystem class adds more functionality to OMPython. It provides methods to query information about models, to modify data (parameters, inputs, ...) and to simulate them. The corresponding API is described below.

Two implementations are available:

- `ModelicaSystemOMC` compiles the model with OMC and can therefore do everything the OpenModelica compiler can do. This is the default choice and the one described below.
- `ModelicaSystemRunner` only runs an already compiled model executable. It needs no OMC at runtime, see *Running a pre-compiled model*.

To get started, create a ModelicaSystem object:

```
>>> import OMPython
>>> mod = OMPython.ModelicaSystemOMC()
```

The constructor for a `ModelicaSystemOMC` object creates an `OMCSessionLocal` by default. If this is not desired or additional configuration is needed, several options exist:

- `command_line_options` (optional) - a list of additional command line options for OMC. The list elements are provided to OMC via `setCommandLineOptions()` in addition to OMPython's default options. The default of OMPython itself sets `--linearizationDumpLanguage=python` and `--generateSymbolicLinearization`, which make `linearize()` fast and let the model executable be reused for a linearization. Use `use_default_command_line_options=False` to disable these defaults; any `command_line_options` are still applied, and an omitted or empty list then runs without command line options:
- `use_default_command_line_options` (optional, default `True`) - whether to apply OMPython's default linearization options.
- `work_directory` (optional) - the directory which is used for the model build and for temporary files such as the model executable and the result file. If it is not given, a unique temporary directory is created for the instance, see *The work directory*.
- `omhome` (optional) - the OpenModelica installation directory, i.e. the directory which contains `bin/omc`. It is only used when the session is created, so it has no effect in combination with `session`. If it is not given, the directory is taken from the `OPENMODELICAHOME` environment variable, and otherwise derived from the `omc` command in `PATH`.
- `session` (optional) - an existing session to use. This is the way to combine `ModelicaSystem` with a Docker, WSL or port based session:

```
>>> docker_omc = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-
↪ompython")
>>> mod = OMPython.ModelicaSystemOMC(session=docker_omc)
```

After a ModelicaSystem object is created, the model can be defined:

```
>>> model_path = mod.get_session().sendExpression("getInstallationDirectoryPath()") +
↪"/share/doc/omc/testmodels/"
>>> mod.model(model_name="BouncingBall", model_file=model_path + "BouncingBall.mo")
```

The class method `model()` allows several arguments:

- `model_name` - The model name (as string). If the model is wrapped within a Modelica package, the namespace must also be included, e.g. `"MyPackage.BouncingBall"`.
- `model_file` - the path where to find the model file, either absolute or relative to the current working directory. The file should use the Modelica file extension ".mo". Because the path is resolved by OMC, a relative path refers to the working directory of the session, not to the working directory of the Python process.
- `libraries` - A third input argument (optional) is used to specify the list of dependent libraries or dependent Modelica files. Here, it is possible to just provide the library name or a tuple of library name and version. The libraries are loaded before the model itself is loaded:

```
>>> mod.model(model_name="BouncingBall", model_file=model_path + "BouncingBall.mo",␣
↪libraries=["Modelica"])
>>> mod.model(model_name="BouncingBall", model_file=model_path + "BouncingBall.mo",␣
↪libraries=[("Modelica","3.2.3"), "PowerSystems"])
```

- `variable_filter` - Optional string which sets a filter for the output variables. It is defined as a regular expression. Only variables fully matching the regexp will be stored in the result file. Leaving it unspecified is equivalent to ".*". A filter can also be changed later using `set_variable_filter()`.
- `build` - Optional boolean controlling whether the model should be built when `model()` is called. If False, the model is only loaded and `buildModel()` has to be called before the model can be simulated.

### 32.3.1 Build Model

The `buildModel()` API can either directly be executed on model definition (see above) or be called separately.

```
>>> mod.buildModel()
```

It accepts an optional `variableFilter` argument which sets the regular expression filter for the variables to be stored in the result file; without it the filter of `model()` or `set_variable_filter()` is used, and if that is unset as well then `".*"`. `buildModel()` translates the changes which were applied via `sendExpression()` - for example a changed parameter of the model - into a new build, and afterwards verifies that the model executable and the initialization file were really produced. If you only change parameters, input values or simulation options, you do not need to rebuild the model; just call `simulate()` again.

The following methods give direct access to the underlying OMC session, and to the identity of the model which is currently defined:

- `get_session()` returns the session which is used by this instance.
- `get_model_name()` returns the name of the model which was defined via `model()`.
- `sendExpression(expr, parsed=True, raise_on_error=True)` is a wrapper for `OMCSession*.sendExpression()`.
- `set_command_line_options(command_line_option)` sets a command line option for OMC via `setCommandLineOptions()`. Call `buildModel()` afterwards for it to take effect.

### 32.3.2 The work directory

Every `ModelicaSystem` instance owns a work directory. The model is built in that directory and all files which are produced by the instance - the model executable, the generated C code, the simulation result file and the input CSV file - are placed there.

- `getWorkDirectory()` returns the directory as an `OMCPath` object.
- `setWorkDirectory(work_directory=None)` changes the work directory. If called without argument, a new unique temporary directory is created.

```
mod = OMPython.ModelicaSystemOMC(work_directory="/tmp/my_build_dir")
mod.model(model_name="BouncingBall", model_file="BouncingBall.mo")
print(mod.getWorkDirectory())
```

Because the work directory is unique per instance, one `ModelicaSystem` instance corresponds to one model build. If you need several independent simulations of the same model, create one instance per simulation.

### 32.3.3 Standard get methods

The following methods read values from the currently defined model:

- `getQuantities(names=None)` - a list of dictionaries describing every variable of the model.
- `getParameters(names=None)` - the parameter values.
- `getInputs(names=None)` - the input signal values.
- `getContinuous(names=None)` - the values of the continuous signals.
- `getContinuousInitial(names=None)` and `getContinuousFinal(names=None)` - the values of the continuous signals before and after the simulation.
- `getOutputs(names=None)` - the values of the outputs.
- `getOutputsInitial(names=None)` and `getOutputsFinal(names=None)` - the values of the outputs before and after the simulation.
- `getSimulationOptions(names=None)`, `getLinearizationOptions(names=None)` and `getOptimizationOptions(names=None)` - the options of the respective simulation mode.

- `getLinearInputs()`, `getLinearOutputs()` and `getLinearStates()` - plain lists of the variable names which are used for linearization. These take no argument at all.
- `getSolutions(varList=None, resultfile=None)` - the simulation results, see below.

All of them except the three linearization name lists and `getSolutions()` accept the same three forms of the `names` argument:

- `getParameters()` - no argument; returns a dictionary which maps names to values.
- `getParameters("c")` - a single name; returns a list with the one value.
- `getParameters(["c", "radius"])` - a list of names; returns a list of values in the order in which the names were requested.

The name has to exist, otherwise a `KeyError` is raised. The one exception is a list of names, where a name which does not exist is silently skipped. The type of the returned values depends on the method:

- `getParameters()`, `getSimulationOptions()`, `getLinearizationOptions()` and `getOptimizationOptions()` always return strings, because a parameter or an option value can be an arbitrary Modelica expression which has not been evaluated yet. Note that even numerical option values such as `tolerance` are strings. Use `float()` if you need a number.
- `getQuantities()` returns one dictionary per requested variable, with the keys `alias`, `aliasvariable`, `causality`, `changeable`, `description`, `max`, `min`, `name`, `start`, `unit` and `variability`.
- `getInputs()` returns the `start` attribute of the input as a string while the model has not been changed, and a list of `(time, value)` tuples after `setInputs()` was called.
- `getContinuous()`, `getOutputs()` and their `Initial`/`Final` variants return `numpy.float64` values, or `None` for a variable which has no start value, for example a derivative such as `der(height)`.

Note the difference between the initial and the final variants: before a simulation, `getContinuous()` and `getOutputs()` return the initial values, after a simulation the values at `stopTime`. The explicit variants only ever return the initial respectively the final values, and the final ones raise a `ModelicaSystemError` if no simulation was run.

### 32.3.4 Usage of getMethods

The examples below show a BouncingBall model, once defined and built but not yet simulated, and once after `simulate()` was called.

```
>>> mod.getQuantities()
[{'alias': 'noAlias', 'aliasvariable': None, 'causality': 'local',
  'changeable': 'true', 'description': None, 'max': None, 'min': None,
  'name': 'height', 'start': '1.0', 'unit': None, 'variability': 'continuous'},
 # ...

>>> mod.getQuantities("height")
[{'alias': 'noAlias', 'aliasvariable': None, 'causality': 'local',
  'changeable': 'true', 'description': None, 'max': None, 'min': None,
  'name': 'height', 'start': '1.0', 'unit': None, 'variability': 'continuous'}]

>>> mod.getQuantities(["c", "radius"])
[{'alias': 'noAlias', ..., 'name': 'c', 'start': '0.9', ..., 'variability': 'parameter
↪'},
 {'alias': 'noAlias', ..., 'name': 'radius', 'start': '0.1', ..., 'variability':
↪'parameter'}]

>>> mod.getParameters()
{'c': '0.9', 'radius': '0.1'}

>>> mod.getParameters(["c", "radius"])
```

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```
['0.9', '0.1']

>>> mod.getContinuous()
{'height': 1.0, 'der(height)': None, 'velocity': 0.0, 'der(velocity)': None}

>>> mod.getContinuous(["velocity", "height"])
[0.0, 1.0]

>>> mod.getInputs()
{}

>>> mod.getOutputs()
{}

>>> mod.getSimulationOptions()
{'startTime': '0.0', 'stopTime': '2.0', 'stepSize': '0.002', 'tolerance': '1e-06',
 'solver': 'dassl', 'outputFormat': 'mat'}

>>> mod.getSimulationOptions(["stepSize", "tolerance"])
['0.002', '1e-06']
```

An empty dictionary here is correct: `BouncingBall` has no inputs and no outputs, because `height` has the causality `local`. Use `getQuantities("height")` to see the causality of a variable, and `getContinuous()` for its value.

After a simulation, `getContinuous()` and `getOutputs()` return the values at `stopTime`:

```
>>> mod.simulate()
>>> mod.getContinuous()
{'height': 0.6590703905294362, 'der(height)': -1.825929609047952,
 'velocity': -1.825929609047952, 'der(velocity)': -9.81}

>>> mod.getContinuousFinal("height")
[0.6590703905294362]
```

The `getSolutions()` method can be used in two different ways:

- Without a `varList` it returns the names of the variables for which results are available.
- With a `varList` it returns the data itself, as a two dimensional `numpy` array with one row per variable and one column per time point.

If no `resultfile` is given, the result file of the last `simulate()` call is used. This makes it possible to read results of an earlier simulation, and to compare simulations and perform regression testing:

```
>>> mod.getSolutions()
('time', 'height', 'velocity', 'der(height)', 'der(velocity)', 'c', 'radius')

>>> mod.getSolutions(["time", "height"])
array([[0.000e+00, 5.000e-04, 1.000e-03, ..., 2.000e+00],
       [1.000e+00, 9.999e-01, 9.997e-01, ..., 6.591e-01]])

>>> mod.getSolutions(["time", "height"], resultfile="/tmp/other_run.mat")
```

The method `plot(plotdata, resultfile=None)` passes the given expression to the plotting facility of OMC, for example `mod.plot("height")`. Because OMC itself creates the plot, it only works if the session is an `OMCSessionLocal`; Docker and WSL sessions have no access to a display.

### 32.3.5 Standard set methods

The following methods change the values of the currently defined model:

- `setParameters()` sets the values of model parameters.
- `setContinuous()` sets the initial values of continuous variables.
- `setSimulationOptions()`, `setLinearizationOptions()` and `setOptimizationOptions()` set the options of the respective simulation mode.
- `setInputs()` sets the time based input signals of the model, see below.

All of them take keyword arguments, i.e. the values are provided as a dictionary, and return `True` if the values were accepted. A name which does not exist, or which belongs to a different kind of variable, raises a `ModelicaSystemError`. The values are stored as strings, because a Modelica parameter can be an arbitrary expression which has not been evaluated yet:

```
mod.setParameters(radius=14)
mod.setParameters(radius=14, c=0.5)
mod.setParameters(**{"radius": 14, "c": 0.5})
```

Additionally, the following helper methods are available:

- `isParameterChangeable(name)` returns whether the parameter can be changed without recompiling the model, i.e. whether its `changeable` attribute is not `false`. A parameter is not changeable if it is structural, final, protected, evaluated or has a non-constant binding.
- `set_variable_filter(variable_filter=None, escape=False)` sets the regular expression which selects the variables to be stored in the result file. With `escape=True` all regular expression special characters in the filter are escaped, so that a literal string can be used. An invalid regular expression raises a `ModelicaSystemError`, and `None` removes the filter.
- `toInputs(data)` converts a dictionary of lists - as returned by `pandas.DataFrame.to_dict(orient='list')` - into the input format used by `setInputs()`. The dictionary must contain a `time` key.
- `setInputsCSV(csvfile)` reads the time based input data from a CSV file. The file has to contain a header row, the first column is used as time, and the header of the remaining columns defines the input names. Note that this file is read by the local Python process, so the path has to be a local path even if the session itself is a Docker, WSL or port based one. The method returns `None`.

### 32.3.6 Usage of setMethods

```
>>> mod.setInputs(cAi=1, Ti=2)             # set constant input signals

>>> mod.setParameters(radius=14)            # set one parameter

>>> mod.setParameters(radius=14, c=0.5)     # set several parameters at once

>>> mod.setContinuous(height=2.0)           # set an initial value of a continuous␣
↪variable

>>> mod.setSimulationOptions(stopTime=2.0, tolerance=1e-08)
```

The input signals are the one exception to the "value as string" rule of the other set methods. A value may be given as a single number, which is then held constant over the whole simulation, or as a list of (time, value) tuples, which defines a piecewise linear signal. The time values have to be in increasing order and must not be smaller than `startTime`:

```
>>> mod.setSimulationOptions(startTime=0.0, stopTime=2.0)
>>> mod.setInputs(u=[(0.0, 0.0), (1.0, 1.0), (2.0, 0.5)])
>>> mod.setInputs(u=0.5)                    # constant over [0.0, 2.0]
```

### 32.3.7 Simulation

An example of how to get parameter names and change the value of parameters using set methods and finally simulate the "BouncingBall.mo" model is given below.

```
>>> mod.getParameters()
{'c': '0.9', 'radius': '0.1'}

>>> mod.setParameters(radius=14, c=0.5)
```

To check whether new values are updated to the model, we can again query getParameters().

```
>>> mod.getParameters()
{'c': '0.5', 'radius': '14'}
```

Note that the values are strings, so the order of the dictionary is not sorted and the values have to be compared as strings.

The model can be simulated using the `simulate` API in the following ways:

- without any arguments,
- with a `resultfile` keyword argument,
- with a `simargs` keyword argument, i.e. runtime simulation flags supported by OpenModelica.

```
>>> mod.simulate()      # default result file name will be used
>>> mod.simulate(resultfile="tmpbouncingBall.mat")
>>> mod.simulate(simargs={"noEventEmit": None, "noRestart": None, "override": {"e": 0.
↪3, "g": 10}})
```

All changes which were made via the set methods - parameters, continuous values, simulation options and inputs - are passed to the model executable as command line arguments when `simulate()` is called. `override` is a special key: it takes a dictionary of variable names and values which is translated into the corresponding `-override` runtime flag. Setting an override value to `None` removes it again. The remaining keys of `simargs` are the runtime flags of the compiled model, where a key without value (`None`) becomes a flag and a key with a value becomes `-key=value`.

Note that the `simargs` dictionary is passed on unchanged, i.e. it is not validated against the model. An unknown key results in an error from the model executable, which OMPython reports as a `ModelicaSystemError`.

`simulate()` returns nothing on success. The result file is available in the work directory under the name `<model_name>_res.mat`, unless a `resultfile` was given.

If you only need the command line of a simulation - for example to run it later, on a different machine, or in parallel - use `simulate_cmd()` instead of `simulate()`. It applies all pending changes and returns a `ModelExecutionConfig` object, see *Execute Compiled Models*, which can be turned into a runnable command:

```
from OMPython import ModelExecutionConfig

cmd = mod.simulate_cmd(result_file=mod.getWorkDirectory() / "MyRes.mat",
                       simargs={"noRestart": None})
execution = cmd.definition()   # -> ModelExecutionRun
print(" ".join(execution.get_cmd()))
returncode = execution.run()    # run the simulation
```

`simulate_cmd()` is the basis of the DoE functionality, see *Design of Experiments*.

### 32.3.8 Linearization

The following methods are used for linearization.

- linearize()
- getLinearizationOptions()
- setLinearizationOptions()
- getLinearInputs()
- getLinearOutputs()
- getLinearStates()

```
>>> mod.getLinearizationOptions()
{'startTime': '0.0', 'stopTime': '1.0', 'stepSize': '0.002', 'tolerance': '1e-08'}

>>> mod.getLinearizationOptions(["startTime", "stopTime"])
['0.0', '1.0']

>>> mod.setLinearizationOptions(stopTime=2.0, tolerance=1e-06)

>>> mod.linearize()      # returns a LinearizationResult object

>>> mod.getLinearInputs()    # list of the input names used when forming the matrices
['u']

>>> mod.getLinearOutputs()   # list of the output names used when forming the matrices
['y']

>>> mod.getLinearStates()    # list of the state names used when forming the matrices
['x']
```

`linearize()` accepts an optional `lintime` argument to override the `stopTime` of the linearization, and an optional `simargs` argument to pass runtime flags such as an input file:

```
mod.linearize(lintime=2.0)
mod.linearize(simargs={"csvInput": "my_input.csv"})
```

The returned `LinearizationResult` can be used in three ways, depending on how much information you need:

```
# (a) unpack just the matrices
A, B, C, D = mod.linearize()

# (b) access all attributes by name
result = mod.linearize()
print(result.A, result.B, result.C, result.D)
print(result.n, result.m, result.p)          # number of states, inputs, outputs
print(result.x0, result.u0)                  # fixed point and the input at the fixed␣
↪point
print(result.stateVars, result.inputVars, result.outputVars)

# (c) index access, for backwards compatibility with the tuple which linearize()␣
↪returned before
A = mod.linearize()[0]
```

### 32.3.9 Optimization

Besides simulating and linearizing a model, `ModelicaSystemOMC` can also run a model-based optimization. The optimization problem is defined in the model itself via an `optimize` algorithm annotation; `ModelicaSystem` only controls the simulation options of that run.

```
>>> mod.getOptimizationOptions()
{'startTime': '0.0', 'stopTime': '1.0', 'numberOfIntervals': '500',
 'stepSize': '0.002', 'tolerance': '1e-08'}

>>> mod.setOptimizationOptions(stopTime=2.0, numberOfIntervals=1000)

>>> mod.optimize()
```

`optimize()` returns a dictionary. Besides the path to the result file, it contains the options which were used and the time which was spent in the different compilation and simulation phases:

```
result = mod.optimize()
print(result['resultFile'])
print(result['simulationOptions'])  # -> startTime = 0.0, stopTime = 1.0, ...
print(result['timeFrontend'], result['timeTotal'])
```

Note that `optimize()` sets the compiler flag `-g=Optimica` via `set_command_line_options()` in order to generate the simulation code of the optimization problem. The flag stays set, so a model which was optimized once keeps the Optimica backend for all following `buildModel()` calls of the same instance.

Reading the result file works in the same way as after a simulation:

```
mod.getSolutions(resultfile=result['resultFile'])
mod.getSolutions("y", resultfile=result['resultFile'])
```

### 32.3.10 Plotting

`plot(plotdata, resultfile=None)` forwards the plot to the OMC `plot()` API call and displays the result in the plot window of the OMC installation:

```
mod.plot("height")
```

Because the plot is rendered by OMC, which needs access to a local display, `plot()` only works for a local session. It is not available when the session runs OMC in Docker or in WSL. To plot results in that case, read them with `getSolutions()` and plot them with the plotting library of your choice.

### 32.3.11 Running a pre-compiled model

If the model has already been compiled elsewhere and you only want to run the resulting executable - for example on a machine without an OpenModelica installation, inside a CI job, or in a container image which only contains the model binary - use `ModelicaSystemRunner`. It does not need an OMC server and does not use ZeroMQ.

```
import OMPython

mod = OMPython.ModelicaSystemRunner(work_directory="/path/to/build_dir")
mod.setup(model_name="BouncingBall", variable_filter=".*")
mod.setParameters(radius=14, c=0.5)
mod.setSimulationOptions(stopTime=2.0)
mod.simulate()
print(mod.getWorkDirectory() / "BouncingBall_res.mat")
```

`setup()` replaces `model()` because there is nothing to load or to compile. It expects the files which OMC produced for the model to be present in the work directory, which must be passed via the `work_directory` argument of the constructor:

- the model executable, either as <model_name> or <model_name>.exe. On Windows an additional <model_name>.bat file is expected; OMPython reads the library path from it.
- the model initialization file <model_name>_init.xml, which provides the model structure. The quantities of the model - and therefore all get methods - are read from this file.

The constructor also accepts a `session` argument, but it has to be an `OMSessionRunner`; any other session raises a `ModelicaSystemError`, because running a model executable does not need a compiler.

All get and set methods, `simulate()`, `simulate_cmd()` and `linearize()` behave as described above. The methods which need OMC are not available on this class, because they are defined in `ModelicaSystemOMC` only. This affects:

An `ModelicaSystemRunner` instance cannot be reused for a second model; a second call of `setup()` raises a `ModelicaSystemError`, so create a new instance instead.

## 32.4 Design of Experiments

A design of experiments (DoE) is a systematic way of running a model many times with different parameter values, and of collecting the results. `ModelicaDoE` takes a model which was defined with `ModelicaSystem` and expands a dictionary of parameter value lists into all combinations of these values, runs the corresponding simulations, and reports which results are available where.

Two implementations are available, matching the two `ModelicaSystem` implementations:

- `ModelicaDoEOMC` for a model defined by `ModelicaSystemOMC`.
- `ModelicaDoERunner` for a model defined by `ModelicaSystemRunner`.

The difference matters for the *structural* parameters, see below.

The following example defines a small model, varies four parameters and runs the resulting eight simulations:

```
import OMPython
import pathlib

mypath = pathlib.Path('.')

model = mypath / "M.mo"
model.write_text(
    "model M\n"
    "  parameter Integer p=1;\n"
    "  parameter Integer q=1;\n"
    "  parameter Real a = -1;\n"
    "  parameter Real b = -1;\n"
    "  Real x[p];\n"
    "  Real y[q];\n"
    "equation\n"
    "  der(x) = a * fill(1.0, p);\n"
    "  der(y) = b * fill(1.0, q);\n"
    "end M;\n"
)

param = {
    # structural
    'p': [1, 2],
    'q': [3, 4],
    # non-structural
    'a': [5, 6],
    'b': [7, 8],
}
```

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```
resdir = mypath / 'DoE'
resdir.mkdir(exist_ok=True)

mod = OMPython.ModelicaSystemOMC()
mod.model(model_name="M", model_file=model.as_posix())
doe_mod = OMPython.ModelicaDoEOMC(
    mod=mod,
    parameters=param,
    resultpath=resdir,
    simargs={"override": {'stopTime': 1.0}},
)
doe_mod.prepare()
doe_def = doe_mod.get_doe_definition()
doe_mod.simulate()
doe_sol = doe_mod.get_doe_solutions()
```

The constructor of `ModelicaDoEOMC` takes the following arguments:

- `mod` - the `ModelicaSystemOMC` instance which holds the model. The type is checked, so a `ModelicaSystemRunner` has to be combined with `ModelicaDoERunner`.
- `parameters` - a dictionary which maps a parameter name to a list of values to be used for that parameter. All combinations of the lists are simulated, so the example above defines 2x2x2x2 = 8 simulations. A name which does not exist in the model raises an error in `prepare()`.
- `resultpath` - the directory in which the result files are stored. It has to exist already, because it is resolved but not created; otherwise a `ModelicaSystemError` is raised. The default is a temporary directory.
- `simargs` - the runtime flags which are used for every simulation, in the same format as the `simargs` argument of `simulate()`.

Two further methods complete the interface: `get_session()` returns the session in use and `get_resultpath()` returns the directory the results are written to. `get_doe_command()` returns the prepared simulations as a dictionary which maps each result file name to a `ModelExecutionRun` object, which is useful to run the DoE somewhere else; `simulate()` simply runs these commands in parallel.

The workflow always consists of the same four steps.

**1. prepare()** evaluates the parameters and builds the list of simulations. It returns the number of simulations which were defined. This is the step which distinguishes the two implementations:

- A *structural* parameter - for example an array size - changes the equations of the model, so the model has to be recompiled for every value it takes. `prepare()` therefore creates one build per combination of the structural parameters.
- A *non-structural* parameter - for example a resistance or a spring constant - does not change the equations. All of its values can be passed to the same model executable at runtime.

The two kinds are told apart with `isParameterChangeable()`, so the classification is derived from the model and not from the names in the `parameters` dictionary.

For `ModelicaDoEOMC` the structural parameters are handled by sending `setParameterValue()` to OMC and rebuilding the model for every combination, which is why a DoE on structural parameters is comparatively slow. Note that `prepare()` changes the work directory of the `ModelicaSystem` instance to the per-combination build directory, so do not reuse that instance for something else afterwards.

`ModelicaDoERunner` cannot recompile at all, so it can only vary non-structural parameters; passing a structural parameter raises a `ModelicaSystemError`.

**2. get_doe_definition()** returns the DoE as a dictionary, where each key is a result file name and the value is a dictionary of the simulation settings, including the structural and non-structural parameter values of that run. The three fixed keys of that dictionary are `DICT_ID_STRUCTURE`, `DICT_ID_NON_STRUCTURE` and

`DICT_RESULT_AVAILABLE`; the last one is set to `True` by `simulate()` for every run which produced a result file. The data converts directly to a pandas dataframe:

```
import pandas as pd

doe_df = pd.DataFrame.from_dict(data=doe_mod.get_doe_definition(), orient='index')
print(doe_df)
```

**3. simulate(num_workers=3)** runs the simulations which were defined by `prepare()`, using the given number of worker threads. It returns `True` if all simulations finished successfully, and `False` otherwise, so a partial failure does not abort your script. The number of workers is a pure performance setting; increase it to use more CPU cores, and set it to 1 for a deterministic, easy to debug run. A simulation which fails is logged as a warning, so enable the `OMPython.modelica_doe_abc` logger to see the details. Calling `simulate()` without a preceding `prepare()` raises a `ModelicaSystemError`.

**4. get_doe_solutions(var_list=None)** is only available on `ModelicaDoEOMC`, because it needs OMC to read the result files. It returns a dictionary which maps each result file name to a dictionary with the keys `'msg'` and `'data'`; the `'data'` entry contains one numpy array per variable. A run whose result file is missing or unreadable is reported in `'msg'` with an empty `'data'` dictionary instead of raising, so a single failed simulation does not cost you all results:

```
doe_sol = doe_mod.get_doe_solutions()
# {'DOE_0000000000_0000000000.mat': {'msg': 'Simulation available',
#                                    'data': {'time': array([...]), 'x': array([...])}},
#  ...}

doe_sol = doe_mod.get_doe_solutions(["time", "x"])   # restrict the variables
```

The underlying function `OMPython.modelica_doe_omc.doe_get_solutions()` can also be called directly, which is useful if the DoE definition is stored somewhere else. The data converts to a pandas dataframe per run:

```
import pandas as pd

for name, run in doe_sol.items():
    run['df'] = pd.DataFrame.from_dict(data=run['data']) if run['data'] else None
```

## 32.5 Execute Compiled Models

Everything OMPython does with a simulation boils down to running the model executable. The module `OMPython.model_execution` implements this step, independently of OMC, and is therefore usable on its own. It is the layer below `ModelicaSystem.simulate()`, and it is what makes it possible to run a model executable which lives in a different environment than the Python process.

### 32.5.1 ModelExecutionConfig

`ModelExecutionConfig` collects everything which is needed to run a compiled model: the directory the model was built in, the command prefix needed to reach that environment, the model name, and the command line arguments. Because the arguments are stored separately from the environment, the same configuration can be inspected, modified and executed independently.

```
from OMPython import ModelExecutionConfig

cmd = ModelExecutionConfig(
    runpath="/tmp/tmpxxxx",
    cmd_prefix=[],          # e.g. ['docker', 'exec', '--user', '1000', '<container_id>']
    cmd_local=True,         # is the environment the local one?
    cmd_windows=False,      # is the environment a Windows one?
    model_name="BouncingBall",
```

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```
    timeout=300.0,          # optional, default is 300 s
)
```

`runpath`, `cmd_prefix` and `model_name` are required; `model_name` is needed because it determines the name of the executable and of the Windows batch file. Note that `runpath` has to be the path as seen from within the environment, so for a Docker or WSL environment it is the path inside the container, not a local path.

The arguments are managed with four methods:

- `arg_set(key, val=None)` sets one argument. A value of `None` results in a plain flag `-key`; any other value results in `-key=value`. Setting a key which is already set replaces the value and logs a warning.
- `arg_get(key)` returns the value of one argument, or `None` if it is not set.
- `args_set(args)` sets several arguments at once from a dictionary. This is the same format as the `simargs` argument of `simulate()`.
- `get_cmd_args()` returns the resulting argument list as a list of strings, sorted by argument name.

The `override` key is treated specially: its value is a dictionary of variable names and values which is sorted by name and joined into the single `-override=name=value,name=value` argument that the model executable expects. Values are converted to their Modelica representation, so Python `True` becomes `true` and numbers are formatted accordingly.

```
cmd.arg_set("noRestart", None)
cmd.arg_set("r", "MyRes.mat")
cmd.arg_set("override", {"e": 0.3, "g": 10, "s": "false"})
cmd.get_cmd_args()
# ['-noRestart', '-override=e=0.3,g=10,s=false', '-r=MyRes.mat']
```

```
cmd.args_set({"noEventEmit": None, "override": {"e": 0.3}})
print(cmd.arg_get("noEventEmit"))  # -> None (a flag has no value)
```

`definition()` freezes the configuration into a `ModelExecutionRun` object, which is what finally knows about the model executable and the command line to run.

### 32.5.2 ModelExecutionRun

`ModelExecutionRun` is a data class holding the resolved command line:

- `cmd_path` - the directory the model was built in, as seen by the environment.
- `cmd_model_name` - the name of the model.
- `cmd_prefix` - the command prefix needed to re-enter the environment, e.g. for Docker.
- **`cmd_model_executable` - the full path of the executable, including the `.exe`** suffix on Windows.
- `cmd_args` - the command line arguments.
- **`cmd_result_file` - the result file of the run. If no `-r` argument was set, it** defaults to `<model_name>.mat` in the build directory.
- `cmd_timeout` - the timeout for the run, in seconds.
- **`cmd_library_path` - an additional library search path, which is only needed for a local** Windows environment. OMPython derives it from the generated `*.bat` file.
- **`cmd_cwd_local` - the working directory to use on the local system. This is only set when** the environment is the local one, because in Docker or WSL the local directory has no meaning.

The two methods of this class are:

- `get_cmd()` returns the complete command line as a list of strings: prefix, executable and arguments. This is the form expected by `subprocess.run()`, and it is a convenient way to log, print or verify the command which is executed.
- `run()` executes the command and returns its return code. The standard output of the executable is logged, an error on standard error or a non-zero exit status raises a `ModelExecutionException`, and a run which exceeds `cmd_timeout` also raises a `ModelExecutionException`.

```
execution = cmd.definition()
print(" ".join(execution.get_cmd()))
execution.run()
```

Because this layer only starts a process, it imposes no restrictions on the model. You can use it to run models that OMPython did not build, and to run a model in a Docker container or in WSL by passing the corresponding `cmd_prefix`.

## 32.6 Parsers - Parsing OMC Return Data

The OMC server answers every request with a string. OMPython converts that string into a Python object before handing it to you, and this conversion is done by the parsers of this section. You can also use them directly, for example to post-process a raw OMC answer.

`sendExpression(expr, parsed=True)` first tries the typed parser and, if that fails, falls back to the basic parser. So the default gives you the most detailed result which the two parsers can produce, and only a string which neither of them understands is returned unchanged. With `parsed=False` the unmodified OMC answer is returned.

### 32.6.1 OMParser - the basic parser

`OMParser.om_parser_basic(string)` converts the most common Modelica literals into Python values:

- Integers, floating point numbers and numbers in scientific notation become `int` and `float`.
- `true` and `false` become `True` and `False`.
- Sets in the form `{1,2,3}` become `{'SET1': {'Set1': [1, 2, 3]}}`. The wrapper keys `SET1` and `Set1` reflect the "set" semantics of the Modelica notation.
- Strings are returned **including** their quotes.
- Anything the parser does not understand is returned unchanged as a string. It never raises.

```
from OMPython.OMParser import om_parser_basic

om_parser_basic("1")         # -> 1
om_parser_basic("1.0e-3")    # -> 0.001
om_parser_basic("true")      # -> True
om_parser_basic("{1,2,3}")   # -> {'SET1': {'Set1': [1, 2, 3]}}
om_parser_basic('"abc"')     # -> '"abc"'
om_parser_basic("1,2,3")     # -> '1,2,3'   (unchanged, not an error)
```

Besides `om_parser_basic()`, the module provides the helper functions which the parser is built from, such as `typeCheck()`, `bool_from_string()` and `formatSimRes()`. They are useful if you need to post-process an OMC result in the same way as OMPython does.

### 32.6.2 OMTypedParser - the typed parser

`OMTypedParser.om_parser_typed(string)` is built with the `pyparsing` library and converts a wider range of Modelica values, using a strict grammar:

- Integers, floating point numbers and booleans as above.
- Strings **without** their quotes, so `"abc"` becomes `abc`.

- Tuples, i.e. both the array form `{1,2}` and the tuple form `(1,2)`, become a Python `tuple`.
- Array dimensions may be given as an expression, so `{1+1, 2*3}` becomes `(2, 6)`.
- Modelica records of the form `record R a=1, b="x" end R;` become a Python `dict`.
- `SOME(x)` is unwrapped to `x`, and `NONE()` becomes `None`. Note that the parentheses are part of the syntax: a bare `NONE` is returned as the string `'NONE'`.
- The empty string and the empty tuple `()` are recognized as `None` and `()`.
- Anything the grammar does not match raises a `pyparsing.ParseException`.

```
from OMPython.OMTypedParser import om_parser_typed

om_parser_typed("1")                  # -> 1
om_parser_typed('"abc"')              # -> 'abc'   (no quotes!)
om_parser_typed("{1,2,3}")            # -> (1, 2, 3)
om_parser_typed("{1+1, 2*3}")         # -> (2, 6)
om_parser_typed('record R a=1 end R;')  # -> {'a': 1}
om_parser_typed("SOME(1.0)")          # -> 1.0
om_parser_typed("NONE()")             # -> None
om_parser_typed("NONE")               # -> 'NONE'  (the string, not None!)
om_parser_typed("Modelica.Blocks")  # -> 'Modelica.Blocks'
om_parser_typed("1,2,3")              # -> raises ParseException
om_parser_typed("Modelica.Units.SI.Frequency(1.0)")  # -> raises ParseException
```

### 32.6.3 Choosing a parser

The two parsers differ in a way that matters when you post-process OMC answers:

- Use `om_parser_basic()` when you want a result which never fails and where keeping the exact text of everything unrecognised is more useful than rejecting it.
- Use `om_parser_typed()` when you want real Python types - in particular unquoted strings and tuples instead of the nested `SET1` dictionaries - and you are prepared to handle a parse error.

The parsers are a moving target: `sendExpression()` currently uses the typed parser for its default path, and the session classes are being moved to it. As a consequence, the exact type of a value returned by `sendExpression()` is an implementation detail. If your code depends on a specific type, ask for it explicitly rather than relying on the default:

```
omc.sendExpression("getVersion()", parsed=False)            # exact string from OMC
om_parser_typed(omc.sendExpression("getVersion()", parsed=False))
```

## 32.7 Compatibility with OMPython v4.0.0

The data above describes the current OMPython interface, which reorganized the API of OMPython v4.0.0. During a transition period both interfaces are available: the new one documented in this chapter, and a compatibility layer which keeps the old class and method names working.

Every compatibility class issues a `DeprecationWarning` when it is instantiated, and it will be removed in a future version. Existing scripts therefore keep running, but the warnings point out what to change. The warning is only shown by default if warnings are enabled for `DeprecationWarning`, which Python hides outside of `__main__`; run your script with `python -W default::DeprecationWarning` to see them.

The following table lists the v4.0.0 names and their replacements.

| OMPython v4.0.0 | OMPython current |
|---|---|
| `OMCSessionZMQ` | `OMCSessionLocal` |
| `OMCProcessLocal` | `OMCSessionLocal` |
| `OMCProcessPort` | `OMCSessionPort` |
| `OMCProcessDocker` | `OMCSessionDocker` |
| `OMCProcessDockerContainer` | `OMCSessionDockerContainer` |
| `OMCProcessWSL` | `OMCSessionWSL` |
| `OMCSessionCmd` | `OMCSession*.sendExpression()` |
| `OMCSessionException` | `OMSessionException` |
| `ModelicaSystem` | `ModelicaSystemOMC` |
| `ModelicaSystemCmd` | `ModelicaSystem.simulate_cmd()` |
| `ModelicaSystemDoE` | `ModelicaDoEOMC` / `ModelicaDoERunner` |
| `parse_simflags` | the `simargs` dictionary of `simulate()` |

All of these names are still re-exported from the package root, so `OMPython.OMCSessionZMQ` and friends keep working. Only `ModelicaSystemCmd` has to be imported from its module:

```
from OMPython.ModelicaSystem import ModelicaSystemCmd
```

Note that `OMPython.OMCSessionException` still refers to the compatibility subclass, while the exception which the current code raises is `OMPython.OMSessionException`. Change your `except` clauses accordingly, otherwise they will not catch anything:

```
# OMPython v4.0.0
try:
    omc.sendExpression("getVersion()")
except OMPython.OMCSessionException:
    pass

# current
try:
    omc.sendExpression("getVersion()")
except OMPython.OMSessionException:
    pass
```

The most important changes to be aware of are the following.

### 32.7.1 Sessions and the `omc_process` argument

The v4.0.0 code passed the OMC process definition as `omc_process`, and `OMCSessionZMQ` was the one class which combined the session and the process. Both are now the same object, and the argument is called `session`:

```
# OMPython v4.0.0
omc = OMPython.OMCSessionZMQ(omc_process=OMPython.OMCProcessDocker())

# current
omc = OMPython.OMCSessionDocker(docker="openmodelica/openmodelica:v1.27.0-ompython")
```

The constructor argument `OMCSessionZMQ.omc_process` and the parameter of the same name in the compatibility class `ModelicaSystem` are still accepted; `ModelicaSystemOMC` only takes `session`.

### 32.7.2 Defining a model

In v4.0.0 the model was passed to the constructor of `ModelicaSystem` as `fileName` and `modelName`. It is now defined by a separate `model()` call, which also makes it possible to load libraries first:

```
# OMPython v4.0.0
mod = OMPython.ModelicaSystem("BouncingBall.mo", "BouncingBall", lmodel=["Modelica"])

# current
mod = OMPython.ModelicaSystemOMC()
mod.model(model_name="BouncingBall", model_file="BouncingBall.mo", libraries=[
↪"Modelica"])
```

The constructor keywords `fileName`, `modelName`, `lmodel`, `commandLineOptions`, `variableFilter` and `customBuildDirectory` are still accepted, and map to `model_file`, `model_name`, `libraries`, `command_line_options`, `variable_filter` and `work_directory` respectively.

### 32.7.3 Setting values

The v4.0.0 set methods took either a single `"name=value"` string or a list of such strings. They now take keyword arguments, which removes the need to escape the values and gives a proper error message on typos:

```
# OMPython v4.0.0
mod.setParameters(["radius=14", "c=0.5"])

# current
mod.setParameters(radius=14, c=0.5)
```

The string form still works on the compatibility class and issues a `DeprecationWarning`. The difference is not only cosmetic: the v4.0.0 form had to split the string on =, which made a value containing = impossible and silently dropped everything after a second =. It also removed all spaces from the string, so a value like `"a + b"` was mangled into `"a+b"`. The current implementation keeps a value as it was given and reports a space in a key or value as an error, and it names an unknown key in the error message instead of doing nothing.

### 32.7.4 Runtime flags

`simflags` was a single string holding the runtime flags of the model executable, which had to be quoted and escaped by hand. `simargs` is a dictionary which is translated into the correct command line, including the special handling of the `override` flag:

```
# OMPython v4.0.0
mod.simulate(simflags="-noEventEmit -noRestart -override=e=0.3,g=9.71")

# current
mod.simulate(simargs={"noEventEmit": None, "noRestart": None, "override": {"e": 0.3,
↪"g": 9.71}})
```

The `simflags` argument is still accepted by the compatibility class, in `simulate()`, `simulate_cmd()` and `linearize()`. `parse_simflags()` is available as well, but there is no need for it any more.

### 32.7.5 Linearization results

`linearize()` used to return the list `[A, B, C, D]`. It now returns a `LinearizationResult` object which carries the matrices together with the dimensions and the variable names. Unpacking and indexing still work, so most existing code continues to run:

```
A, B, C, D = mod.linearize()      # still works
A = mod.linearize()[0]            # still works
result = mod.linearize()          # new
print(result.n, result.stateVars)
```

### 32.7.6 Limitations of the compatibility layer

The compatibility layer covers the naming and the call signatures, not the behaviour:

- The work directory and the result file are unique per instance in the current version, so an instance cannot be reused for a second model build.
- Setting a structural parameter via `setParameters()` raises a `ModelicaSystemError` in the current version, because the model would have to be recompiled. Use `sendExpression()` followed by `buildModel()` to change such a parameter.
- The compatibility classes only wrap the constructors and the methods which changed their signature. Attributes of the v4.0.0 objects, for example the `omc_process` attribute of `OMCSessionZMQ`, are not guaranteed to stay available; use `get_session()`.
- Only the new classes are documented and tested. Behaviour which is only reachable through the compatibility layer may change without further notice.

CHAPTER

# THIRTYTHREE

# OMMATLAB - OPENMODELICA MATLAB INTERFACE

OMMatlab - the OpenModelica Matlab API is a free, open source, highly portable Matlab-based interactive session handler for Modelica scripting. It provides the modeler with components for creating a complete Modelica modeling, compilation and simulation environment based on the latest OpenModelica library standard available. OMMatlab is architectured to combine both the solving strategy and model building. So domain experts (people writing the models) and computational engineers (people writing the solver code) can work on one unified tool that is industrially viable for optimization of Modelica models, while offering a flexible platform for algorithm development and research. OMMatlab is not a standalone package, it depends upon the OpenModelica installation.

OMMatlab is implemented in Matlab and depends on ZeroMQ - high performance asynchronous messaging library and it supports the Modelica Standard Library version 3.2 that is included in starting with OpenModelica 1.9.2.

To install OMMatlab follow the instructions at https://github.com/OpenModelica/OMMatlab

## 33.1 Features of OMMatlab

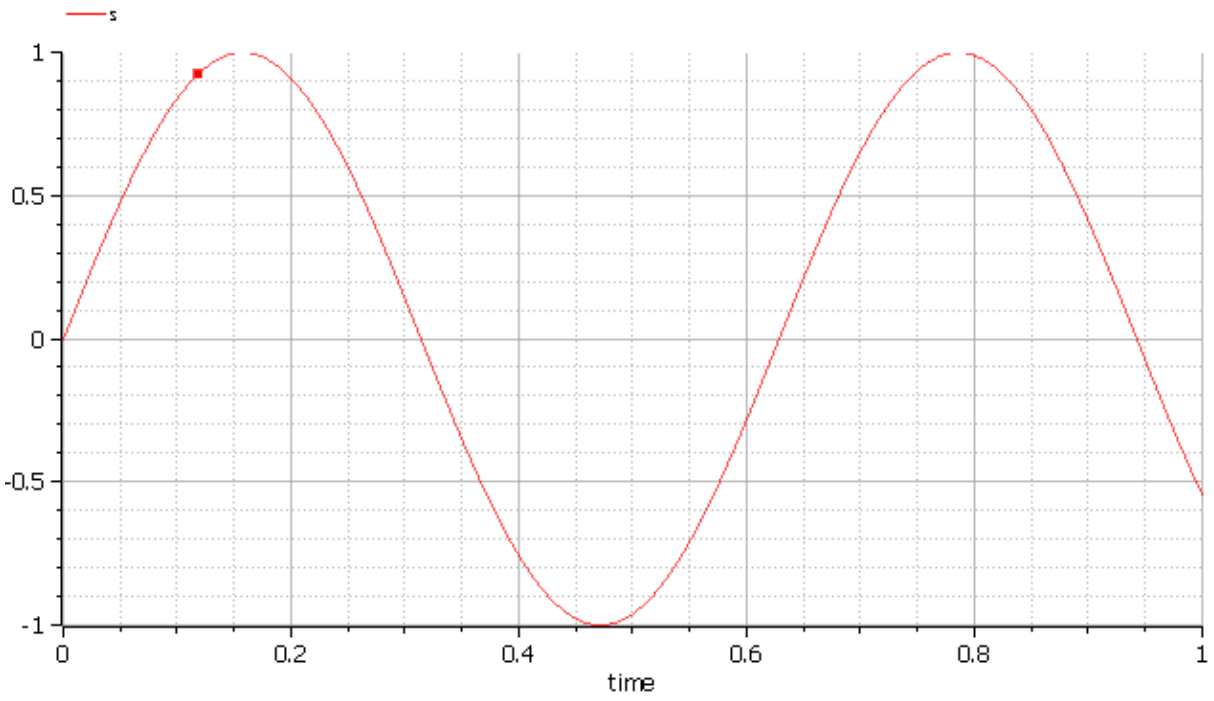
The OMMatlab package contains the following features:

- Import the OMMatlab package in Matlab
- Connect with the OpenModelica compiler through zmq sockets
- Able to interact with the OpenModelica compiler through the *available API*
- All the API calls are communicated with the help of the sendExpression method implemented in a Matlab pacakge
- The results are returned as strings

## 33.2 Test Commands

To get started, create a OMMatlab session object:

```
>>> import OMMatlab.*
>>> omc= OMMatlab()
>>> omc.sendExpression("getVersion()")
'v1.13.0-dev-531-gde26b558a (64-bit)'
>>> omc.sendExpression("loadModel(Modelica)")
'true'
>>> omc.sendExpression("model a Real s; equation s=sin(10*time); end a;")
'{a}'
>>> omc.sendExpression("simulate(a)")
>>> omc.sendExpression("plot(s)")
'true'
```




### 33.2.1 Advanced OMMatlab Features

OMMatlab package has advanced functionality for querying more information about the models and simulate them. A list of new user friendly API functionality allows user to extract information about models using matlab objects. A list of API functionality is described below.

To get started, create a ModelicaSystem object:

```
>>> import OMMatlab.*
>>> omc= OMMatlab()
>>> omc.ModelicaSystem("BouncingBall.mo","BouncingBall")
```

The object constructor requires a minimum of 2 input arguments which are strings, and third input argument which is optional .

- The first input argument must be a string with the file name of the Modelica code, with Modelica file extension ".mo". If the Modelica file is not in the current directory, then the file path must also be included.
- The second input argument must be a string with the name of the Modelica model including the namespace if the model is wrapped within a Modelica package.
- The third input argument (optional) is used to specify the list of dependent libraries or dependent Modelica files The argument can be passed as a string or array of strings e.g.,

```
>>> omc.ModelicaSystem("BouncingBall.mo","BouncingBall",["Modelica", "SystemDynamics",
↪ "dcmotor.mo"])
```

- The fourth input argument (optional), which is used to set the command line options e.g.,

```
>>> omc.ModelicaSystem("BouncingBall.mo","BouncingBall",["Modelica", "SystemDynamics",
↪ "dcmotor.mo"],"-d=newInst")
```

Matlab does not support keyword arguments, and hence inorder to skip an argument, empty list should be used "[]" e.g.,

```
>>> omc.ModelicaSystem("BouncingBall.mo","BouncingBall",[],"-d=newInst")
```

## 33.3 WorkDirectory

For each Matlab session a temporary work directory is created and the results are published in that working directory, Inorder to get the workdirectory the users can use the following API

```
>>> omc.getWorkDirectory()
'C:/Users/arupa54/AppData/Local/Temp/tp7dd648e5_5de6_4f66_b3d6_90bce1fe1d58'
```

## 33.4 BuildModel

The buildModel API can be used after ModelicaSystem(), in case the model needs to be updated or additional simulationflags needs to be set using sendExpression()

```
>>> omc.buildModel()
```

## 33.5 Standard get methods

- getQuantities()
- showQuantities()
- getContinuous()
- getInputs()
- getOutputs()
- getParameters()
- getSimulationOptions()
- getSolutions()

Three calling possibilities are accepted using getXXX() where "XXX" can be any of the above functions (eg:) getParameters().

- getXXX() without input argument, returns a dictionary with names as keys and values as values.
- getXXX(S), where S is a string of names.
- getXXX(["S1","S2"]) where S1 and S1 are array of string elements

## 33.6 Usage of getMethods

```
>>> omc.getQuantities() // method-1, list of all variables from xml file
+----------+------------+--------------------------+--------------+------------+-------
↪----+---------------+-------+
| name     | changeable | description              | variability  | causality  | alias␣
↪    | aliasVariable | value |
+----------+------------+--------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'h'      | 'true'     | 'height of ball'         | 'continuous' | 'internal' |
↪'noAlias' | ''            | '1.0' |
+----------+------------+--------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'v'      | 'true'     | 'velocity of ball'       | 'continuous' | 'internal' |
↪'noAlias' | ''            | ''    |
+----------+------------+--------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'der(h)' | 'false'    | 'der(height of ball)'    | 'continuous' | 'internal' |
```

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```
↪'noAlias' | ''            | ''    |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'der(v)' | 'false'    | 'der(velocity of ball)' | 'continuous' | 'internal' |
↪'noAlias' | ''            | ''    |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
```

```
>>> omc.getQuantities("h") // method-2, to query information about single quantity
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| name     | changeable | description             | variability  | causality  | alias␣
↪    | aliasVariable | value |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'h'      | 'true'     | 'height of ball'        | 'continuous' | 'internal' |
↪'noAlias' | ''            | '1.0' |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
```

```
>>> omc.getQuantities(["h","v"]) // method-3, to query information about list of␣
↪quantity
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| name     | changeable | description             | variability  | causality  | alias␣
↪    | aliasVariable | value |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'h'      | 'true'     | 'height of ball'        | 'continuous' | 'internal' |
↪'noAlias' | ''            | '1.0' |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
| 'v'      | 'true'     | 'velocity of ball'      | 'continuous' | 'internal' |
↪'noAlias' | ''            | ''    |
+----------+------------+-------------------------+--------------+------------+-------
↪----+---------------+-------+
```

```
>>> omc.getContinuous() // method-1, returns struct of continuous variable
struct with fields:
  h     : '1.0'
  v     : ''
  der_h_: ''
  der_v_: ''
```

```
>>> omc.getContinuous(["h","v"])   // method-2, returns string array
"1.0"    ""
```

```
>>> omc.getInputs()
struct with no fields
```

```
>>> omc.getOutputs()
struct with no fields
```

```
>>> omc.getParameters()  // method-1
```

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```
struct with fields:
        e: '0.7'
        g: '9.810000000000001'
```

```
>>> omc.getParameters(["c","radius"]) // method-2
"0.7"  "9.810000000000001"
```

```
>>> omc.getSimulationOptions()  // method-1
struct with fields:
        startTime: '0'
         stopTime: '1'
         stepSize: '0.002'
        tolerance: '1e-006'
           solver: 'dassl'
```

```
>>> omc.getSimulationOptions(["stepSize","tolerance"]) // method-2
"0.002", "1e-006"
```

**The getSolution method can be used in two different ways.**

1. using default result filename
2. use the result filenames provided by user

This provides a way to compare simulation results and perform regression testing

```
>>> omc.getSolutions() // method-1 returns string arrays of simulation variables for␣
↪which results are available, the default result filename is taken
"time", "height", ""velocity", "der(height)", "der(velocity)", "c", "radius"
```

```
>>> omc.getSolutions(["time","h"])  // return list of cell arrays
1×2 cell array
{1×506 double}    {1×506 double}
```

```
>>> omc.getSolutions([],"c:/tmpbouncingBall.mat") // method-2 returns string arrays␣
↪of simulation variables for which results are available , the resulfile location is␣
↪provided by user
"time", "height", "velocity", "der(height)", "der(velocity)", "c", "radius"
```

```
>>> omc.getSolutions(["time","h"],"c:/tmpbouncingBall.mat") // return list of cell␣
↪arrays
1×2 cell array
{1×506 double}    {1×506 double}
```

## 33.7 Standard set methods

- setInputs()
- setParameters()
- setSimulationOptions()

Two setting possibilities are accepted using setXXXs(),where "XXX" can be any of above functions.

- setXXX("Name=value") string of keyword assignments
- setXXX(["Name1=value1","Name2=value2","Name3=value3"]) array of string of keyword assignments

## 33.8 Usage of setMethods

```
>>> omc.setInputs("cAi=1") // method-1
```

```
>>> omc.setInputs(["cAi=1","Ti=2"]) // method-2
```

```
>>> omc.setParameters("e=14") // method-1
```

```
>>> omc.setParameters(["e=14","g=10.8"]) // method-2 setting parameter value using␣
↪array of string
```

```
>>> omc.setSimulationOptions(["stopTime=2.0","tolerance=1e-08"])
```

## 33.9 Advanced Simulation

An example of how to do advanced simulation to set parameter values using set methods and finally simulate the "BouncingBall.mo" model is given below .

```
>>> omc.getParameters()
struct with fields:
        e: '0.7'
        g: '9.810000000000001'
```

```
>>> omc.setParameters(["e=0.9","g=9.83"])
```

To check whether new values are updated to model , we can again query the getParameters().

```
>>> omc.getParameters()
struct with fields:
    e: "0.9"
    g: "9.83"
```

Similary we can also use setInputs() to set a value for the inputs during various time interval can also be done using the following.

```
>>> omc.setInputs("cAi=1")
```

**The model can be simulated using the *simulate* API in the following ways,**

1. without any arguments
2. resultfile names provided by user (only filename is allowed and not the location)
3. simflags - runtime simulationflags supported by OpenModelica

```
>>> omc.simulate() // method-1 default result file name will be used
>>> omc.simulate("tmpbouncingBall.mat") // method-2 resultfile name provided by users
>>> omc.simulate([],"-noEventEmit -noRestart -override=e=0.3,g=9.71") // method-3␣
↪simulationflags provided by users, since matlab does not support keyword argument␣
↪we skip argument1 result file with empty list
```

## 33.10 Linearization

The following methods are available for linearization of a modelica model

- linearize()

- getLinearizationOptions()
- setLinearizationOptions()
- getLinearInputs()
- getLinearOutputs()
- getLinearStates()

## 33.11 Usage of Linearization methods

```
>>> omc.getLinearizationOptions()  // method-1
```

```
>>> omc.getLinearizationOptions(["startTime","stopTime"]) // method-2
"0.0", "1.0"
```

```
>>> omc.setLinearizationOptions(["stopTime=2.0","tolerance=1e-08"])
```

```
>>> omc.linearize()  //returns a list 2D arrays (matrices) A, B, C and D.
```

```
>>> omc.getLinearInputs()  //returns a list of strings of names of inputs used when␣
↪forming matrices.
```

```
>>> omc.getLinearOutputs() //returns a list of strings of names of outputs used when␣
↪forming matrices.
```

```
>>> omc.getLinearStates() // returns a list of strings of names of states used when␣
↪forming matrices.
```

CHAPTER

# THIRTYFOUR

# OMJULIA - OPENMODELICA JULIA SCRIPTING

OMJulia - the OpenModelica Julia API is a free, open source, highly portable Julia based interactive session handler for Julia scripting of OpenModelica API functionality. It provides the modeler with components for creating a complete Julia-Modelica modeling, compilation and simulation environment based on the latest OpenModelica implementation and Modelica library standard available. OMJulia is architectured to combine both the solving strategy and model building. Thus, domain experts (people writing the models) and computational engineers (people writing the solver code) can work on one unified tool that is industrially viable for optimization of Modelica models, while offering a flexible platform for algorithm development and research. OMJulia is not a standalone package, it depends upon the OpenModelica installation.

OMJulia.jl is implemented in Julia and depends on ZeroMQ - high performance asynchronous messaging library.

The latest OMJulia.jl documentation can be found online: OMJulia.jl documentation

CHAPTER

# THIRTYFIVE

# JUPYTER-OPENMODELICA

An OpenModelica Kernel for Jupyter Notebook. All commands are interpreted by OMPython which communicates with OpenModelica Compiler and the results are presented to user.

The project is available at https://github.com/OpenModelica/jupyter-openmodelica.

Follow the Readme file to install and start running modelica models directly in Jupyter Notebook

CHAPTER

# THIRTYSIX

# SCRIPTING API

The following are short summaries of OpenModelica scripting commands. These commands are useful for loading and saving classes, reading and storing data, plotting of results, and various other tasks.

The arguments passed to a scripting function should follow syntactic and typing rules for Modelica and for the scripting function in question. In the following tables we briefly indicate the types or character of the formal parameters to the functions by the following notation:

- String typed argument, e.g. "hello", "myfile.mo".
- **TypeName - class, package or function name, e.g. MyClass,** Modelica.Math.
- VariableName - variable name, e.g. `v1`, `v2`, `vars1[2].x`, etc.
- Integer or Real typed argument, e.g. 35, 3.14, xintvariable.
- options - optional parameters with named formal parameter passing.

## 36.1 OpenModelica Scripting Commands

The following are brief descriptions of the scripting commands available in the OpenModelica environment. See also https://build.openmodelica.org/Documentation/OpenModelica.Scripting.html. All commands are shown in alphabetical order:

### 36.1.1 interactiveDumpAbsynToJL

Dumps the AST into a Julia representation.

```
function interactiveDumpAbsynToJL
  output String res;
end interactiveDumpAbsynToJL;
```

### 36.1.2 relocateFunctions

Update symbols in the running program to ones defined in the given shared object.

```
function relocateFunctions
  input String fileName;
  input String names[:, 2];
  output Boolean success;
end relocateFunctions;
```

### 36.1.3 GC_expand_hp

Forces the GC to expand the heap to accomodate more data.

```
function GC_expand_hp
  input Integer size;
  output Boolean success;
end GC_expand_hp;
```

### 36.1.4 GC_gcollect_and_unmap

Forces the GC to collect and unmap memory.

### 36.1.5 GC_get_prof_stats

Returns a record with the GC statistics.

```
function GC_get_prof_stats
  output GC_PROFSTATS gcStats;
end GC_get_prof_stats;
```

### 36.1.6 GC_set_max_heap_size

Forces the GC to limit the maximum heap size.

```
function GC_set_max_heap_size
  input Real size "In bytes; a Real so that sizes past 2^31 fit";
  output Boolean success;
end GC_set_max_heap_size;
```

### 36.1.7 addClassAnnotation

Adds an annotation to a class.

```
function addClassAnnotation
  input TypeName class_;
  input ExpressionOrModification annotate;
  output Boolean bool;
end addClassAnnotation;
```

### 36.1.8 addComponent

Adds a component to the given class.

```
function addComponent
  input TypeName componentName;
  input TypeName typeName;
  input TypeName classPath;
  input Expression binding = $Code(());
  input ExpressionOrModification modification = $Code();
  input Expression comment = $Code(());
  input Expression annotate = $Code(());
  output Boolean success;
end addComponent;
```

### 36.1.9 addConnection

Adds a connection to the given class.

```
function addConnection
  input VariableName connector1;
  input VariableName connector2;
  input TypeName className;
  input Expression comment = $Code(());
  input Expression annotate = $Code(());
  output Boolean success;
end addConnection;
```

### 36.1.10 addEquation

Adds an equation to a class.

```
function addEquation
  input TypeName className "The name of the class to add the equation to";
  input String eq "The equation given as a string";
  input Boolean isInitial = false "Whether the equation should be added as an initial␣
↪or normal equation";
  output Boolean success "true if the equation could be added, otherwise false";
end addEquation;
```

### 36.1.11 addInitialState

Adds an initial state to a class.

```
function addInitialState
  input TypeName cl;
  input String state;
  input ExpressionOrModification annotate;
  output Boolean bool;
end addInitialState;
```

### 36.1.12 addTransition

Adds a transition to a class.

```
function addTransition
  input TypeName cl;
  input String from;
  input String to;
  input String condition;
  input Boolean immediate = true;
  input Boolean reset = true;
  input Boolean synchronize = false;
  input Integer priority = 1;
  input ExpressionOrModification annotate;
  output Boolean bool;
end addTransition;
```

### 36.1.13 alarm

Schedules an alarm signal for the process.

```
impure function alarm
  input Integer seconds;
  output Integer previousSeconds;
end alarm;
```

### 36.1.14 appendEnvironmentVar

Appends a variable to the environment variables list.

```
function appendEnvironmentVar
  input String var;
  input String value;
  output String result "returns \"error\" if the variable could not be appended";
end appendEnvironmentVar;
```

### 36.1.15 basename

Returns the base name (file part) of a file path.

```
function basename
  input String path;
  output String basename;
end basename;
```

### 36.1.16 buildEncryptedPackage

Builds an encrypted package for a class.

```
function buildEncryptedPackage
  input TypeName className "the class that should encrypted";
  input Boolean encrypt = true;
  output Boolean success;
end buildEncryptedPackage;
```

### 36.1.17 buildLabel

Calls buildModel with the --generateLabeledSimCode flag enabled.

```
function buildLabel
  input TypeName className "the class that should be built";
  input Real startTime = 0.0 "the start time of the simulation. <default> = 0.0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "dassl" "integration method used for simulation. <default> =␣
↪dassl";
  input String fileNamePrefix = "" "fileNamePrefix. <default> = \"\"";
  input String options = "" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "" "cflags. <default> = \"\"";
  input String simflags = "" "simflags. <default> = \"\"";
  output String[2] buildModelResults;
end buildLabel;
```

### 36.1.18 buildModel

Translates a Modelica model into C code and builds a simulation executable.

```
function buildModel
  input TypeName className "the class that should be built";
  input Real startTime = "<default>" "the start time of the simulation. <default> = 0.
↪0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "<default>" "integration method used for simulation. <default>
↪ = dassl";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"\"";
  input String options = "<default>" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "<default>" "cflags. <default> = \"\"";
  input String simflags = "<default>" "simflags. <default> = \"\"";
  output String[2] buildModelResults;
end buildModel;
```

### 36.1.19 buildModelFMU

Translates a Modelica model into a Functional Mockup Unit.

```
function buildModelFMU
  input TypeName className "the class that should translated";
  input String version = "2.0" "FMU version, 1.0 or 2.0.";
  input String fmuType = "me" "FMU type, me (model exchange), cs (co-simulation), me_
↪cs (both model exchange and co-simulation)";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"className\"
↪";
  input String platforms[:] = {"static"} "The list of platforms to generate code for.
                                          \"dynamic\"=current platform, dynamically␣
↪link the runtime.
                                          \"static\"=current platform, statically␣
↪link everything.
                                          \"<cpu>-<vendor>-<os>\", host tripple, e.
↪g. \"x86_64-linux-gnu\" or \"x86_64-w64-mingw32\".
                                          \"<cpu>-<vendor>-<os> docker run ghcr.io/
↪openmodelica/crossbuild:v1.28.0\" host triple with OpenModelica supplied Docker␣
↪image, e.g. \"x86_64-linux-gnu docker run ghcr.io/openmodelica/crossbuild:v1.28.0\".
                                          \"<cpu>-<vendor>-<os> docker run <image>\
↪" host triple with Docker image, e.g. \"x86_64-linux-gnu docker run --pull=never␣
↪multiarch/crossbuild\"";
  input Boolean includeResources = false "Depreacted and no effect";
  input String method = "<default>" "integration method embedded in a Co-Simulation␣
↪FMU. <default> = dassl";
  output String generatedFileName "Returns the full path of the generated FMU.";
end buildModelFMU;
```

### 36.1.20 cd

Changes the working directory.

```
function cd
  input String newWorkingDirectory = "";
```

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```
  output String workingDirectory;
end cd;
```

### 36.1.21 checkAllModelsRecursive

Checks all models recursively and returns number of variables and equations.

```
function checkAllModelsRecursive
  input TypeName className;
  input Boolean checkProtected = false "Checks also protected classes if true";
  output String result;
end checkAllModelsRecursive;
```

### 36.1.22 checkCodeGraph

Checks if the given taskgraph has the same structure as the graph described in the codefile.

```
function checkCodeGraph
  input String graphfile;
  input String codefile;
  output String[:] result;
end checkCodeGraph;
```

### 36.1.23 checkInterfaceOfPackages

Checks the interfaces of MetaModelica packages.

```
function checkInterfaceOfPackages
  input TypeName cl;
  input String dependencyMatrix[:, :];
  output Boolean success;
end checkInterfaceOfPackages;
```

### 36.1.24 checkModel

Checks a model and returns the number of variables and equations.

```
function checkModel
  input TypeName className;
  output String result;
end checkModel;
```

### 36.1.25 checkSettings

Display some diagnostics.

```
function checkSettings
  output CheckSettingsResult result;
end checkSettings;
```

### 36.1.26 checkTaskGraph

Checks if the given taskgraph has the same structure as the reference taskgraph and if all attributes are set correctly.

```
function checkTaskGraph
  input String filename;
  input String reffilename;
  output String[:] result;
end checkTaskGraph;
```

### 36.1.27 classAnnotationExists

Checks if an annotation exists in a class.

```
function classAnnotationExists
  input TypeName className;
  input TypeName annotationName;
  output Boolean exists;
end classAnnotationExists;
```

### 36.1.28 clear

Clears loaded classes and user defined variables.

```
function clear
  output Boolean success;
end clear;
```

### 36.1.29 clearCommandLineOptions

Resets all command line options to their default values.

```
function clearCommandLineOptions
  output Boolean success;
end clearCommandLineOptions;
```

### 36.1.30 clearDebugFlags

Resets all debug flags to their default values.

```
function clearDebugFlags
  output Boolean success;
end clearDebugFlags;
```

### 36.1.31 clearMessages

Clears the error buffer.

```
function clearMessages
  output Boolean success;
end clearMessages;
```

### 36.1.32 clearProgram

Clears loaded classes.

```
function clearProgram
  output Boolean success;
end clearProgram;
```

### 36.1.33 clearVariables

Clears all user defined variables.

```
function clearVariables
  output Boolean success;
end clearVariables;
```

### 36.1.34 closeSimulationResultFile

Closes the current simulation results file.

```
function closeSimulationResultFile
  output Boolean success;
end closeSimulationResultFile;
```

### 36.1.35 codeToString

Converts a $Code expression to a string.

```
function codeToString
  input $Code className;
  output String string;
end codeToString;
```

### 36.1.36 compareFiles

Checks if two files are equal or not.

```
impure function compareFiles
  input String file1;
  input String file2;
  output Boolean isEqual;
end compareFiles;
```

### 36.1.37 compareFilesAndMove

Overwrites a file with another if they differ.

```
impure function compareFilesAndMove
  input String newFile;
  input String oldFile;
  output Boolean success;
end compareFilesAndMove;
```

### 36.1.38 convertPackageToLibrary

Runs the conversion script for a library on a selected package.

```
function convertPackageToLibrary
  input TypeName packageToConvert;
  input TypeName library;
  input String libraryVersion;
  output Boolean success;
end convertPackageToLibrary;
```

### 36.1.39 convertUnits

Gets conversion factors for two units.

```
function convertUnits
  input String s1;
  input String s2;
  output Boolean unitsCompatible;
  output Real scaleFactor;
  output Real offset;
end convertUnits;
```

### 36.1.40 copy

Copies a file.

```
function copy
  input String source;
  input String destination;
  output Boolean success;
end copy;
```

### 36.1.41 copyClass

Copies a class within the same level.

```
function copyClass
  input TypeName className "the class that should be copied";
  input String newClassName "the name for new class";
  input TypeName withIn = $Code(__OpenModelica_TopLevel) "the within path for new␣
↪class";
  output Boolean result;
end copyClass;
```

### 36.1.42 countMessages

Returns the number of buffered messages.

```
function countMessages
  output Integer numMessages;
  output Integer numErrors;
  output Integer numWarnings;
end countMessages;
```

### 36.1.43 createModel

Creates a new empty model.

```
function createModel
  input TypeName className;
  output Boolean success;
end createModel;
```

### 36.1.44 deleteClass

Unloads a class.

```
function deleteClass
  input TypeName className;
  output Boolean success;
end deleteClass;
```

### 36.1.45 deleteComponent

Deletes a component from the given class.

```
function deleteComponent
  input TypeName componentName;
  input TypeName classPath;
  output Boolean success;
end deleteComponent;
```

### 36.1.46 deleteConnection

Deletes a connection in the given class.

```
function deleteConnection
  input VariableName connector1;
  input VariableName connector2;
  input TypeName className;
  output Boolean success;
end deleteConnection;
```

### 36.1.47 deleteEquation

Deletes an equation in a class.

### 36.1.48 deleteFile

Deletes a file with the given name.

```
function deleteFile
  input String fileName;
  output Boolean success;
end deleteFile;
```

### 36.1.49 deleteInitialState

Deletes an initial state in a class.

```
function deleteInitialState
  input TypeName cl;
  input String state;
  output Boolean bool;
end deleteInitialState;
```

### 36.1.50 deleteTransition

Deletes a transition from a class.

```
function deleteTransition
  input TypeName cl;
  input String from;
```

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```
  input String to;
  input String condition;
  input Boolean immediate;
  input Boolean reset;
  input Boolean synchronize;
  input Integer priority;
  output Boolean bool;
end deleteTransition;
```

### 36.1.51 deltaSimulationResults

Calculates the sum of absolute errors.

```
function deltaSimulationResults
  input String filename;
  input String reffilename;
  input String method "method to compute then error. choose 1norm, 2norm, maxerr";
  input String[:] vars = fill("", 0);
  output Real result;
end deltaSimulationResults;
```

### 36.1.52 diffModelicaFileListings

Creates diffs of two strings corresponding to Modelica files

```
function diffModelicaFileListings
  input String before;
  input String after;
  input DiffFormat diffFormat = DiffFormat.color;
  input Boolean failOnSemanticsChange = false "Defaults to returning after instead of␣
↪hard fail";
  output String result;
end diffModelicaFileListings;
```

### 36.1.53 diffSimulationResults

Compares simulation results.

```
function diffSimulationResults
  input String actualFile;
  input String expectedFile;
  input String diffPrefix;
  input Real relTol = 1e-3 "y tolerance";
  input Real relTolDiffMinMax = 1e-4 "y tolerance based on the difference between the␣
↪maximum and minimum of the signal";
  input Real rangeDelta = 0.002 "x tolerance";
  input String[:] vars = fill("", 0);
  input Boolean keepEqualResults = false;
  output Boolean success;
  output String[:] failVars;
end diffSimulationResults;
```

### 36.1.54 diffSimulationResultsHtml

Compares simulation results and generates an HTML report.

```
function diffSimulationResultsHtml
  input String var;
  input String actualFile;
  input String expectedFile;
  input Real relTol = 1e-3 "y tolerance";
  input Real relTolDiffMinMax = 1e-4 "y tolerance based on the difference between the␣
↪maximum and minimum of the signal";
  input Real rangeDelta = 0.002 "x tolerance";
  output String html;
end diffSimulationResultsHtml;
```

### 36.1.55 directoryExists

Returns whether the given directory exists or not.

```
function directoryExists
  input String dirName;
  output Boolean exists;
end directoryExists;
```

### 36.1.56 dirname

Returns the directory name of a file path.

```
function dirname
  input String path;
  output String dirname;
end dirname;
```

### 36.1.57 disableNewInstantiation

Disables the new (default) instantiation.

```
function disableNewInstantiation
  output Boolean success;
end disableNewInstantiation;
```

### 36.1.58 dumpXMLDAE

Outputs the DAE system corresponding to a specific model.

```
function dumpXMLDAE
  input TypeName className;
  input String translationLevel = "flat" "flat, optimiser, backEnd, or stateSpace";
  input Boolean addOriginalAdjacencyMatrix = false;
  input Boolean addSolvingInfo = false;
  input Boolean addMathMLCode = false;
  input Boolean dumpResiduals = false;
  input String fileNamePrefix = "<default>" "this is the className in string form by␣
↪default";
  input String rewriteRulesFile = "" "the file from where the rewiteRules are read,␣
↪default is empty which means no rewrite rules";
  output Boolean success "if the function succeeded true/false";
```

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```
  output String xmlfileName "the Xml file";
end dumpXMLDAE;
```

### 36.1.59 echo

Turns interactive output on or off.

```
function echo
  input Boolean setEcho;
  output Boolean newEcho;
end echo;
```

### 36.1.60 enableNewInstantiation

Enables the new (default) instantiation.

```
function enableNewInstantiation
  output Boolean success;
end enableNewInstantiation;
```

### 36.1.61 escapeXML

Replaces characters in a string with XML escape characters.

```
function escapeXML
  input String inStr;
  output String outStr;
end escapeXML;
```

### 36.1.62 evaluateProbe

```
function evaluateProbe
  input String fileName "A file whose classes are loaded.";
  input String nodeId "The id of a node of getProbeTree.";
  input String property "One of the properties of the node.";
  input String contextModel = "" "The model translated for the simulation properties,␣
↪the model the node is in if empty.";
  input Boolean prettyPrint = false;
  output String result;
end evaluateProbe;
```

### 36.1.63 existClass

Returns whether the given class exists or not.

```
function existClass
  input TypeName cl;
  output Boolean exists;
end existClass;
```

### 36.1.64 existModel

Returns whether the given model exists or not.

### 36.1.65 existPackage

Returns whether the given package exists or not.

### 36.1.66 exit

Forces omc to quit with the given exit status.

```
function exit
  input Integer status;
end exit;
```

### 36.1.67 exportToFigaro

Exports a model to a Figaro database.

```
function exportToFigaro
  input TypeName path;
  input String directory = cd();
  input String database;
  input String mode;
  input String options;
  input String processor;
  output Boolean success;
end exportToFigaro;
```

### 36.1.68 extendsFrom

Returns true if the given class extends from the given base class.

```
function extendsFrom
  input TypeName className;
  input TypeName baseClassName;
  output Boolean res;
end extendsFrom;
```

### 36.1.69 filterSimulationResults

Creates a simulation results file with selected variables.

```
function filterSimulationResults
  input String inFile;
  input String outFile;
  input String[:] vars;
  input Integer numberOfIntervals = 0 "0=Do not resample";
  input Boolean removeDescription = false;
  input Boolean hintReadAllVars = true;
  output Boolean success;
end filterSimulationResults;
```

### 36.1.70 generateCode

Generates code for a function.

```
function generateCode
  input TypeName className;
  output Boolean success;
end generateCode;
```

### 36.1.71 generateEntryPoint

Generates an entry point for a MetaModelica program.

```
function generateEntryPoint
  input String fileName;
  input TypeName entryPoint;
  input String url = "https://trac.openmodelica.org/OpenModelica/newticket";
end generateEntryPoint;
```

### 36.1.72 generateHeader

Generates header file for external MetaModelica functions.

```
function generateHeader
  input String fileName;
  output Boolean success;
end generateHeader;
```

### 36.1.73 generateScriptingAPI

Generates the scripting API.

```
function generateScriptingAPI
  input TypeName cl;
  input String name;
  output Boolean success;
  output String moFile;
  output String qtFile;
  output String qtHeader;
end generateScriptingAPI;
```

### 36.1.74 generateSeparateCode

Generates code for a MetaModelica package.

```
function generateSeparateCode
  input TypeName className;
  input Boolean cleanCache = false "If true, the cache is reset between each␣
↪generated package. This conserves memory at the cost of speed.";
  output Boolean success;
end generateSeparateCode;
```

### 36.1.75 generateSeparateCodeDependencies

Generates dependencies for a MetaModelica package.

```
function generateSeparateCodeDependencies
  input String stampSuffix = ".c" "Suffix to add to dependencies (often .c.stamp)";
  output String[:] dependencies;
end generateSeparateCodeDependencies;
```

### 36.1.76 generateSeparateCodeDependenciesMakefile

Generates dependencies Makefile for a MetaModelica package.

```
function generateSeparateCodeDependenciesMakefile
  input String filename "The file to write the makefile to";
  input String directory = "" "The relative path of the generated files";
  input String suffix = ".c" "Often .stamp since we do not update all the files";
  output Boolean success;
end generateSeparateCodeDependenciesMakefile;
```

### 36.1.77 generateVerificationScenarios

Generate scenarios for a verification model.

```
function generateVerificationScenarios
  input TypeName path;
  output Boolean success;
end generateVerificationScenarios;
```

### 36.1.78 getAlgorithmCount

Counts the number of algorithm sections in a class.

```
function getAlgorithmCount
  input TypeName class_;
  output Integer count;
end getAlgorithmCount;
```

### 36.1.79 getAlgorithmItemsCount

Counts the number of algorithm statements in a class.

```
function getAlgorithmItemsCount
  input TypeName class_;
  output Integer count;
end getAlgorithmItemsCount;
```

### 36.1.80 getAllSubtypeOf

Returns the list of all classes that extend from className given a parentClass where the lookup for className should start

```
function getAllSubtypeOf
  input TypeName className;
  input TypeName parentClass = $Code(AllLoadedClasses);
  input Boolean qualified = false "Not implemented";
  input Boolean includePartial = false;
  input Boolean sort = false;
  output TypeName classNames[:];
end getAllSubtypeOf;
```

### 36.1.81 getAnnotationCount

Counts the number of annotation sections in a class.

```
function getAnnotationCount
  input TypeName class_;
  output Integer count;
end getAnnotationCount;
```

### 36.1.82 getAnnotationModifierValue

Returns the value for a modifier in the given annotation.

```
function getAnnotationModifierValue
  input TypeName className;
  input String annotationName;
  input String modifierName;
  output String modifierValue;
end getAnnotationModifierValue;
```

### 36.1.83 getAnnotationNamedModifiers

Returns the names of the modifiers in the given annotation.

```
function getAnnotationNamedModifiers
  input TypeName className;
  input String annotationName;
  output String[:] modifierNames;
end getAnnotationNamedModifiers;
```

### 36.1.84 getAnnotationVersion

Returns the current annotation version.

```
function getAnnotationVersion
  output String annotationVersion;
end getAnnotationVersion;
```

### 36.1.85 getAvailableIndexReductionMethods

Returns the currently available index reduction methods.

```
function getAvailableIndexReductionMethods
  output String[:] allChoices;
  output String[:] allComments;
end getAvailableIndexReductionMethods;
```

### 36.1.86 getAvailableLibraries

Returns a list of all available libraries.

```
function getAvailableLibraries
  output String[:] libraries;
end getAvailableLibraries;
```

### 36.1.87 getAvailableLibraryVersions

Returns the installed versions of a library.

```
function getAvailableLibraryVersions
  input TypeName libraryName;
  output String[:] librariesAndVersions;
end getAvailableLibraryVersions;
```

### 36.1.88 getAvailableMatchingAlgorithms

Returns the available matching algorithms.

```
function getAvailableMatchingAlgorithms
  output String[:] allChoices;
  output String[:] allComments;
end getAvailableMatchingAlgorithms;
```

### 36.1.89 getAvailablePackageConversionsFrom

Returns the versions that provide conversion from the requested version of the library.

```
function getAvailablePackageConversionsFrom
  input TypeName pkg;
  input String version;
  output String[:] convertsTo;
end getAvailablePackageConversionsFrom;
```

### 36.1.90 getAvailablePackageConversionsTo

Returns the versions that provide conversion to the requested version of the library.

```
function getAvailablePackageConversionsTo
  input TypeName pkg;
  input String version;
  output String[:] convertsTo;
end getAvailablePackageConversionsTo;
```

### 36.1.91 getAvailablePackageVersions

Returns the versions that provide the requested version of the library.

```
function getAvailablePackageVersions
  input TypeName pkg;
  input String version;
  output String[:] withoutConversion;
end getAvailablePackageVersions;
```

### 36.1.92 getAvailableTearingMethods

Returns the available tearing methods.

```
function getAvailableTearingMethods
  output String[:] allChoices;
  output String[:] allComments;
end getAvailableTearingMethods;
```

### 36.1.93 getBooleanClassAnnotation

Checks if an annotation exists and returns its value

```
function getBooleanClassAnnotation
  input TypeName className;
  input TypeName annotationName;
  output Boolean value;
end getBooleanClassAnnotation;
```

### 36.1.94 getBuiltinType

Returns the builtin type e.g Real, Integer, Boolean & String of the class.

```
function getBuiltinType
  input TypeName cl;
  output String name;
end getBuiltinType;
```

### 36.1.95 getCFlags

Returns the C compiler flags (CFLAGS) used for simulation code.

```
function getCFlags
  output String outString;
end getCFlags;
```

### 36.1.96 getCXXCompiler

Returns the C++ compiler (CXX) used for simulation code.

```
function getCXXCompiler
  output String compiler;
end getCXXCompiler;
```

### 36.1.97 getClassComment

Returns a class's comment.

```
function getClassComment
  input TypeName cl;
  output String comment;
end getClassComment;
```

### 36.1.98 getClassDiagram

```
function getClassDiagram
  input TypeName className;
  input String fileName = "" "The file to write the diagram to, if not empty.";
  input String format = "plantuml" "plantuml, mermaid or drawio.";
  input Integer depth = 1 "How many levels of used classes to include.";
  input String exclude[:] = {"Modelica.Icons"} "Classes and packages to leave out.";
  input Boolean showModifiers = true;
  output String diagram "The diagram, or the file name if it was written to a file.";
end getClassDiagram;
```

### 36.1.99 getClassInformation

Returns information about a class.

```
function getClassInformation
  input TypeName cl;
  output String restriction, comment;
  output Boolean partialPrefix, finalPrefix, encapsulatedPrefix;
  output String fileName;
  output Boolean fileReadOnly;
  output Integer lineNumberStart, columnNumberStart, lineNumberEnd, columnNumberEnd;
```

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```
  output String dimensions[:];
  output Boolean isProtectedClass;
  output Boolean isDocumentationClass;
  output String version;
  output String preferredView;
  output Boolean state;
  output String access;
  output String versionDate;
  output String versionBuild;
  output String dateModified;
  output String revisionId;
end getClassInformation;
```

### 36.1.100 getClassNames

Returns the list of class names defined in the class.

```
function getClassNames
  input TypeName class_ = $Code(AllLoadedClasses);
  input Boolean recursive = false;
  input Boolean qualified = false;
  input Boolean sort = false;
  input Boolean builtin = false "List also builtin classes if true";
  input Boolean showProtected = false "List also protected classes if true";
  input Boolean includeConstants = false "List also constants in the class if true";
  output TypeName classNames[:];
end getClassNames;
```

### 36.1.101 getClassRestriction

Returns the restriction of the given class.

```
function getClassRestriction
  input TypeName cl;
  output String restriction;
end getClassRestriction;
```

### 36.1.102 getCommandLineOptions

Returns all command line options who have non-default values as a list of strings.

```
function getCommandLineOptions
  output String[:] flags;
end getCommandLineOptions;
```

### 36.1.103 getCompiler

Returns the C compiler (CC) used for simulation code.

```
function getCompiler
  output String compiler;
end getCompiler;
```

### 36.1.104 getComponentAnnotations

Returns the annotations of the components in the given class.

```
function getComponentAnnotations
  input TypeName className;
  output Expression result;
end getComponentAnnotations;
```

### 36.1.105 getComponentComment

Returns the comment on a component.

```
function getComponentComment
  input TypeName className;
  input TypeName componentName;
  output String comment;
end getComponentComment;
```

### 36.1.106 getComponentCondition

Returns the condition of the given component in the given class as a string.

```
function getComponentCondition
  input TypeName className;
  input TypeName componentName;
  output String result;
end getComponentCondition;
```

### 36.1.107 getComponentCount

Returns the number of components in a class.

```
function getComponentCount
  input TypeName classPath;
  output Integer count;
end getComponentCount;
```

### 36.1.108 getComponentModifierNames

Returns the list of class component modifiers.

```
function getComponentModifierNames
  input TypeName class_;
  input String componentName;
  output String[:] modifiers;
end getComponentModifierNames;
```

### 36.1.109 getComponentModifierValue

Returns the binding equation of a component.

```
function getComponentModifierValue
  input TypeName class_;
  input TypeName modifier;
  output String value;
end getComponentModifierValue;
```

### 36.1.110 getComponentModifierValues

Returns the modifier for a component.

```
function getComponentModifierValues
  input TypeName class_;
  input TypeName modifier;
  output String value;
end getComponentModifierValues;
```

### 36.1.111 getComponents

Returns information about the component in a given class.

```
function getComponents
  input TypeName className;
  input Boolean useQuotes = false;
end getComponents;
```

### 36.1.112 getComponentsTest

Returns an array of records with information about the components of the given class.

```
function getComponentsTest
  input TypeName name;
  output Component[:] components;
  record Component
    String className "the type of the component";
    String name "the name of the component";
    String comment "the comment of the component";
    Boolean isProtected "true if component is protected";
    Boolean isFinal "true if component is final";
    Boolean isFlow "true if component is flow";
    Boolean isStream "true if component is stream";
    Boolean isReplaceable "true if component is replaceable";
    String variability "'constant', 'parameter', 'discrete', ''";
    String innerOuter "'inner', 'outer', ''";
    String inputOutput "'input', 'output', ''";
    String dimensions[:] "array with the dimensions of the component";
  end Component;
end getComponentsTest;
```

### 36.1.113 getConfigFlagValidOptions

Returns the list of valid options for a string config flag, and the description strings for these options if available.

```
function getConfigFlagValidOptions
  input String flag;
  output String validOptions[:];
  output String mainDescription;
  output String descriptions[:];
end getConfigFlagValidOptions;
```

### 36.1.114 getConnectionCount

Counts the number of connect equation in a class.

```
function getConnectionCount
  input TypeName className;
  output Integer count;
end getConnectionCount;
```

### 36.1.115 getConnectionList

Returns an list of all connect equations including those within loops

```
function getConnectionList
  input TypeName className;
  output String[:, :] result;
end getConnectionList;
```

### 36.1.116 getConnectorCount

Returns the number of public connectors in the given class.

```
function getConnectorCount
  input TypeName className;
  output Integer count;
end getConnectorCount;
```

### 36.1.117 getConversionsFromVersions

Returns the versions this library can convert from with and without conversions.

```
function getConversionsFromVersions
  input TypeName pack;
  output String[:] withoutConversion;
  output String[:] withConversion;
end getConversionsFromVersions;
```

### 36.1.118 getCrefInfo

Deprecated; use getClassInformation instead.

```
function getCrefInfo
  input TypeName cl;
  output Expression[:] result;
end getCrefInfo;
```

### 36.1.119 getDefUseChains

```
function getDefUseChains
  input TypeName className "A class, or a component declared in a class.";
  input String fileName = "" "The file to write the JSON to, if not empty.";
  input TypeName scope = $Code(AllLoadedClasses) "The class to look for the uses in.";
  input Boolean prettyPrint = false;
  output String chains "The JSON, or the file name if it was written to a file.";
end getDefUseChains;
```

### 36.1.120 getDefaultComponentName

Returns the default component name for a class.

```
function getDefaultComponentName
  input TypeName cl;
  output String name;
end getDefaultComponentName;
```

### 36.1.121 getDefaultComponentPrefixes

Returns the default component prefixes for a class.

```
function getDefaultComponentPrefixes
  input TypeName cl;
  output String prefixes;
end getDefaultComponentPrefixes;
```

### 36.1.122 getDefaultOpenCLDevice

Returns the id for the default OpenCL device to be used.

```
function getDefaultOpenCLDevice
  output Integer defdevid;
end getDefaultOpenCLDevice;
```

### 36.1.123 getDefinitionAt

```
function getDefinitionAt
  input String fileName "A file of a loaded class.";
  input Integer line;
  input Integer column "Starting at 1, counting bytes.";
  input Boolean prettyPrint = false;
  output String definition;
end getDefinitionAt;
```

### 36.1.124 getDependencyGraph

```
function getDependencyGraph
  input TypeName scope = $Code(AllLoadedClasses) "The classes to include.";
  input String fileName = "" "The file to write the JSON to, if not empty.";
  input Boolean prettyPrint = false;
  output String graph "The JSON, or the file name if it was written to a file.";
end getDependencyGraph;
```

### 36.1.125 getDerivedClassModifierNames

Returns a derived class's modifier names.

```
function getDerivedClassModifierNames
  input TypeName className;
  output String[:] modifierNames;
end getDerivedClassModifierNames;
```

### 36.1.126 getDerivedClassModifierValue

Returns a derived class's modifier value.

```
function getDerivedClassModifierValue
  input TypeName className;
  input TypeName modifierName;
  output String modifierValue;
end getDerivedClassModifierValue;
```

### 36.1.127 getDerivedUnits

Returns the list of derived units for the specified base unit.

```
function getDerivedUnits
  input String baseUnit;
  output String[:] derivedUnits;
end getDerivedUnits;
```

### 36.1.128 getDiagramAnnotation

Returns the Diagram annotation for a given class.

```
function getDiagramAnnotation
  input TypeName className;
  output Expression result;
end getDiagramAnnotation;
```

### 36.1.129 getDocumentationAnnotation

Returns the Documentation annotation defined in the class.

```
function getDocumentationAnnotation
  input TypeName cl;
  output String out[3] "{info,revision,infoHeader}";
end getDocumentationAnnotation;
```

### 36.1.130 getElementAnnotation

Returns the annotation on a component or class element as a string.

```
function getElementAnnotation
  input TypeName elementName;
  output String annotationString;
end getElementAnnotation;
```

### 36.1.131 getElementAnnotations

Returns the annotations of the components and short class definitions in the given class.

```
function getElementAnnotations
  input TypeName className;
  output Expression result;
end getElementAnnotations;
```

### 36.1.132 getElementModifierNames

Returns the list of element (component or short class) modifiers in a class.

```
function getElementModifierNames
  input TypeName className;
  input String elementName;
  output String[:] modifiers;
end getElementModifierNames;
```

### 36.1.133 getElementModifierValue

Returns the binding equation for an element.

```
function getElementModifierValue
  input TypeName className;
  input TypeName modifier;
  output String value;
end getElementModifierValue;
```

### 36.1.134 getElementModifierValues

Returns the modifier for an element.

```
function getElementModifierValues
  input TypeName className;
  input TypeName modifier;
  output String value;
end getElementModifierValues;
```

### 36.1.135 getElements

Returns information about the elements in a given class.

```
function getElements
  input TypeName className;
  input Boolean useQuotes = false;
end getElements;
```

### 36.1.136 getElementsInfo

Returns information about the elements in a given class.

```
function getElementsInfo
  input TypeName className;
  output Expression result;
end getElementsInfo;
```

### 36.1.137 getEnumerationLiterals

Returns the literals for a given enumeration type.

```
function getEnumerationLiterals
  input TypeName className;
  output String[:] result;
end getEnumerationLiterals;
```

### 36.1.138 getEnvironmentVar

Returns the value of the given environment variable.

```
function getEnvironmentVar
  input String var;
  output String value "returns empty string on failure";
end getEnvironmentVar;
```

### 36.1.139 getEquationCount

Counts the number of equation sections in a class.

```
function getEquationCount
  input TypeName class_;
  output Integer count;
end getEquationCount;
```

### 36.1.140 getEquationItemsCount

Counts the number of equations in a class.

```
function getEquationItemsCount
  input TypeName class_;
  output Integer count;
end getEquationItemsCount;
```

### 36.1.141 getErrorString

Returns current error messages.

```
impure function getErrorString
  input Boolean warningsAsErrors = false;
  output String errorString;
end getErrorString;
```

### 36.1.142 getExtendsModifierNames

Returns the names of the modifiers on an extends clause.

```
function getExtendsModifierNames
  input TypeName className;
  input TypeName extendsName;
  input Boolean useQuotes = false;
  output String modifiers;
end getExtendsModifierNames;
```

### 36.1.143 getExtendsModifierValue

Returns the modifier value for a modifier on an extends clause.

```
function getExtendsModifierValue
  input TypeName className;
  input TypeName extendsName;
  input TypeName modifierName;
  output Expression result;
end getExtendsModifierValue;
```

### 36.1.144 getExternalFunctionSpecification

Returns information about a function's external specification.

```
function getExternalFunctionSpecification
  input TypeName functionName;
  output Expression result;
end getExternalFunctionSpecification;
```

### 36.1.145 getExternalFunctions

Describes the external "C" functions of a library.

```
function getExternalFunctions
  input TypeName className;
  output String json;
end getExternalFunctions;
```

### 36.1.146 getHomeDirectoryPath

Returns the path to the current user's HOME directory.

```
function getHomeDirectoryPath
  output String homeDirectoryPath;
end getHomeDirectoryPath;
```

### 36.1.147 getIconAnnotation

Returns the Icon annotation for a given class.

```
function getIconAnnotation
  input TypeName className;
  output Expression result;
end getIconAnnotation;
```

### 36.1.148 getImportCount

Counts the number of import-clauses in a class.

```
function getImportCount
  input TypeName class_;
  output Integer count;
end getImportCount;
```

### 36.1.149 getImportedNames

Returns the definition names of all import-clauses in a class.

```
function getImportedNames
  input TypeName class_;
  output String[:] out_public;
  output String[:] out_protected;
end getImportedNames;
```

### 36.1.150 getIndexReductionMethod

Returns the currently used index reduction method.

```
function getIndexReductionMethod
  output String selected;
end getIndexReductionMethod;
```

### 36.1.151 getInheritanceCount

Returns the numbers of extends clauses in the given class.

```
function getInheritanceCount
  input TypeName className;
  output Integer count;
end getInheritanceCount;
```

### 36.1.152 getInheritedClasses

Returns the list of inherited classes in a class.

```
function getInheritedClasses
  input TypeName name;
  output TypeName inheritedClasses[:];
end getInheritedClasses;
```

### 36.1.153 getInitialAlgorithmCount

Counts the number of initial algorithm sections in a class.

```
function getInitialAlgorithmCount
  input TypeName class_;
  output Integer count;
end getInitialAlgorithmCount;
```

### 36.1.154 getInitialAlgorithmItemsCount

Counts the number of initial algorithm statements in a class.

```
function getInitialAlgorithmItemsCount
  input TypeName class_;
  output Integer count;
end getInitialAlgorithmItemsCount;
```

### 36.1.155 getInitialEquationCount

Counts the number of initial equation sections in a class.

```
function getInitialEquationCount
  input TypeName class_;
  output Integer count;
end getInitialEquationCount;
```

### 36.1.156 getInitialEquationItemsCount

Counts the number of initial equations in a class.

```
function getInitialEquationItemsCount
  input TypeName class_;
  output Integer count;
end getInitialEquationItemsCount;
```

### 36.1.157 getInitialStates

Returns a list of initial states in a class.

```
function getInitialStates
  input TypeName cl;
  output String[:, :] initialStates;
end getInitialStates;
```

### 36.1.158 getInstallationDirectoryPath

Returns the installation directory path.

```
function getInstallationDirectoryPath
  output String installationDirectoryPath;
end getInstallationDirectoryPath;
```

### 36.1.159 getInstanceDiagram

```
function getInstanceDiagram
  input TypeName className;
  input String fileName = "" "The file to write the diagram to, if not empty.";
  input String format = "plantuml" "plantuml, mermaid or drawio.";
  input Integer depth = 1 "How many levels of components to draw as boxes of their␣
↪own.";
  input String exclude[:] = fill("", 0) "Classes and packages whose instances are␣
↪left out.";
  input Boolean showConnections = true;
  input Boolean showProtected = false "Also show the protected elements.";
  input Boolean expandArrays = false "A box for each element of an array of␣
↪components.";
  output String diagram "The diagram, or the file name if it was written to a file.";
end getInstanceDiagram;
```

### 36.1.160 getInstantiatedParametersAndValues

Returns the top-level parameter names and values from the DAE.

```
function getInstantiatedParametersAndValues
  input TypeName cls;
  output String[:] values;
end getInstantiatedParametersAndValues;
```

### 36.1.161 getLanguageStandard

Returns the current Modelica Language Standard in use.

```
function getLanguageStandard
  output String outVersion;
end getLanguageStandard;
```

### 36.1.162 getLinker

Returns the linker (LINK) used for simulation code.

```
function getLinker
  output String linker;
end getLinker;
```

### 36.1.163 getLinkerFlags

Returns the linker flags (LDFLAGS) used for simulation code.

```
function getLinkerFlags
  output String linkerFlags;
end getLinkerFlags;
```

### 36.1.164 getLoadedLibraries

Returns the loaded libraries.

```
function getLoadedLibraries
  output String[:, 2] libraries;
end getLoadedLibraries;
```

### 36.1.165 getMMfileTotalDependencies

Returns imports for a MetaModelica package.

```
function getMMfileTotalDependencies
  input String in_package_name;
  input String public_imports_dir;
  output String[:] total_pub_imports;
end getMMfileTotalDependencies;
```

### 36.1.166 getMatchingAlgorithm

Returns the currently used matching algorithm.

```
function getMatchingAlgorithm
  output String selected;
end getMatchingAlgorithm;
```

### 36.1.167 getMemorySize

Returns the amount of system memory.

```
function getMemorySize
  output Real memory(unit = "MiB");
end getMemorySize;
```

### 36.1.168 getModelFigures

Returns the figures defined in the class' figures sub-annotation of Documentation.

```
function getModelFigures
  input TypeName name;
  output Figure[:] figures;
end getModelFigures;
```

### 36.1.169 getModelInstance

Dumps a model instance as a JSON string.

```
function getModelInstance
  input TypeName className;
  input TypeName context = $Code(__NoContext);
  input String modifier = "";
  input Boolean prettyPrint = false;
  output String result;
end getModelInstance;
```

### 36.1.170 getModelInstanceAnnotation

Dumps the annotation of a model using the same JSON format as getModelInstance.

```
function getModelInstanceAnnotation
  input TypeName className;
  input String[:] filter = fill("", 0);
  input Boolean prettyPrint = false;
  output String result;
end getModelInstanceAnnotation;
```

### 36.1.171 getModelInstanceAnnotationReference

Like getModelInstanceAnnotation, but returns an integer handle to an in-memory structure instead of a JSON string (see getModelInstanceReference).

```
function getModelInstanceAnnotationReference
  input TypeName className;
  input String[:] filter = fill("", 0);
  output Integer handle;
end getModelInstanceAnnotationReference;
```

### 36.1.172 getModelInstanceReference

Like getModelInstance, but returns an integer handle to an in-memory model instance structure instead of a JSON string (see issue #15219). The handle is intended to be read directly by an in-process client such as OMEdit and must be released with releaseModelInstanceReference. Returns 0 on failure.

```
function getModelInstanceReference
  input TypeName className;
  input TypeName context = $Code(__NoContext);
  input String modifier = "";
  output Integer handle;
end getModelInstanceReference;
```

### 36.1.173 getModelicaPath

Returns the Modelica library path.

```
function getModelicaPath
  output String modelicaPath;
end getModelicaPath;
```

### 36.1.174 getNamedAnnotation

Returns the value of the annotation with the given name in the given class.

```
function getNamedAnnotation
  input TypeName className;
  input TypeName annotationName;
  output Expression result;
end getNamedAnnotation;
```

### 36.1.175 getNoSimplify

Returns true if noSimplify flag is set.

```
function getNoSimplify
  output Boolean noSimplify;
end getNoSimplify;
```

### 36.1.176 getNthAlgorithm

Returns the n:th algorithm section in a class.

```
function getNthAlgorithm
  input TypeName class_;
  input Integer index;
  output String result;
end getNthAlgorithm;
```

### 36.1.177 getNthAlgorithmItem

Returns the n:th algorithm statement in a class.

```
function getNthAlgorithmItem
  input TypeName class_;
  input Integer index;
  output String result;
end getNthAlgorithmItem;
```

### 36.1.178 getNthAnnotationString

Returns the n:th annotation section as string.

```
function getNthAnnotationString
  input TypeName class_;
  input Integer index;
  output String result;
end getNthAnnotationString;
```

### 36.1.179 getNthComponent

Returns the type, name, and description string of the n:th component in the given class.

```
function getNthComponent
  input TypeName className;
  input Integer n;
  output Expression result;
end getNthComponent;
```

### 36.1.180 getNthComponentAnnotation

Returns the annotation for the n:th component in the given class.

```
function getNthComponentAnnotation
  input TypeName className;
  input Integer n;
  output Expression result;
end getNthComponentAnnotation;
```

### 36.1.181 getNthComponentCondition

Returns the condition for the n:th component in the given class as a string.

```
function getNthComponentCondition
  input TypeName className;
  input Integer n;
  output String result;
end getNthComponentCondition;
```

### 36.1.182 getNthComponentModification

Returns the modification for the n:th component in the given class.

```
function getNthComponentModification
  input TypeName className;
  input Integer n;
  output ExpressionOrModification result[:];
end getNthComponentModification;
```

### 36.1.183 getNthConnection

Returns the n:th connection.

```
function getNthConnection
  input TypeName className;
  input Integer index;
  output String[:] result;
end getNthConnection;
```

### 36.1.184 getNthConnectionAnnotation

Returns the annotation of the n:th connect clause in the class.

```
function getNthConnectionAnnotation
  input TypeName className;
  input Integer index;
  output Expression result;
end getNthConnectionAnnotation;
```

### 36.1.185 getNthConnector

Returns the name and type of the n:th public connector in the given class.

```
function getNthConnector
  input TypeName className;
  input Integer n;
```

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```
  output Expression result;
end getNthConnector;
```

### 36.1.186 getNthConnectorIconAnnotation

Returns the Icon annotation from the type of the n:th public connector in the given class.

```
function getNthConnectorIconAnnotation
  input TypeName className;
  input Integer n;
  output Expression result;
end getNthConnectorIconAnnotation;
```

### 36.1.187 getNthEquation

Returns the n:th equation section in a class.

```
function getNthEquation
  input TypeName class_;
  input Integer index;
  output String result;
end getNthEquation;
```

### 36.1.188 getNthEquationItem

Returns the n:th equation in a class.

```
function getNthEquationItem
  input TypeName class_;
  input Integer index;
  output String result;
end getNthEquationItem;
```

### 36.1.189 getNthImport

Returns the n:th import-clause.

```
function getNthImport
  input TypeName class_;
  input Integer index;
  output String out[3] "{\"Path\",\"Id\",\"Kind\"}";
end getNthImport;
```

### 36.1.190 getNthInheritedClass

Returns the name of the n:th inherited class in the given class.

```
function getNthInheritedClass
  input TypeName className;
  input Integer n;
  output TypeName baseClass;
end getNthInheritedClass;
```

### 36.1.191 getNthInheritedClassDiagramMapAnnotation

Returns the IconMap annotation for the n:th inherited class in the given class.

```
function getNthInheritedClassDiagramMapAnnotation
  input TypeName className;
  input Integer n;
  output Expression result;
end getNthInheritedClassDiagramMapAnnotation;
```

### 36.1.192 getNthInheritedClassIconMapAnnotation

Returns the IconMap annotation for the n:th inherited class in the given class.

```
function getNthInheritedClassIconMapAnnotation
  input TypeName className;
  input Integer n;
  output Expression result;
end getNthInheritedClassIconMapAnnotation;
```

### 36.1.193 getNthInitialAlgorithm

Returns the n:th initial algorithm section in a class.

```
function getNthInitialAlgorithm
  input TypeName class_;
  input Integer index;
  output String result;
end getNthInitialAlgorithm;
```

### 36.1.194 getNthInitialAlgorithmItem

Returns the n:th initial algorithm statement in a class.

```
function getNthInitialAlgorithmItem
  input TypeName class_;
  input Integer index;
  output String result;
end getNthInitialAlgorithmItem;
```

### 36.1.195 getNthInitialEquation

Returns the n:th initial equation section in a class.

```
function getNthInitialEquation
  input TypeName class_;
  input Integer index;
  output String result;
end getNthInitialEquation;
```

### 36.1.196 getNthInitialEquationItem

Returns the n:th initial equation in a class.

```
function getNthInitialEquationItem
  input TypeName class_;
  input Integer index;
```

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```
  output String result;
end getNthInitialEquationItem;
```

### 36.1.197 getOrderConnections

Returns true if orderConnections flag is set.

```
function getOrderConnections
  output Boolean orderConnections;
end getOrderConnections;
```

### 36.1.198 getPackages

Returns the list of packages defined in the class.

```
function getPackages
  input TypeName class_ = $Code(AllLoadedClasses);
  output TypeName classNames[:];
end getPackages;
```

### 36.1.199 getParameterNames

Returns the names of all parameters in a given class.

```
function getParameterNames
  input TypeName class_;
  output String[:] parameters;
end getParameterNames;
```

### 36.1.200 getParameterValue

Returns the value of a parameter of the class.

```
function getParameterValue
  input TypeName class_;
  input String parameterName;
  output String parameterValue;
end getParameterValue;
```

### 36.1.201 getProbeTree

```
function getProbeTree
  input String fileName "A file whose classes are loaded.";
  input Boolean prettyPrint = false;
  output String tree;
end getProbeTree;
```

### 36.1.202 getReplaceableChoices

Returns all replaceable choices for a class with choicesAllMatching.

```
function getReplaceableChoices
  input TypeName baseClass;
  input TypeName parentClass;
  input Boolean includePartial = false;
```

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```
  input Boolean sort = false;
  output String choices[:, :];
end getReplaceableChoices;
```

### 36.1.203 getSettings

Returns some settings.

```
function getSettings
  output String settings;
end getSettings;
```

### 36.1.204 getShortDefinitionBaseClassInformation

Returns information about a short class definition.

```
function getShortDefinitionBaseClassInformation
  input TypeName className;
  output Expression result;
end getShortDefinitionBaseClassInformation;
```

### 36.1.205 getShowAnnotations

Returns the value of the --showAnnotations flag.

```
function getShowAnnotations
  output Boolean show;
end getShowAnnotations;
```

### 36.1.206 getSimulationOptions

Returns the startTime, stopTime, tolerance, and interval based on the experiment annotation.

```
function getSimulationOptions
  input TypeName name;
  input Real defaultStartTime = 0.0;
  input Real defaultStopTime = 1.0;
  input Real defaultTolerance = 1e-6;
  input Integer defaultNumberOfIntervals = 500 "May be overridden by defining␣
↪defaultInterval instead";
  input Real defaultInterval = 0.0 "If = 0.0, then numberOfIntervals is used to␣
↪calculate the step size";
  output Real startTime;
  output Real stopTime;
  output Real tolerance;
  output Integer numberOfIntervals;
  output Real interval;
end getSimulationOptions;
```

### 36.1.207 getSourceFile

Returns the filename of the class.

```
function getSourceFile
  input TypeName class_;
```

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```
  output String filename "empty on failure";
end getSourceFile;
```

### 36.1.208 getTearingMethod

Returns the currently used tearing method.

```
function getTearingMethod
  output String selected;
end getTearingMethod;
```

### 36.1.209 getTempDirectoryPath

Returns the current user temporary directory location.

```
function getTempDirectoryPath
  output String tempDirectoryPath;
end getTempDirectoryPath;
```

### 36.1.210 getTimeStamp

Returns the timestamp for a class.

```
function getTimeStamp
  input TypeName cl;
  output Real timeStamp;
  output String timeStampAsString;
end getTimeStamp;
```

### 36.1.211 getTotalModel

Saves a model and dependencies to a single string.

```
function getTotalModel
  input TypeName className;
  input Boolean stripAnnotations = false;
  input Boolean stripComments = false;
  input Boolean obfuscate = false;
  output String result;
end getTotalModel;
```

### 36.1.212 getTransitions

Returns list of transitions for the given class.

```
function getTransitions
  input TypeName cl;
  output String[:, :] transitions;
end getTransitions;
```

### 36.1.213 getUsedClassNames

Returns the list of class names used in the total program defined by the class.

```
function getUsedClassNames
  input TypeName className;
  output TypeName classNames[:];
end getUsedClassNames;
```

### 36.1.214 getUses

Returns the libraries used by a package.

```
function getUses
  input TypeName pack;
  output String[:, :] uses;
end getUses;
```

### 36.1.215 getVectorizationLimit

Returns the vectorization limit used by the old frontend.

```
function getVectorizationLimit
  output Integer vectorizationLimit;
end getVectorizationLimit;
```

### 36.1.216 getVersion

Returns the version of the compiler or a Modelica library.

```
function getVersion
  input TypeName cl = $Code(OpenModelica);
  output String version;
end getVersion;
```

### 36.1.217 help

Display the OpenModelica help text.

```
function help
  input String topic = "topics";
  output String helpText;
end help;
```

### 36.1.218 iconv

Converts a string from one character encoding to another.

```
function iconv
  input String string;
  input String from;
  input String to = "UTF-8";
  output String result;
end iconv;
```

### 36.1.219 importFMU

Imports a Functional Mockup Unit.

```
function importFMU
  input String filename "the fmu file name";
  input String workdir = "<default>" "The output directory for imported FMU files.
↪<default> will put the files to current working directory.";
  input Integer loglevel = 3 "loglevel_nothing=0;loglevel_fatal=1;loglevel_error=2;
↪loglevel_warning=3;loglevel_info=4;loglevel_verbose=5;loglevel_debug=6";
  input Boolean fullPath = false "When true the full output path is returned␣
↪otherwise only the file name.";
  input Boolean debugLogging = false "When true the FMU's debug output is printed.";
  input Boolean generateInputConnectors = true "When true creates the input connector␣
↪pins.";
  input Boolean generateOutputConnectors = true "When true creates the output␣
↪connector pins.";
  input TypeName modelName = $Code(Default) "Name of the generated model. If default␣
↪then the name is auto generated using FMU information.";
  output String generatedFileName "Returns the full path of the generated file.";
end importFMU;
```

### 36.1.220 importFMUModelDescription

Imports modelDescription.xml

```
function importFMUModelDescription
  input String filename "the fmu file name";
  input String workdir = "<default>" "The output directory for imported FMU files.
↪<default> will put the files to current working directory.";
  input Integer loglevel = 3 "loglevel_nothing=0;loglevel_fatal=1;loglevel_error=2;
↪loglevel_warning=3;loglevel_info=4;loglevel_verbose=5;loglevel_debug=6";
  input Boolean fullPath = false "When true the full output path is returned␣
↪otherwise only the file name.";
  input Boolean debugLogging = false "When true the FMU's debug output is printed.";
  input Boolean generateInputConnectors = true "When true creates the input connector␣
↪pins.";
  input Boolean generateOutputConnectors = true "When true creates the output␣
↪connector pins.";
  output String generatedFileName "Returns the full path of the generated file.";
end importFMUModelDescription;
```

### 36.1.221 inferBindings

Update bindings for a verification model.

```
function inferBindings
  input TypeName path;
  output Boolean success;
end inferBindings;
```

### 36.1.222 installPackage

Installs a package.

```
function installPackage
  input TypeName pkg;
  input String version = "";
  input Boolean exactMatch = false;
  output Boolean result;
end installPackage;
```

### 36.1.223 installWasmToolchain

Installs the sysroot wasm external "C" code is compiled against.

```
function installWasmToolchain
  input Boolean cxx = false "Also libc++, for C++ code";
  output String sysroot;
end installWasmToolchain;
```

### 36.1.224 instantiateModel

Instantiates a model and returns the flattened model.

```
function instantiateModel
  input TypeName className;
  output String result;
end instantiateModel;
```

### 36.1.225 isBlock

Checks if a given class is a block.

```
function isBlock
  input TypeName cl;
  output Boolean b;
end isBlock;
```

### 36.1.226 isClass

Checks if a given class is a class.

```
function isClass
  input TypeName cl;
  output Boolean b;
end isClass;
```

### 36.1.227 isConnector

Checks if a given class is a connector or expandable connector.

```
function isConnector
  input TypeName cl;
  output Boolean b;
end isConnector;
```

### 36.1.228 isConstant

Checks if a component in a class is a constant.

```
function isConstant
  input TypeName componentName;
  input TypeName className;
  output Boolean result;
end isConstant;
```

### 36.1.229 isEnumeration

Checks if a given class is an enumeration.

```
function isEnumeration
  input TypeName cl;
  output Boolean b;
end isEnumeration;
```

### 36.1.230 isExperiment

Checks if a class is an experiment.

```
function isExperiment
  input TypeName name;
  output Boolean res;
end isExperiment;
```

### 36.1.231 isExtendsModifierFinal

Returns whether a modifier on an extends clause is final or not.

```
function isExtendsModifierFinal
  input TypeName className;
  input TypeName extendsName;
  input TypeName modifierName;
  output Boolean isFinal;
end isExtendsModifierFinal;
```

### 36.1.232 isFunction

Checks if a given class is a function.

```
function isFunction
  input TypeName cl;
  output Boolean b;
end isFunction;
```

### 36.1.233 isModel

Checks if a given class is a model.

```
function isModel
  input TypeName cl;
  output Boolean b;
end isModel;
```

### 36.1.234 isOperator

Checks if a given class is an operator.

```
function isOperator
  input TypeName cl;
  output Boolean b;
end isOperator;
```

### 36.1.235 isOperatorFunction

Checks if a given class is an operator function.

```
function isOperatorFunction
  input TypeName cl;
  output Boolean b;
end isOperatorFunction;
```

### 36.1.236 isOperatorRecord

Checks if a given class is an operator record.

```
function isOperatorRecord
  input TypeName cl;
  output Boolean b;
end isOperatorRecord;
```

### 36.1.237 isOptimization

Checks if a given class is an optimization.

```
function isOptimization
  input TypeName cl;
  output Boolean b;
end isOptimization;
```

### 36.1.238 isPackage

Checks if a given class is a package.

```
function isPackage
  input TypeName cl;
  output Boolean b;
end isPackage;
```

### 36.1.239 isParameter

Checks whether a component in a class is a parameter.

```
function isParameter
  input TypeName componentName;
  input TypeName className;
  output Boolean result;
end isParameter;
```

### 36.1.240 isPartial

Checks if a given class is partial.

```
function isPartial
  input TypeName cl;
  output Boolean b;
end isPartial;
```

### 36.1.241 isPrimitive

Checks if a type is primitive.

```
function isPrimitive
  input TypeName className;
  output Boolean result;
end isPrimitive;
```

### 36.1.242 isProtected

Checks if a component in a class is protected.

```
function isProtected
  input TypeName componentName;
  input TypeName className;
  output Boolean result;
end isProtected;
```

### 36.1.243 isProtectedClass

Returns true if the given class c1 has class c2 as one of its protected class.

```
function isProtectedClass
  input TypeName cl;
  input String c2;
  output Boolean b;
end isProtectedClass;
```

### 36.1.244 isRecord

Checks if a given class is a record.

```
function isRecord
  input TypeName cl;
  output Boolean b;
end isRecord;
```

### 36.1.245 isRedeclare

Checks if a given element is a redeclare element.

```
function isRedeclare
  input TypeName element;
  output Boolean b;
end isRedeclare;
```

### 36.1.246 isReplaceable

Checks if a given element is replaceable.

```
function isReplaceable
  input TypeName element;
  output Boolean b;
end isReplaceable;
```

### 36.1.247 isShortDefinition

Returns true if the given class is defined as a short class.

```
function isShortDefinition
  input TypeName class_;
  output Boolean isShortCls;
end isShortDefinition;
```

### 36.1.248 isType

Checks if a given class is a type.

```
function isType
  input TypeName cl;
  output Boolean b;
end isType;
```

### 36.1.249 linearize

Creates a model with symbolic linearization matrices.

```
function linearize
  input TypeName className "the class that should simulated";
  input Real startTime = "<default>" "the start time of the simulation. <default> = 0.
↪0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real stepSize = 0.002 "step size that is used for the result file. <default>␣
↪= 0.002";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "<default>" "integration method used for simulation. <default>
↪ = dassl";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"\"";
  input Boolean storeInTemp = false "storeInTemp. <default> = false";
  input Boolean noClean = false "noClean. <default> = false";
  input String options = "<default>" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "<default>" "cflags. <default> = \"\"";
  input String simflags = "<default>" "simflags. <default> = \"\"";
  output String linearizationResult;
end linearize;
```

### 36.1.250 list

Lists the contents of the given class, or all loaded classes.

```
function list
  input TypeName class_ = $Code(AllLoadedClasses);
  input Boolean interfaceOnly = false;
  input Boolean shortOnly = false "only short class definitions";
  input ExportKind exportKind = ExportKind.Absyn;
  output String contents;
end list;
```

### 36.1.251 listFile

Lists the contents of the file given by the class.

```
function listFile
  input TypeName class_;
  input Boolean nestedClasses = true;
  output String contents;
end listFile;
```

### 36.1.252 listVariables

Lists the names of the active variables in the scripting environment.

```
function listVariables
  output TypeName variables[:];
end listVariables;
```

### 36.1.253 loadClassContentString

Loads class elements from a string and inserts them into the given loaded class.

```
function loadClassContentString
  input String data;
  input TypeName className;
  input Integer offsetX = 0;
  input Integer offsetY = 0;
  output Boolean success;
end loadClassContentString;
```

### 36.1.254 loadEncryptedPackage

Loads an encrypted package.

```
function loadEncryptedPackage
  input String fileName;
  input String workdir = "<default>" "The output directory for imported encrypted␣
↪files. <default> will put the files to current working directory.";
  input Boolean skipUnzip = false "Skips the unzip of .mol if true. In that case we␣
↪expect the files are already extracted e.g., because of parseEncryptedPackage()␣
↪call.";
  input Boolean uses = true;
  input Boolean notify = true "Give a notification of the libraries and versions that␣
↪were loaded";
  input Boolean requireExactVersion = false "If the version is required to be exact,␣
↪if there is a uses Modelica(version=\"3.2\"), Modelica 3.2.1 will not match it.";
  output Boolean success;
end loadEncryptedPackage;
```

### 36.1.255 loadFile

Loads a Modelica file (*.mo).

```
function loadFile
  input String fileName;
  input String encoding = "UTF-8";
  input Boolean uses = true;
```

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```
  input Boolean notify = true "Give a notification of the libraries and versions that␣
↪were loaded";
  input Boolean requireExactVersion = false "If the version is required to be exact,␣
↪if there is a uses Modelica(version=\"3.2\"), Modelica 3.2.1 will not match it.";
  input Boolean allowWithin = true "Whether to allow the file to have a within-clause␣
↪other than 'within;'.";
  output Boolean success;
end loadFile;
```

### 36.1.256 loadFileInteractive

Loads a Modelica file and returns a list of all loaded top-level classes.

```
function loadFileInteractive
  input String filename;
  input String encoding = "UTF-8";
  input Boolean uses = true;
  input Boolean notify = true "Give a notification of the libraries and versions that␣
↪were loaded";
  input Boolean requireExactVersion = false "If the version is required to be exact,␣
↪if there is a uses Modelica(version=\"3.2\"), Modelica 3.2.1 will not match it.";
  output TypeName names[:];
end loadFileInteractive;
```

### 36.1.257 loadFileInteractiveQualified

Loads a Modelica file and returns a list of the top-level classes that were loaded.

```
function loadFileInteractiveQualified
  input String filename;
  input String encoding = "UTF-8";
  output TypeName names[:];
end loadFileInteractiveQualified;
```

### 36.1.258 loadFiles

Loads Modelica files (*.mo).

```
function loadFiles
  input String[:] fileNames;
  input String encoding = "UTF-8";
  input Integer numThreads = OpenModelica.Scripting.numProcessors();
  input Boolean uses = true;
  input Boolean notify = true "Give a notification of the libraries and versions that␣
↪were loaded";
  input Boolean requireExactVersion = false "If the version is required to be exact,␣
↪if there is a uses Modelica(version=\"3.2\"), Modelica 3.2.1 will not match it.";
  input Boolean allowWithin = true "Whether to allow the files to have a within-
↪clause other than 'within;'.";
  output Boolean success;
end loadFiles;
```

### 36.1.259 loadModel

Loads a Modelica library.

```
function loadModel
  input TypeName className;
  input String[:] priorityVersion = {"default"};
  input Boolean notify = false "Give a notification of the libraries and versions␣
↪that were loaded";
  input String languageStandard = "" "Override the set language standard. Parse with␣
↪the given setting, but do not change it permanently.";
  input Boolean requireExactVersion = false "If the version is required to be exact,␣
↪if there is a uses Modelica(version=\"3.2\"), Modelica 3.2.1 will not match it.";
  output Boolean success;
end loadModel;
```

### 36.1.260 loadModelica3D

Loads Modelica3D.

```
function loadModelica3D
  input String version = "3.2.1";
  output Boolean status;
end loadModelica3D;
```

### 36.1.261 loadOMSimulator

Loads the OMSimulator DLL from the default path.

```
function loadOMSimulator
  output Integer status;
end loadOMSimulator;
```

### 36.1.262 loadString

Loads Modelica definitions from a string.

```
function loadString
  input String data;
  input String filename = "<interactive>";
  input String encoding = "UTF-8" "Deprecated as *ALL* strings are now UTF-8 encoded";
  input Boolean merge = false "if merge is true the parsed AST is merged with the␣
↪existing AST,
                               default to false which means that is replaced, not␣
↪merged";
  input Boolean uses = true;
  input Boolean notify = true "Give a notification of the libraries and versions that␣
↪were loaded";
  input Boolean requireExactVersion = false "If the version is required to be exact,
                                             if there is a uses Modelica(version=\
↪"3.2\"),
                                             Modelica 3.2.1 will not match it.";
  output Boolean success;
end loadString;
```

### 36.1.263 mkdir

Creates a directory.

```
function mkdir
  input String newDirectory;
  output Boolean success;
end mkdir;
```

### 36.1.264 modifierToJSON

Parses a modifier given as a string and dumps it as JSON.

```
function modifierToJSON
  input String modifier;
  input Boolean prettyPrint = false;
  output String json;
end modifierToJSON;
```

### 36.1.265 moveClass

Moves a class up or down in a package.

```
function moveClass
  input TypeName className "the class that should be moved";
  input Integer offset "Offset in the class list.";
  output Boolean result;
end moveClass;
```

### 36.1.266 moveClassToBottom

Moves a class to the bottom of its enclosing class.

```
function moveClassToBottom
  input TypeName className;
  output Boolean result;
end moveClassToBottom;
```

### 36.1.267 moveClassToTop

Moves a class to the top of its enclosing class.

```
function moveClassToTop
  input TypeName className;
  output Boolean result;
end moveClassToTop;
```

### 36.1.268 newModel

Creates a new empty model in the given package.

```
function newModel
  input TypeName className;
  input TypeName withinPath;
  output Boolean success;
end newModel;
```

### 36.1.269 ngspicetoModelica

Converts ngspice netlist to Modelica code.

```
function ngspicetoModelica
  input String netlistfileName;
  output Boolean success = false;
end ngspicetoModelica;
```

### 36.1.270 numProcessors

Returns the number of available processors or threads.

```
function numProcessors
  output Integer result;
end numProcessors;
```

### 36.1.271 oms_RunFile

Simulates a single FMU or SSP model.

```
function oms_RunFile
  input String filename;
  output Integer status;
end oms_RunFile;
```

### 36.1.272 oms_addBus

OMSimulator: Adds a bus to a given component.

```
function oms_addBus
  input String cref;
  output Integer status;
end oms_addBus;
```

### 36.1.273 oms_addConnection

Adds a new connection between connectors A and B.

```
function oms_addConnection
  input String crefA;
  input String crefB;
  output Integer status;
end oms_addConnection;
```

### 36.1.274 oms_addConnector

Adds a connector to a given component.

```
function oms_addConnector
  input String cref;
  input oms_causality causality;
  input oms_signal_type type_;
  output Integer status;
end oms_addConnector;
```

### 36.1.275 oms_addConnectorToBus

Adds a connector to a bus.

```
function oms_addConnectorToBus
  input String busCref;
  input String connectorCref;
  output Integer status;
end oms_addConnectorToBus;
```

### 36.1.276 oms_addConnectorToTLMBus

Adds a connector to a TLM bus.

```
function oms_addConnectorToTLMBus
  input String busCref;
  input String connectorCref;
  input String type_;
  output Integer status;
end oms_addConnectorToTLMBus;
```

### 36.1.277 oms_addDynamicValueIndicator

Adds a dynamic value indicator.

```
function oms_addDynamicValueIndicator
  input String signal;
  input String lower;
  input String upper;
  input Real stepSize;
  output Integer status;
end oms_addDynamicValueIndicator;
```

### 36.1.278 oms_addEventIndicator

Adds an event indicator.

```
function oms_addEventIndicator
  input String signal;
  output Integer status;
end oms_addEventIndicator;
```

### 36.1.279 oms_addExternalModel

Adds an external model to a TLM system.

```
function oms_addExternalModel
  input String cref;
  input String path;
  input String startscript;
  output Integer status;
end oms_addExternalModel;
```

### 36.1.280 oms_addSignalsToResults

Adds all variables that match the given regex to the result file.

```
function oms_addSignalsToResults
  input String cref;
  input String regex;
  output Integer status;
end oms_addSignalsToResults;
```

### 36.1.281 oms_addStaticValueIndicator

Adds a static value indicator.

```
function oms_addStaticValueIndicator
  input String signal;
  input Real lower;
  input Real upper;
  input Real stepSize;
  output Integer status;
end oms_addStaticValueIndicator;
```

### 36.1.282 oms_addSubModel

Adds a component to a system.

```
function oms_addSubModel
  input String cref;
  input String fmuPath;
  output Integer status;
end oms_addSubModel;
```

### 36.1.283 oms_addSystem

Adds a (sub-)system to a model or system.

```
function oms_addSystem
  input String cref;
  input oms_system type_;
  output Integer status;
end oms_addSystem;
```

### 36.1.284 oms_addTLMBus

Adds a TLM bus.

```
function oms_addTLMBus
  input String cref;
  input oms_tlm_domain domain;
  input Integer dimensions;
  input oms_tlm_interpolation interpolation;
  output Integer status;
end oms_addTLMBus;
```

### 36.1.285 oms_addTLMConnection

Connects two TLM connectors.

```
function oms_addTLMConnection
  input String crefA;
```

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```
  input String crefB;
  input Real delay;
  input Real alpha;
  input Real linearimpedance;
  input Real angularimpedance;
  output Integer status;
end oms_addTLMConnection;
```

### 36.1.286 oms_addTimeIndicator

Adds a time indicator.

```
function oms_addTimeIndicator
  input String signal;
  output Integer status;
end oms_addTimeIndicator;
```

### 36.1.287 oms_compareSimulationResults

Compares a given signal in two result files.

```
function oms_compareSimulationResults
  input String filenameA;
  input String filenameB;
  input String var;
  input Real relTol;
  input Real absTol;
  output Integer status;
end oms_compareSimulationResults;
```

### 36.1.288 oms_copySystem

Copies a system.

```
function oms_copySystem
  input String source;
  input String target;
  output Integer status;
end oms_copySystem;
```

### 36.1.289 oms_delete

Deletes a connector, component, system, or model object.

```
function oms_delete
  input String cref;
  output Integer status;
end oms_delete;
```

### 36.1.290 oms_deleteConnection

Deletes the connection between two connectors.

```
function oms_deleteConnection
  input String crefA;
```

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```
  input String crefB;
  output Integer status;
end oms_deleteConnection;
```

### 36.1.291 oms_deleteConnectorFromBus

Deletes a connector from a given bus.

```
function oms_deleteConnectorFromBus
  input String busCref;
  input String connectorCref;
  output Integer status;
end oms_deleteConnectorFromBus;
```

### 36.1.292 oms_deleteConnectorFromTLMBus

Deletes a connector from a given TLM bus.

```
function oms_deleteConnectorFromTLMBus
  input String busCref;
  input String connectorCref;
  output Integer status;
end oms_deleteConnectorFromTLMBus;
```

### 36.1.293 oms_export

Exports a composite model to a SPP file.

```
function oms_export
  input String cref;
  input String filename;
  output Integer status;
end oms_export;
```

### 36.1.294 oms_exportDependencyGraphs

Exports the dependency graphs of a given model to dot files.

```
function oms_exportDependencyGraphs
  input String cref;
  input String initialization;
  input String event;
  input String simulation;
  output Integer status;
end oms_exportDependencyGraphs;
```

### 36.1.295 oms_exportSnapshot

Lists the SSD representation of a given model, system, or component.

```
function oms_exportSnapshot
  input String cref;
  output String contents;
  output Integer status;
end oms_exportSnapshot;
```

### 36.1.296 oms_extractFMIKind

Extracts the FMI kind of a given FMU from the file system.

```
function oms_extractFMIKind
  input String filename;
  output Integer kind;
  output Integer status;
end oms_extractFMIKind;
```

### 36.1.297 oms_faultInjection

Defines a new fault injection block.

```
function oms_faultInjection
  input String signal;
  input oms_fault_type faultType;
  input Real faultValue;
  output Integer status;
end oms_faultInjection;
```

### 36.1.298 oms_getBoolean

Get boolean value of a given signal.

```
function oms_getBoolean
  input String cref;
  output Boolean value;
  output Integer status;
end oms_getBoolean;
```

### 36.1.299 oms_getFixedStepSize

Gets the fixed step size.

```
function oms_getFixedStepSize
  input String cref;
  output Real stepSize;
  output Integer status;
end oms_getFixedStepSize;
```

### 36.1.300 oms_getInteger

Get integer value of a given signal.

```
function oms_getInteger
  input String cref;
  input Integer value;
  output Integer status;
end oms_getInteger;
```

### 36.1.301 oms_getModelState

Gets the model state of the given model cref.

```
function oms_getModelState
  input String cref;
```

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```
  output Integer modelState;
  output Integer status;
end oms_getModelState;
```

### 36.1.302 oms_getReal

Get real value.

```
function oms_getReal
  input String cref;
  output Real value;
  output Integer status;
end oms_getReal;
```

### 36.1.303 oms_getSolver

Gets the selected solver method of the given system.

```
function oms_getSolver
  input String cref;
  output Integer solver;
  output Integer status;
end oms_getSolver;
```

### 36.1.304 oms_getStartTime

Gets the start time from the model.

```
function oms_getStartTime
  input String cref;
  output Real startTime;
  output Integer status;
end oms_getStartTime;
```

### 36.1.305 oms_getStopTime

Gets the stop time from the model.

```
function oms_getStopTime
  input String cref;
  output Real stopTime;
  output Integer status;
end oms_getStopTime;
```

### 36.1.306 oms_getSubModelPath

Returns the path of a given component.

```
function oms_getSubModelPath
  input String cref;
  output String path;
  output Integer status;
end oms_getSubModelPath;
```

### 36.1.307 oms_getSystemType

Gets the type of a given system.

```
function oms_getSystemType
  input String cref;
  output Integer type_;
  output Integer status;
end oms_getSystemType;
```

### 36.1.308 oms_getTolerance

Gets the tolerance of a given system or component.

```
function oms_getTolerance
  input String cref;
  output Real absoluteTolerance;
  output Real relativeTolerance;
  output Integer status;
end oms_getTolerance;
```

### 36.1.309 oms_getVariableStepSize

Gets the step size parameters.

```
function oms_getVariableStepSize
  input String cref;
  output Real initialStepSize;
  output Real minimumStepSize;
  output Real maximumStepSize;
  output Integer status;
end oms_getVariableStepSize;
```

### 36.1.310 oms_getVersion

Returns the version of the OMSimulator.

```
function oms_getVersion
  output String version;
end oms_getVersion;
```

### 36.1.311 oms_importFile

Imports a composite model from a SSP file.

```
function oms_importFile
  input String filename;
  output String cref;
  output Integer status;
end oms_importFile;
```

### 36.1.312 oms_importSnapshot

Loads a snapshot to restore a previous model state.

```
function oms_importSnapshot
  input String cref;
```

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```
  input String snapshot;
  output Integer status;
end oms_importSnapshot;
```

### 36.1.313 oms_initialize

Initializes a composite model.

```
function oms_initialize
  input String cref;
  output Integer status;
end oms_initialize;
```

### 36.1.314 oms_instantiate

Instantiates a given composite model.

```
function oms_instantiate
  input String cref;
  output Integer status;
end oms_instantiate;
```

### 36.1.315 oms_list

Lists the SSD representation of a given model, system, or component.

```
function oms_list
  input String cref;
  output String contents;
  output Integer status;
end oms_list;
```

### 36.1.316 oms_listUnconnectedConnectors

Lists all unconnected connectors of a given system.

```
function oms_listUnconnectedConnectors
  input String cref;
  output String contents;
  output Integer status;
end oms_listUnconnectedConnectors;
```

### 36.1.317 oms_loadSnapshot

Loads a snapshot to restore a previous model state.

```
function oms_loadSnapshot
  input String cref;
  input String snapshot;
  output String newCref;
  output Integer status;
end oms_loadSnapshot;
```

### 36.1.318 oms_newModel

Creates a new composite model.

```
function oms_newModel
  input String cref;
  output Integer status;
end oms_newModel;
```

### 36.1.319 oms_removeSignalsFromResults

Removes all variables that match the given regex from the result file.

```
function oms_removeSignalsFromResults
  input String cref;
  input String regex;
  output Integer status;
end oms_removeSignalsFromResults;
```

### 36.1.320 oms_rename

Renames a model, system, or component.

```
function oms_rename
  input String cref;
  input String newCref;
  output Integer status;
end oms_rename;
```

### 36.1.321 oms_reset

Reset the composite model after a simulation run.

```
function oms_reset
  input String cref;
  output Integer status;
end oms_reset;
```

### 36.1.322 oms_setBoolean

Sets the value of a given boolean signal.

```
function oms_setBoolean
  input String cref;
  input Boolean value;
  output Integer status;
end oms_setBoolean;
```

### 36.1.323 oms_setCommandLineOption

Sets special flags.

```
function oms_setCommandLineOption
  input String cmd;
  output Integer status;
end oms_setCommandLineOption;
```

### 36.1.324 oms_setFixedStepSize

Sets the fixed step size.

```
function oms_setFixedStepSize
  input String cref;
  input Real stepSize;
  output Integer status;
end oms_setFixedStepSize;
```

### 36.1.325 oms_setInteger

Sets the value of a given integer signal.

```
function oms_setInteger
  input String cref;
  input Integer value;
  output Integer status;
end oms_setInteger;
```

### 36.1.326 oms_setLogFile

Redirects logging output to file or std streams.

```
function oms_setLogFile
  input String filename;
  output Integer status;
end oms_setLogFile;
```

### 36.1.327 oms_setLoggingInterval

Sets the logging interval of the simulation.

```
function oms_setLoggingInterval
  input String cref;
  input Real loggingInterval;
  output Integer status;
end oms_setLoggingInterval;
```

### 36.1.328 oms_setLoggingLevel

Enables/disables debug logging.

```
function oms_setLoggingLevel
  input Integer logLevel;
  output Integer status;
end oms_setLoggingLevel;
```

### 36.1.329 oms_setReal

Sets the value of a given real signal.

```
function oms_setReal
  input String cref;
  input Real value;
  output Integer status;
end oms_setReal;
```

### 36.1.330 oms_setRealInputDerivative

Sets the first order derivative of a real input signal.

```
function oms_setRealInputDerivative
  input String cref;
  input Real value;
  output Integer status;
end oms_setRealInputDerivative;
```

### 36.1.331 oms_setResultFile

Sets the result file of the simulation.

```
function oms_setResultFile
  input String cref;
  input String filename;
  input Integer bufferSize;
  output Integer status;
end oms_setResultFile;
```

### 36.1.332 oms_setSignalFilter

Sets a signal filter.

```
function oms_setSignalFilter
  input String cref;
  input String regex;
  output Integer status;
end oms_setSignalFilter;
```

### 36.1.333 oms_setSolver

Sets the solver method for the given system.

```
function oms_setSolver
  input String cref;
  input oms_solver solver;
  output Integer status;
end oms_setSolver;
```

### 36.1.334 oms_setStartTime

Sets the start time of the simulation.

```
function oms_setStartTime
  input String cref;
  input Real startTime;
  output Integer status;
end oms_setStartTime;
```

### 36.1.335 oms_setStopTime

Sets the stop time of the simulation.

```
function oms_setStopTime
  input String cref;
```

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```
  input Real stopTime;
  output Integer status;
end oms_setStopTime;
```

### 36.1.336 oms_setTLMPositionAndOrientation

Sets initial position and orientation for a TLM 3D interface.

```
function oms_setTLMPositionAndOrientation
  input String cref;
  input Real x1;
  input Real x2;
  input Real x3;
  input Real A11;
  input Real A12;
  input Real A13;
  input Real A21;
  input Real A22;
  input Real A23;
  input Real A31;
  input Real A32;
  input Real A33;
  output Integer status;
end oms_setTLMPositionAndOrientation;
```

### 36.1.337 oms_setTLMSocketData

Sets data for TLM socket communication.

```
function oms_setTLMSocketData
  input String cref;
  input String address;
  input Integer managerPort;
  input Integer monitorPort;
  output Integer status;
end oms_setTLMSocketData;
```

### 36.1.338 oms_setTempDirectory

Sets new temp directory.

```
function oms_setTempDirectory
  input String newTempDir;
  output Integer status;
end oms_setTempDirectory;
```

### 36.1.339 oms_setTolerance

Sets the tolerance for a given model or system.

```
function oms_setTolerance
  input String cref;
  input Real absoluteTolerance;
  input Real relativeTolerance;
  output Integer status;
end oms_setTolerance;
```

### 36.1.340 oms_setVariableStepSize

Sets the step size parameters for methods with stepsize control.

```
function oms_setVariableStepSize
  input String cref;
  input Real initialStepSize;
  input Real minimumStepSize;
  input Real maximumStepSize;
  output Integer status;
end oms_setVariableStepSize;
```

### 36.1.341 oms_setWorkingDirectory

Sets a new working directory.

```
function oms_setWorkingDirectory
  input String newWorkingDir;
  output Integer status;
end oms_setWorkingDirectory;
```

### 36.1.342 oms_simulate

Simulates a composite model.

```
function oms_simulate
  input String cref;
  output Integer status;
end oms_simulate;
```

### 36.1.343 oms_stepUntil

Simulates a composite model until a given time value.

```
function oms_stepUntil
  input String cref;
  input Real stopTime;
  output Integer status;
end oms_stepUntil;
```

### 36.1.344 oms_terminate

Terminates a given composite model.

```
function oms_terminate
  input String cref;
  output Integer status;
end oms_terminate;
```

### 36.1.345 optimize

Generates an optimization executable for a Modelica/Optimica model and runs it.

```
function optimize
  input TypeName className "the class that should simulated";
  input Real startTime = "<default>" "the start time of the simulation. <default> = 0.
↪0";
```

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```
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real stepSize = 0.002 "step size that is used for the result file. <default>␣
↪= 0.002";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = DAE.SCONST("optimization") "optimize a modelica/optimica␣
↪model.";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"\"";
  input Boolean storeInTemp = false "storeInTemp. <default> = false";
  input Boolean noClean = false "noClean. <default> = false";
  input String options = "<default>" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "<default>" "cflags. <default> = \"\"";
  input String simflags = "<default>" "simflags. <default> = \"\"";
  output String optimizationResults;
end optimize;
```

### 36.1.346 parseEncryptedPackage

Parses an encrypted package and returns the names of the parsed classes.

```
function parseEncryptedPackage
  input String fileName;
  input String workdir = "<default>" "The output directory for imported encrypted␣
↪files. <default> will put the files to current working directory.";
  output TypeName names[:];
end parseEncryptedPackage;
```

### 36.1.347 parseFile

Parses a Modelica file and returns the parsed classes.

```
function parseFile
  input String filename;
  input String encoding = "UTF-8";
  output TypeName names[:];
end parseFile;
```

### 36.1.348 parseString

Parses a string containing Modelica definitions and returns the parsed classes.

```
function parseString
  input String data;
  input String filename = "<interactive>";
  output TypeName names[:];
end parseString;
```

### 36.1.349 plot

Displays a plot with selected variables using OMPlot.

```
function plot
  input VariableNames vars "The variables you want to plot";
  input Boolean externalWindow = false "Opens the plot in a new plot window";
  input String fileName = "<default>" "The filename containing the variables.
↪<default> will read the last simulation result";
  input String title = "" "This text will be used as the diagram title.";
  input String grid = "simple" "Sets the grid for the plot i.e., simple, detailed,␣
↪none or xonly.";
  input Boolean logX = false "Determines whether or not the horizontal axis is␣
↪logarithmically scaled.";
  input Boolean logY = false "Determines whether or not the vertical axis is␣
↪logarithmically scaled.";
  input String xLabel = "time" "This text will be used as the horizontal label in the␣
↪diagram.";
  input String yLabel = "" "This text will be used as the left vertical label in the␣
↪diagram.";
  input Real xRange[2] = {0.0, 0.0} "Determines the horizontal interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real yRange[2] = {0.0, 0.0} "Determines the left vertical interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real curveWidth = 1.0 "Sets the width of the curve.";
  input Integer curveStyle = 1 "Sets the style of the curve. SolidLine=1, DashLine=2,␣
↪DotLine=3, DashDotLine=4, DashDotDotLine=5, Sticks=6, Steps=7.";
  input String legendPosition = "top" "Sets the POSITION of the legend i.e., left,␣
↪right, top, bottom, none.";
  input String footer = "" "This text will be used as the diagram footer.";
  input Boolean autoScale = true "Use auto scale while plotting.";
  input Boolean forceOMPlot = false "if true launches OMPlot and doesn't call␣
↪callback function even if it is defined.";
  input String yAxis = "L" "Sets the variable to be plotted on the left (L) or right␣
↪(R) y-axis.";
  input String yLabelRight = "" "This text will be used as the right vertical label␣
↪in the diagram.";
  input Real yRangeRight[2] = {0.0, 0.0} "Determines the right vertical interval that␣
↪is visible in the diagram. {0,0} will select a suitable range.";
  output Boolean success "Returns true on success";
end plot;
```

### 36.1.350 plotAll

Displays a plot with all variables using OMPlot.

```
function plotAll
  input Boolean externalWindow = false "Opens the plot in a new plot window";
  input String fileName = "<default>" "The filename containing the variables.
↪<default> will read the last simulation result";
  input String title = "" "This text will be used as the diagram title.";
  input String grid = "simple" "Sets the grid for the plot i.e., simple, detailed,␣
↪none or xonly.";
  input Boolean logX = false "Determines whether or not the horizontal axis is␣
↪logarithmically scaled.";
  input Boolean logY = false "Determines whether or not the vertical axis is␣
↪logarithmically scaled.";
  input String xLabel = "time" "This text will be used as the horizontal label in the␣
```

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```
↪diagram.";
  input String yLabel = "" "This text will be used as the left vertical label in the␣
↪diagram.";
  input Real xRange[2] = {0.0, 0.0} "Determines the horizontal interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real yRange[2] = {0.0, 0.0} "Determines the left vertical interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real curveWidth = 1.0 "Sets the width of the curve.";
  input Integer curveStyle = 1 "Sets the style of the curve. SolidLine=1, DashLine=2,␣
↪DotLine=3, DashDotLine=4, DashDotDotLine=5, Sticks=6, Steps=7.";
  input String legendPosition = "top" "Sets the POSITION of the legend i.e., left,␣
↪right, top, bottom, none.";
  input String footer = "" "This text will be used as the diagram footer.";
  input Boolean autoScale = true "Use auto scale while plotting.";
  input Boolean forceOMPlot = false "if true launches OMPlot and doesn't call␣
↪callback function even if it is defined.";
  input String yAxis = "L" "Sets the variable to be plotted on the left (L) or right␣
↪(R) y-axis.";
  input String yLabelRight = "" "This text will be used as the right vertical label␣
↪in the diagram.";
  input Real yRangeRight[2] = {0.0, 0.0} "Determines the right vertical interval that␣
↪is visible in the diagram. {0,0} will select a suitable range.";
  output Boolean success "Returns true on success";
end plotAll;
```

### 36.1.351 plotParametric

Displays a parametric plot with two variables using OMPlot.

```
function plotParametric
  input VariableName xVariable;
  input VariableName yVariable;
  input Boolean externalWindow = false "Opens the plot in a new plot window";
  input String fileName = "<default>" "The filename containing the variables.
↪<default> will read the last simulation result";
  input String title = "" "This text will be used as the diagram title.";
  input String grid = "simple" "Sets the grid for the plot i.e., simple, detailed,␣
↪none or xonly.";
  input Boolean logX = false "Determines whether or not the horizontal axis is␣
↪logarithmically scaled.";
  input Boolean logY = false "Determines whether or not the vertical axis is␣
↪logarithmically scaled.";
  input String xLabel = "" "This text will be used as the horizontal label in the␣
↪diagram.";
  input String yLabel = "" "This text will be used as the left vertical label in the␣
↪diagram.";
  input Real xRange[2] = {0.0, 0.0} "Determines the horizontal interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real yRange[2] = {0.0, 0.0} "Determines the left vertical interval that is␣
↪visible in the diagram. {0,0} will select a suitable range.";
  input Real curveWidth = 1.0 "Sets the width of the curve.";
  input Integer curveStyle = 1 "Sets the style of the curve. SolidLine=1, DashLine=2,␣
↪DotLine=3, DashDotLine=4, DashDotDotLine=5, Sticks=6, Steps=7.";
  input String legendPosition = "top" "Sets the POSITION of the legend i.e., left,␣
↪right, top, bottom, none.";
  input String footer = "" "This text will be used as the diagram footer.";
```

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```
  input Boolean autoScale = true "Use auto scale while plotting.";
  input Boolean forceOMPlot = false "if true launches OMPlot and doesn't call␣
↪callback function even if it is defined.";
  input String yAxis = "L" "Sets the variable to be plotted on the left (L) or right␣
↪(R) y-axis.";
  input String yLabelRight = "" "This text will be used as the right vertical label␣
↪in the diagram.";
  input Real yRangeRight[2] = {0.0, 0.0} "Determines the right vertical interval that␣
↪is visible in the diagram. {0,0} will select a suitable range.";
  output Boolean success "Returns true on success";
end plotParametric;
```

### 36.1.352 previous_saveTotalModel

Saves a model and dependencies to a single file, the previous way.

```
function previous_saveTotalModel
  input String fileName;
  input TypeName className;
  input Boolean stripAnnotations = false;
  input Boolean stripComments = false;
  input Boolean obfuscate = false;
  output Boolean success;
end previous_saveTotalModel;
```

### 36.1.353 qualifyPath

Returns the fully qualified path for the given path in a class.

```
function qualifyPath
  input TypeName classPath;
  input TypeName path;
  output TypeName qualifiedPath;
end qualifyPath;
```

### 36.1.354 readFile

Returns the contents of a file.

```
impure function readFile
  input String fileName;
  output String contents;
end readFile;
```

### 36.1.355 readSimulationResult

Reads a result file, returning a matrix corresponding to the variables and size given.

```
function readSimulationResult
  input String filename;
  input VariableNames variables "e.g. {a.b, a[1].b[3].c}, or a single VariableName";
  input Integer size = 0 "0=read any size... If the size is not the same as the␣
↪result-file, this function fails";
  output Real result[:, :];
end readSimulationResult;
```

### 36.1.356 readSimulationResultSize

Returns the number of intervals that are present in the output file.

```
function readSimulationResultSize
  input String fileName;
  output Integer sz;
end readSimulationResultSize;
```

### 36.1.357 readSimulationResultVars

Returns the variables in a simulation results file.

```
function readSimulationResultVars
  input String fileName;
  input Boolean readParameters = true;
  input Boolean openmodelicaStyle = false;
  output String[:] vars;
end readSimulationResultVars;
```

### 36.1.358 realpath

Get full path name of file or directory name

```
function realpath
  input String name "Absolute or relative file or directory name";
  output String fullName "Full path of 'name'";
end realpath;
```

### 36.1.359 reduceTerms

Calls buildModel with the --reduceTerms flag enabled.

```
function reduceTerms
  input TypeName className "the class that should be built";
  input Real startTime = 0.0 "the start time of the simulation. <default> = 0.0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "dassl" "integration method used for simulation. <default> =␣
↪dassl";
  input String fileNamePrefix = "" "fileNamePrefix. <default> = \"\"";
  input String options = "" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "" "cflags. <default> = \"\"";
  input String simflags = "" "simflags. <default> = \"\"";
  input String labelstoCancel = "";
  output String[2] buildModelResults;
end reduceTerms;
```

### 36.1.360 refactorClass

Updates old graphical annotations to Modelica standard ones in a class.

```
function refactorClass
  input TypeName className;
  output String result;
end refactorClass;
```

### 36.1.361 refactorDiagramAnnotation

Updates an old Diagram annotation to a Modelica standard one in the given class.

```
function refactorDiagramAnnotation
  input TypeName className;
  output Expression result;
end refactorDiagramAnnotation;
```

### 36.1.362 refactorIconAnnotation

Updates an old Icon annotation to a Modelica standard one in the given class.

```
function refactorIconAnnotation
  input TypeName className;
  output Expression result;
end refactorIconAnnotation;
```

### 36.1.363 regex

Matches a string with a regular expression and returns the result.

```
function regex
  input String str;
  input String re;
  input Integer maxMatches = 1 "The maximum number of matches that will be returned";
  input Boolean extended = true "Use POSIX extended or regular syntax";
  input Boolean caseInsensitive = false;
  output Integer numMatches "-1 is an error, 0 means no match, else returns a number␣
↪1..maxMatches";
  output String matchedSubstrings[maxMatches] "unmatched strings are returned as empty
↪";
end regex;
```

### 36.1.364 regexBool

Returns true if the string matches the regular expression.

```
function regexBool
  input String str;
  input String re;
  input Boolean extended = true "Use POSIX extended or regular syntax";
  input Boolean caseInsensitive = false;
  output Boolean matches;
end regexBool;
```

### 36.1.365 regularFileExists

Returns whether the given file exists or not.

```
function regularFileExists
  input String fileName;
  output Boolean exists;
end regularFileExists;
```

### 36.1.366 releaseModelInstanceReference

Releases a handle returned by getModelInstanceReference or getModelInstanceAnnotationReference. Returns true on success.

```
function releaseModelInstanceReference
  input Integer handle;
  output Boolean success;
end releaseModelInstanceReference;
```

### 36.1.367 reloadClass

Reloads the file associated with the given loaded class.

```
function reloadClass
  input TypeName name;
  input String encoding = "UTF-8";
  output Boolean success;
end reloadClass;
```

### 36.1.368 remove

Removes a file or directory.

```
function remove
  input String path;
  output Boolean success "Returns true on success.";
end remove;
```

### 36.1.369 removeComponentModifiers

Removes the component modifiers.

```
function removeComponentModifiers
  input TypeName class_;
  input String componentName;
  input Boolean keepRedeclares = false;
  output Boolean success;
end removeComponentModifiers;
```

### 36.1.370 removeElementModifiers

Removes the element (component or short class) modifiers.

```
function removeElementModifiers
  input TypeName className;
  input String componentName;
  input Boolean keepRedeclares = false;
```

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```
  output Boolean success;
end removeElementModifiers;
```

### 36.1.371 removeExtendsModifiers

Removes the extends modifiers of a class.

```
function removeExtendsModifiers
  input TypeName className;
  input TypeName baseClassName;
  input Boolean keepRedeclares = false;
  output Boolean success;
end removeExtendsModifiers;
```

### 36.1.372 renameClass

Renames a class and updates references to it.

```
function renameClass
  input TypeName oldName "The path of the class to rename.";
  input TypeName newName "The new non-qualified name of the class.";
  output TypeName[:] result;
end renameClass;
```

### 36.1.373 renameComponent

Renames a component and updates references to it.

```
function renameComponent
  input TypeName classPath;
  input VariableName oldName;
  input VariableName newName;
  output TypeName[:] result;
end renameComponent;
```

### 36.1.374 renameComponentInClass

Renames a component in a class.

```
function renameComponentInClass
  input TypeName classPath;
  input VariableName oldName;
  input VariableName newName;
  output TypeName[:] result;
end renameComponentInClass;
```

### 36.1.375 reopenStandardStream

Changes which file is associated with a standard stream.

```
function reopenStandardStream
  input StandardStream _stream;
  input String filename;
  output Boolean success;
end reopenStandardStream;
```

### 36.1.376 restoreAST

Restores an AST that was previously stored with storeAST.

```
function restoreAST
  input Integer id;
  output Boolean success;
end restoreAST;
```

### 36.1.377 reverseLookup

```
function reverseLookup
  input TypeName name;
  input TypeName scope = $Code(AllLoadedClasses);
  input Boolean exactMatch = true;
  input Boolean prettyPrint = false;
  output String matches;
end reverseLookup;
```

### 36.1.378 rewriteBlockCall

Function for property modeling, transforms block calls into instantiations for a loaded model

```
function rewriteBlockCall
  input TypeName className;
  input TypeName inDefs;
  output Boolean success;
end rewriteBlockCall;
```

### 36.1.379 runConversionScript

Runs a conversion script on a selected package.

```
function runConversionScript
  input TypeName packageToConvert;
  input String scriptFile;
  output Boolean success;
end runConversionScript;
```

### 36.1.380 runScript

Runs the mos-script specified by the filename.

```
impure function runScript
  input String fileName "*.mos";
  output String result;
end runScript;
```

### 36.1.381 runScriptParallel

Runs multiple scripts in parallel.

```
function runScriptParallel
  input String scripts[:];
  input Integer numThreads = numProcessors();
  input Boolean useThreads = false;
```

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```
  output Boolean results[:];
end runScriptParallel;
```

### 36.1.382 save

Saves a class to the file(s) it's defined in.

```
function save
  input TypeName className;
  output Boolean success;
end save;
```

### 36.1.383 saveAll

Saves the entire loaded AST to file.

```
function saveAll
  input String fileName;
  output Boolean success;
end saveAll;
```

### 36.1.384 saveModel

Saves a loaded model to the given file.

```
function saveModel
  input String fileName;
  input TypeName className;
  output Boolean success;
end saveModel;
```

### 36.1.385 saveTotalModel

Saves a model and dependencies to a single file.

```
function saveTotalModel
  input String fileName;
  input TypeName className;
  input Boolean stripAnnotations = false;
  input Boolean stripComments = false;
  input Boolean obfuscate = false;
  output Boolean success;
end saveTotalModel;
```

### 36.1.386 saveTotalModelDebug

Saves a model and dependencies to a single file using a heuristic.

```
function saveTotalModelDebug
  input String filename;
  input TypeName className;
  input Boolean stripAnnotations = false;
  input Boolean stripComments = false;
  input Boolean obfuscate = false;
  output Boolean success;
end saveTotalModelDebug;
```

### 36.1.387 saveTotalSCode

Alias for saveTotalModel

### 36.1.388 searchClassNames

Searches for a string in the loaded classes.

```
function searchClassNames
  input String searchText;
  input Boolean findInText = false;
  output TypeName classNames[:];
end searchClassNames;
```

### 36.1.389 setAnnotationVersion

Sets the annotation version.

```
function setAnnotationVersion
  input String annotationVersion;
  output Boolean success;
end setAnnotationVersion;
```

### 36.1.390 setCFlags

Sets the C compiler flags (CFLAGS) used for simulation code.

```
function setCFlags
  input String inString;
  output Boolean success;
end setCFlags;
```

### 36.1.391 setCXXCompiler

Sets the C++ compiler (CXX) used for simulation code.

```
function setCXXCompiler
  input String compiler;
  output Boolean success;
end setCXXCompiler;
```

### 36.1.392 setCheapMatchingAlgorithm

Sets the cheap matching algorithm.

```
function setCheapMatchingAlgorithm
  input Integer matchingAlgorithm;
  output Boolean success;
end setCheapMatchingAlgorithm;
```

### 36.1.393 setClassComment

Sets a class comment.

```
function setClassComment
  input TypeName class_;
  input String filename;
```

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```
  output Boolean success;
end setClassComment;
```

### 36.1.394 setCommandLineOptions

Sets command line options for the compiler.

```
function setCommandLineOptions
  input String options;
  output Boolean success;
end setCommandLineOptions;
```

### 36.1.395 setCompiler

Sets the C compiler (CC) used for simulation code.

```
function setCompiler
  input String compiler;
  output Boolean success;
end setCompiler;
```

### 36.1.396 setCompilerFlags

Same as setCFlags.

```
function setCompilerFlags
  input String compilerFlags;
  output Boolean success;
end setCompilerFlags;
```

### 36.1.397 setComponentComment

Sets the comment on a component.

```
function setComponentComment
  input TypeName className;
  input TypeName componentName;
  input String comment;
  output Boolean success;
end setComponentComment;
```

### 36.1.398 setComponentCondition

Sets the condition of a component in a class. An empty string removes the condition.

```
function setComponentCondition
  input TypeName className;
  input TypeName componentName;
  input String condition;
  output Boolean success;
end setComponentCondition;
```

### 36.1.399 setComponentDimensions

Sets the array dimensions of a component.

```
function setComponentDimensions
  input TypeName className;
  input TypeName componentName;
  input Expression dimensions;
  output Boolean success;
end setComponentDimensions;
```

### 36.1.400 setComponentModifierValue

Deprecated; alias for setElementModifierValue.

### 36.1.401 setComponentProperties

Sets the properties of a component in a class.

```
function setComponentProperties
  input TypeName className;
  input TypeName componentName;
  input Boolean[:] prefixArray;
  input String[1] variability;
  input Boolean[2] innerOuter;
  input String[1] direction;
  output Boolean success;
end setComponentProperties;
```

### 36.1.402 setConnectionComment

Sets the description string on a connect equation in the given class.

```
function setConnectionComment
  input TypeName className;
  input VariableName connector1;
  input VariableName connector2;
  input String comment;
  output Boolean success;
end setConnectionComment;
```

### 36.1.403 setDebugFlags

Sets compiler debug flags.

```
function setDebugFlags
  input String debugFlags;
  output Boolean success;
end setDebugFlags;
```

### 36.1.404 setDefaultOpenCLDevice

Sets the default OpenCL device to be used. 0 selects one automatically.

```
function setDefaultOpenCLDevice
  input Integer defdevid;
  output Boolean success;
end setDefaultOpenCLDevice;
```

### 36.1.405 setDocumentationAnnotation

Sets the Documentation annotation in a class.

```
function setDocumentationAnnotation
  input TypeName class_;
  input String info = "";
  input String revisions = "";
  output Boolean bool;
end setDocumentationAnnotation;
```

### 36.1.406 setElementAnnotation

Sets the annotation on a component or class element.

```
function setElementAnnotation
  input TypeName elementName;
  input ExpressionOrModification annotationMod;
  output Boolean success;
end setElementAnnotation;
```

### 36.1.407 setElementModifierValue

Sets a modifier on an element in a class definition.

```
function setElementModifierValue
  input TypeName className;
  input TypeName elementName;
  input ExpressionOrModification modifier;
  output Boolean success;
end setElementModifierValue;
```

### 36.1.408 setElementType

Changes the type of a component or short class element.

```
function setElementType
  input TypeName elementName;
  input VariableName typeName;
  output Boolean success;
end setElementType;
```

### 36.1.409 setEnvironmentVar

Sets the value of the given environment variable.

```
function setEnvironmentVar
  input String var;
  input String value;
  output Boolean success;
end setEnvironmentVar;
```

### 36.1.410 setExtendsModifier

Sets a modifier on an extends clause in a class definition.

```
function setExtendsModifier
  input TypeName className;
  input TypeName extendsName;
  input ExpressionOrModification modifier;
  output Boolean success;
end setExtendsModifier;
```

### 36.1.411 setExtendsModifierValue

Sets a modifier on an element in an extends clause in a class.

```
function setExtendsModifierValue
  input TypeName className;
  input TypeName extendsName;
  input TypeName elementName;
  input ExpressionOrModification modifier;
  output Boolean success;
end setExtendsModifierValue;
```

### 36.1.412 setIndexReductionMethod

Sets the index reduction method.

```
function setIndexReductionMethod
  input String method;
  output Boolean success;
end setIndexReductionMethod;
```

### 36.1.413 setInitXmlStartValue

Sets the start value for a variable in an initialization file.

```
function setInitXmlStartValue
  input String fileName;
  input String variableName;
  input String startValue;
  input String outputFile;
  output Boolean success = false;
end setInitXmlStartValue;
```

### 36.1.414 setInstallationDirectoryPath

Sets the OPENMODELICAHOME environment variable.

```
function setInstallationDirectoryPath
  input String installationDirectoryPath;
  output Boolean success;
end setInstallationDirectoryPath;
```

### 36.1.415 setLanguageStandard

Sets the Modelica Language Standard.

```
function setLanguageStandard
  input String inVersion;
  output Boolean success;
end setLanguageStandard;
```

### 36.1.416 setLinker

Sets the linker (LINK) used for simulation code.

```
function setLinker
  input String linker;
  output Boolean success;
end setLinker;
```

### 36.1.417 setLinkerFlags

Sets the linker flags (LDFLAGS) used for simulation code.

```
function setLinkerFlags
  input String linkerFlags;
  output Boolean success;
end setLinkerFlags;
```

### 36.1.418 setMatchingAlgorithm

Sets the matching algorithm.

```
function setMatchingAlgorithm
  input String matchingAlgorithm;
  output Boolean success;
end setMatchingAlgorithm;
```

### 36.1.419 setModelicaPath

Sets the Modelica library path.

```
function setModelicaPath
  input String modelicaPath;
  output Boolean success;
end setModelicaPath;
```

### 36.1.420 setNoSimplify

Sets the noSimplify flag.

```
function setNoSimplify
  input Boolean noSimplify;
  output Boolean success;
end setNoSimplify;
```

### 36.1.421 setOrderConnections

Sets the orderConnection flag.

```
function setOrderConnections
  input Boolean orderConnections;
  output Boolean success;
end setOrderConnections;
```

### 36.1.422 setParameterValue

Sets the binding equation of a component.

```
function setParameterValue
  input TypeName className;
  input TypeName variableName;
  input Expression value;
  output Boolean success;
end setParameterValue;
```

### 36.1.423 setPostOptModules

Sets post optimization modules for the backend.

```
function setPostOptModules
  input String modules;
  output Boolean success;
end setPostOptModules;
```

### 36.1.424 setPreOptModules

Sets pre optimization modules for the backend.

```
function setPreOptModules
  input String modules;
  output Boolean success;
end setPreOptModules;
```

### 36.1.425 setShowAnnotations

Sets the value of the --showAnnotations flag.

```
function setShowAnnotations
  input Boolean show;
  output Boolean success;
end setShowAnnotations;
```

### 36.1.426 setSourceFile

Sets the filename for a class.

```
function setSourceFile
  input TypeName class_;
  input String filename;
  output Boolean success;
end setSourceFile;
```

### 36.1.427 setTearingMethod

Sets the tearing method used by the backend.

```
function setTearingMethod
  input String tearingMethod;
  output Boolean success;
end setTearingMethod;
```

### 36.1.428 setTempDirectoryPath

Sets the current user temporary directory location.

```
function setTempDirectoryPath
  input String tempDirectoryPath;
  output Boolean success;
end setTempDirectoryPath;
```

### 36.1.429 setVectorizationLimit

Sets the vectorization limit used by the old frontend.

```
function setVectorizationLimit
  input Integer vectorizationLimit;
  output Boolean success;
end setVectorizationLimit;
```

### 36.1.430 simulate

Simulates a model.

```
function simulate
  input TypeName className "the class that should simulated";
  input Real startTime = "<default>" "the start time of the simulation. <default> = 0.
↪0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "<default>" "integration method used for simulation. <default>
↪ = dassl";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"\"";
  input String options = "<default>" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "<default>" "cflags. <default> = \"\"";
  input String simflags = "<default>" "simflags. <default> = \"\"";
  input String resimulateExecutable = "" "If non-empty, skip translation and build␣
↪and simulate this already-built executable directly.";
  output SimulationResult simulationResults;
  record SimulationResult
    String resultFile;
    String simulationOptions;
    String messages;
    Real timeFrontend;
    Real timeBackend;
    Real timeSimCode;
    Real timeTemplates;
    Real timeCompile;
    Real timeSimulation;
    Real timeTotal;
  end SimulationResult;
end simulate;
```

### 36.1.431 solveLinearSystem

Solve A*X = B using dgesv.

```
function solveLinearSystem
  input Real[size(B, 1), size(B, 1)] A;
  input Real[:] B;
  output Real[size(B, 1)] X;
  output Integer info;
end solveLinearSystem;
```

### 36.1.432 sortStrings

Sorts a string array in ascending order.

```
function sortStrings
  input String arr[:];
  output String sorted[:];
end sortStrings;
```

### 36.1.433 stat

Returns status for a file.

```
impure function stat
  input String fileName;
  output Boolean success;
  output Real fileSize;
  output Real mtime;
end stat;
```

### 36.1.434 storeAST

Stores the AST and returns an id that can be used to restore it with restoreAST.

```
function storeAST
  output Integer id;
end storeAST;
```

### 36.1.435 stringReplace

Replaces all occurrences of a token with another token in a string.

```
function stringReplace
  input String str;
  input String source;
  input String target;
  output String res;
end stringReplace;
```

### 36.1.436 stringSplit

Splits a string at the places given by the character

```
function stringSplit
  input String string;
  input String token "single character only";
```

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```
  output String[:] strings;
end stringSplit;
```

### 36.1.437 stringTypeName

Constructs a TypeName from a string.

```
function stringTypeName
  input String str;
  output TypeName cl;
end stringTypeName;
```

### 36.1.438 stringVariableName

Constructs a VariableName from a string.

```
function stringVariableName
  input String str;
  output VariableName cl;
end stringVariableName;
```

### 36.1.439 strtok

Splits a string at the places given by the token.

```
function strtok
  input String string;
  input String token;
  output String[:] strings;
end strtok;
```

### 36.1.440 system

Similar to system(3). Executes the given command in the system shell.

```
impure function system
  input String callStr "String to call: sh -c $callStr";
  input String outputFile = "" "The output is redirected to this file (unless already␣
↪done by callStr)";
  output Integer retval "Return value of the system call; usually 0 on success";
end system;
```

### 36.1.441 system_parallel

Similar to system(3). Executes the given commands in the system shell, in parallel if omc was compiled using OpenMP.

```
impure function system_parallel
  input String callStr[:] "String to call: sh -c $callStr";
  input Integer numThreads = numProcessors();
  output Integer retval[:] "Return value of the system call; usually 0 on success";
end system_parallel;
```

### 36.1.442 testsuiteFriendlyName

Converts a filename to a testsuite friendly one.

```
function testsuiteFriendlyName
  input String path;
  output String fixed;
end testsuiteFriendlyName;
```

### 36.1.443 threadWorkFailed

Exits the current thread with a failure.

### 36.1.444 translateGraphics

Translates old graphical annotations to Modelica standard annotations.

```
function translateGraphics
  input TypeName className;
  output String result;
end translateGraphics;
```

### 36.1.445 translateModel

Translates a modelica model into C code without building it.

```
function translateModel
  input TypeName className "the class that should be built";
  input Real startTime = "<default>" "the start time of the simulation. <default> = 0.
↪0";
  input Real stopTime = 1.0 "the stop time of the simulation. <default> = 1.0";
  input Integer numberOfIntervals = 500 "number of intervals in the result file.
↪<default> = 500";
  input Real tolerance = 1e-6 "tolerance used by the integration method. <default> =␣
↪1e-6";
  input String method = "<default>" "integration method used for simulation. <default>
↪ = dassl";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"\"";
  input String options = "<default>" "options. <default> = \"\"";
  input String outputFormat = "mat" "Format for the result file. <default> = \"mat\"";
  input String variableFilter = ".*" "Only variables fully matching the regexp are␣
↪stored in the result file. <default> = \".*\"";
  input String cflags = "<default>" "cflags. <default> = \"\"";
  input String simflags = "<default>" "simflags. <default> = \"\"";
  output Boolean success;
end translateModel;
```

### 36.1.446 translateModelFMU

Translates a model into C code for a FMU without building it.

```
function translateModelFMU
  input TypeName className "the class that should translated";
  input String version = "2.0" "FMU version, 1.0 or 2.0.";
  input String fmuType = "me" "FMU type, me (model exchange), cs (co-simulation), me_
↪cs (both model exchange and co-simulation)";
  input String fileNamePrefix = "<default>" "fileNamePrefix. <default> = \"className\"
↪";
```

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```
  input String platforms[:] = {"static"} "The list of platforms to generate code for.
                                          \"dynamic\"=current platform, dynamically␣
↪link the runtime.
                                          \"static\"=current platform, statically␣
↪link everything.
                                          \"<cpu>-<vendor>-<os>\", host tripple, e.
↪g. \"x86_64-linux-gnu\" or \"x86_64-w64-mingw32\".
                                          \"<cpu>-<vendor>-<os> docker run ghcr.io/
↪openmodelica/crossbuild:v1.28.0\" host triple with OpenModelica supplied Docker␣
↪image, e.g. \"x86_64-linux-gnu docker run ghcr.io/openmodelica/crossbuild:v1.28.0\".
                                          \"<cpu>-<vendor>-<os> docker run <image>\
↪" host triple with Docker image, e.g. \"x86_64-linux-gnu docker run --pull=never␣
↪multiarch/crossbuild\"";
  input Boolean includeResources = false "include Modelica based resources via␣
↪loadResource or not";
  output Boolean success;
end translateModelFMU;
```

### 36.1.447 translateResidualsDAE

```
function translateResidualsDAE
  input TypeName className;
  input String fileNamePrefix = "<default>";
  output Boolean success;
end translateResidualsDAE;
```

### 36.1.448 typeNameString

Converts a TypeName to a string.

```
function typeNameString
  input TypeName cl;
  output String out;
end typeNameString;
```

### 36.1.449 typeNameStrings

Converts a TypeName to a list of strings.

```
function typeNameStrings
  input TypeName cl;
  output String out[:];
end typeNameStrings;
```

### 36.1.450 typeOf

Returns the type of an interactive variable.

```
function typeOf
  input VariableName variableName;
  output String result;
end typeOf;
```

### 36.1.451 unloadOMSimulator

Frees the OMSimulator instances.

```
function unloadOMSimulator
  output Integer status;
end unloadOMSimulator;
```

### 36.1.452 updateComponent

Updates an existing component.

```
function updateComponent
  input TypeName componentName;
  input TypeName typeName;
  input TypeName classPath;
  input Expression binding = $Code(());
  input ExpressionOrModification modification = $Code();
  input Expression comment = $Code(());
  input Expression annotate = $Code(());
  output Boolean success;
end updateComponent;
```

### 36.1.453 updateConnection

Updates the connection annotation in the class.

```
function updateConnection
  input TypeName className;
  input String from;
  input String to;
  input ExpressionOrModification annotate;
  output Boolean result;
end updateConnection;
```

### 36.1.454 updateConnectionAnnotation

Updates the connection annotation in the class.

```
function updateConnectionAnnotation
  input TypeName className;
  input String from;
  input String to;
  input String annotate;
  output Boolean result;
end updateConnectionAnnotation;
```

### 36.1.455 updateConnectionNames

Updates the connection connector names in the class.

```
function updateConnectionNames
  input TypeName className;
  input String from;
  input String to;
  input String fromNew;
  input String toNew;
```

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```
  output Boolean result;
end updateConnectionNames;
```

### 36.1.456 updateEquation

Replaces an equation with another equation in a class.

```
function updateEquation
  input TypeName className "The name of the class";
  input String oldEq "The equation to replace";
  input String newEq "The equation to replace with";
  input Boolean matchAll = false "Update all matching equations if true, otherwise␣
↪only the first matching";
  input Boolean matchShallow = true "Ignore nested equations if true, otherwise match␣
↪the equations recursively";
  input Boolean matchDescription = false "Match description strings/annotations if␣
↪true, otherwise ignore them";
  input Boolean mergeDescription = false "Keep description string/annotations from␣
↪the old equation if true";
  output Boolean success "true if any equation was updated, otherwise false";
end updateEquation;
```

### 36.1.457 updateInitialState

Updates an initial state in a class.

```
function updateInitialState
  input TypeName cl;
  input String state;
  input ExpressionOrModification annotate;
  output Boolean bool;
end updateInitialState;
```

### 36.1.458 updatePackageIndex

Updates the package index.

```
function updatePackageIndex
  output Boolean result;
end updatePackageIndex;
```

### 36.1.459 updateTransition

Updates a transition in a class.

```
function updateTransition
  input TypeName cl;
  input String from;
  input String to;
  input String oldCondition;
  input Boolean oldImmediate;
  input Boolean oldReset;
  input Boolean oldSynchronize;
  input Integer oldPriority;
  input String newCondition;
  input Boolean newImmediate;
```

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```
  input Boolean newReset;
  input Boolean newSynchronize;
  input Integer newPriority;
  input ExpressionOrModification annotate;
  output Boolean bool;
end updateTransition;
```

### 36.1.460 upgradeInstalledPackages

Upgrades installed packages.

```
function upgradeInstalledPackages
  input Boolean installNewestVersions = true;
  output Boolean result;
end upgradeInstalledPackages;
```

### 36.1.461 uriToFilename

Converts a URI to a filename.

```
function uriToFilename
  input String uri;
  output String filename = "";
end uriToFilename;
```

### 36.1.462 val

Return the value of a variable at a given time in the simulation results

```
function val
  input VariableName var;
  input Real timePoint = 0.0;
  input String fileName = "<default>" "The contents of the currentSimulationResult␣
↪variable";
  output Real valAtTime;
end val;
```

### 36.1.463 writeFile

Writes data to a file.

```
impure function writeFile
  input String fileName;
  input String data;
  input Boolean append = false;
  output Boolean success;
end writeFile;
```

## 36.2 Simulation Parameter Sweep

Following example shows how to update the parameters and re-run the simulation without compiling the model.

```
loadFile("BouncingBall.mo");
getErrorString();
// build the model once
```

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```
buildModel(BouncingBall);
getErrorString();
for i in 1:3 loop
  // We update the parameter e start value from 0.7 to "0.7 + i".
  value := 0.7 + i;
  // call the generated simulation code to produce a result file BouncingBall%i%_res.
↪mat
  system("./BouncingBall -override=e="+String(value)+" -r=BouncingBall" + String(i) +
↪"_res.mat");
  getErrorString();
end for;
```

We used the BouncingBall.mo in the example above. The above example produces three result files each containing different start value for *e* i.e., 1.7, 2.7, 3.7.

## 36.3 Examples

The following is an interactive session with the OpenModelica environment including some of the abovementioned commands and examples. Run the examples below using OMShell or OMNotebook.

We type in a very small model in the command window:

```
model Test "Testing OpenModelica Scripts"
  Real x, y;
equation
  x = 5.0+time; y = 6.0;
end Test;
```

We give the command to flatten a model:

```
>>> instantiateModel(Test)
class Test "Testing OpenModelica Scripts"
  Real x;
  Real y;
equation
  x = 5.0 + time;
  y = 6.0;
end Test;
```

A range expression is typed in:

```
>>> a:=1:10
{1, 2, 3, 4, 5, 6, 7, 8, 9, 10}
```

It is multiplied by 2:

```
>>> a*2
{2, 4, 6, 8, 10, 12, 14, 16, 18, 20}
```

The variables are cleared:

```
>>> clearVariables()
true
```

We print the loaded class test from its internal representation:

```
>>> list(Test)
model Test "Testing OpenModelica Scripts"
  Real x, y;
equation
  x = 5.0 + time;
  y = 6.0;
end Test;
```

We get the name and other properties of a class:

```
>>> getClassNames()
{Test, EQ, ProfilingTest}
>>> getClassComment(Test)
"Testing OpenModelica Scripts"
>>> isPartial(Test)
false
>>> isPackage(Test)
false
>>> isModel(Test)
true
>>> checkModel(Test)
"Check of Test completed successfully.
Class Test has 2 equation(s) and 2 variable(s).
2 of these are trivial equation(s)."
```

The common combination of a simulation followed by getting a value and doing a plot:

```
>>> simulate(Test, stopTime=3.0)
record SimulationResult
    resultFile = "«DOCHOME»/Test_res.mat",
    simulationOptions = "startTime = 0.0, stopTime = 3.0, numberOfIntervals = 500,␣
↪tolerance = 1e-6, method = 'dassl', fileNamePrefix = 'Test', options = '',␣
↪outputFormat = 'mat', variableFilter = '.*', cflags = '', simflags = ''",
    messages = "LOG_SUCCESS       | info    | The initialization finished␣
↪successfully without homotopy method.
LOG_SUCCESS       | info    | The simulation finished successfully.
LOG_STDOUT        | info    | Time measurements are stored in Test_prof.html (human-
↪readable) and Test_prof.xml (for XSL transforms or more details)
",
    timeFrontend = 0.001595267,
    timeBackend = 0.005047994,
    timeSimCode = 0.001231434,
    timeTemplates = 0.0032138270000000003,
    timeCompile = 0.4236819559999999,
    timeSimulation = 0.031892717,
    timeTotal = 0.46674631899999997
end SimulationResult;
>>> val(x , 2.0)
7.0
```

```
>>> plotAll()
```

### 36.3.1 Interactive Function Calls, Reading, and Writing

We enter an assignment of a vector expression, created by the range construction expression 1:12, to be stored in the variable x. The type and the value of the expression is returned.

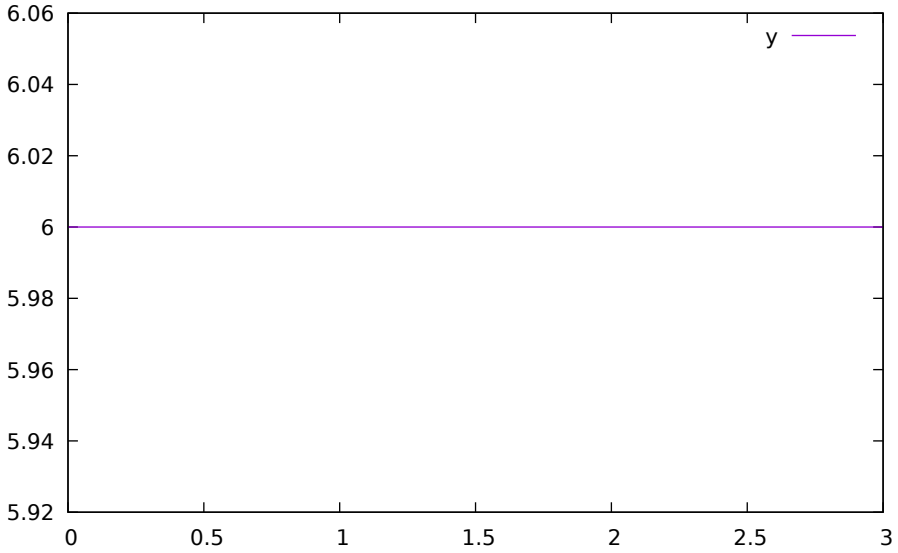



Figure 36.1: Plot generated by OpenModelica+gnuplot

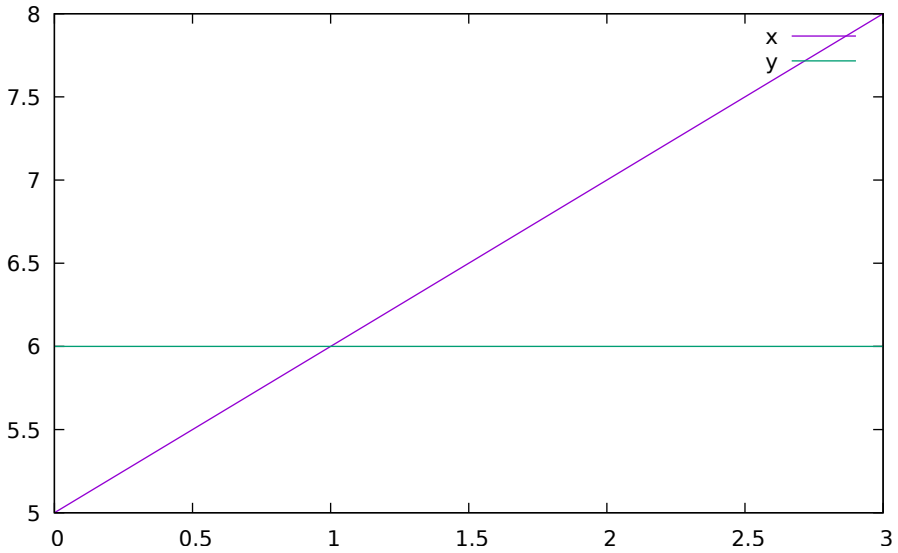



Figure 36.2: Plot generated by OpenModelica+gnuplot

```
>>> x := 1:12
{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12}
```

The function bubblesort is called to sort this vector in descending order. The sorted result is returned together with its type. Note that the result vector is of type Real[:], instantiated as Real[12], since this is the declared type of the function result. The input Integer vector was automatically converted to a Real vector according to the Modelica type coercion rules.

```
>>> loadFile(getInstallationDirectoryPath() + "/share/doc/omc/testmodels/bubblesort.mo
↪")
true
>>> bubblesort(x)
{12.0, 11.0, 10.0, 9.0, 8.0, 7.0, 6.0, 5.0, 4.0, 3.0, 2.0, 1.0}
```

Now we want to try another small application, a simplex algorithm for optimization. First read in a small matrix containing coefficients that define a simplex problem to be solved:

```
>>> a := {
  {-1,-1,-1, 0, 0, 0, 0, 0, 0},
  {-1, 1, 0, 1, 0, 0, 0, 0, 5},
  { 1, 4, 0, 0, 1, 0, 0, 0, 45},
  { 2, 1, 0, 0, 0, 1, 0, 0, 27},
  { 3,-4, 0, 0, 0, 0, 1, 0, 24},
  { 0, 0, 1, 0, 0, 0, 0, 1, 4}
}
{{-1, -1, -1, 0, 0, 0, 0, 0, 0}, {-1, 1, 0, 1, 0, 0, 0, 0, 5}, {1, 4, 0, 0, 1, 0, 0,␣
↪0, 45}, {2, 1, 0, 0, 0, 1, 0, 0, 27}, {3, -4, 0, 0, 0, 0, 1, 0, 24}, {0, 0, 1, 0, 0,
↪ 0, 0, 1, 4}}
```

```
function pivot1
  input Real b[:,:];
  input Integer p;
  input Integer q;
  output Real a[size(b,1),size(b,2)];
protected
  Integer M;
  Integer N;
algorithm
  a := b;
  N := size(a,1)-1;
  M := size(a,2)-1;
  for j in 1:N loop
    for k in 1:M loop
      if j<>p and k<>q then
       a[j,k] := a[j,k]-0.3*j;
      end if;
    end for;
  end for;
  a[p,q] := 0.05;
end pivot1;

function misc_simplex1
  input Real matr[:,:];
  output Real x[size(matr,2)-1];
  output Real z;
  output  Integer q;
  output  Integer p;
```

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```
protected
  Real a[size(matr,1),size(matr,2)];
  Integer M;
  Integer N;
algorithm
  N := size(a,1)-1;
  M := size(a,2)-1;
  a := matr;
  p:=0;q:=0;
  a := pivot1(a,p+1,q+1);
  while not (q==(M) or p==(N)) loop
    q := 0;
    while not (q == (M) or a[0+1,q+1]>1) loop
      q:=q+1;
    end while;
    p := 0;
    while not (p == (N) or a[p+1,q+1]>0.1) loop
      p:=p+1;
    end while;
    if (q < M) and (p < N) and(p>0) and (q>0) then
      a := pivot1(a,p,q);
    end if;
  if(p<=0) and (q<=0) then
     a := pivot1(a,p+1,q+1);
  end if;
  if(p<=0) and (q>0) then
     a := pivot1(a,p+1,q);
  end if;
  if(p>0) and (q<=0) then
     a := pivot1(a,p,q+1);
  end if;
  end while;
  z := a[1,M];
  x := {a[1,i] for i in 1:size(x,1)};
  for i in 1:10 loop
   for j in 1:M loop
    x[j] := x[j]+x[j]*0.01;
   end for;
  end for;
end misc_simplex1;
```

Then call the simplex algorithm implemented as the Modelica function simplex1. This function returns four results, which are represented as a tuple of four return values:

```
>>> misc_simplex1(a)
({0.05523110627056022, -1.1046221254112045, -1.1046221254112045, 0.0, 0.0, 0.0, 0.0,␣
↪0.0}, 0.0, 8, 1)
```

CHAPTER

# THIRTYSEVEN

# OPENMODELICA COMPILER FLAGS

Usage: omc [Options] (Model.mo | Script.mos) [Libraries | .mo-files]

- Libraries: Fully qualified names of libraries to load before processing Model or Script. The libraries should be separated by spaces: Lib1 Lib2 ... LibN.

## 37.1 Options

*-d, --debug*

Sets debug flags. Use *--help=debug* to see available flags.

String list (default *empty*).

*-h, --help*

Displays the help text. Use --help=topics for more information.

String (default *empty*).

*--version*

Print the version and exit.

Boolean (default `false`).

*--target*

Sets the target compiler to use.

String (default gcc). Valid options:

- gcc
- msvc
- msvc10
- msvc12
- msvc13
- msvc15
- msvc19
- vxworks69
- debugrt

*-g, --grammar*

Sets the grammar and semantics to accept.

String (default Modelica).

*--annotationVersion*

Sets the annotation version that should be used.

String (default 3.x). Valid options:

- 1.x
- 2.x
- 3.x

*--std*

Sets the language standard that should be used.

String (default latest).

*--showErrorMessages*

Show error messages immediately when they happen.

Boolean (default `false`).

*--showAnnotations*

Show annotations in the flattened code.

Boolean (default `false`).

*--noSimplify*

Do not simplify expressions if set.

Boolean (default `false`).

*--preOptModules*

Sets the pre optimization modules to use in the back end. See *--help=optmodules* for more info.

String list (default normalInlineFunction,evaluateParameters,simplifyIfEquations,expandDerOperator,clockPartitioning,findStateOrd
Valid options:

- introduceOutputAliases (Introduces aliases for top-level outputs.)
- clockPartitioning (Does the clock partitioning.)
- collapseArrayExpressions (Simplifies {x[1],x[2],x[3]} → x for arrays of whole variable references (simplifies code generation).)
- comSubExp (Introduces alias assignments for variables which are assigned to simple terms i.e. a = b/c; d = b/c; --> a=d)
- dumpDAE (dumps the DAE representation of the current transformation state)
- dumpDAEXML (dumps the DAE as xml representation of the current transformation state)
- encapsulateWhenConditions (This module replaces each when condition with a boolean variable.)
- evalFunc (evaluates functions partially)
- evaluateParameters (Evaluates parameters with annotation(Evaluate=true). Use '--evaluateFinalParameters=true' or '--evaluateProtectedParameters=true' to specify additional parameters to be evaluated. Use '--replaceEvaluatedParameters=true' if the evaluated parameters should be replaced in the DAE. To evaluate all parameters in the Frontend use -d=evaluateAllParameters.)
- expandDerOperator (Expands der(expr) using Derive.differentiteExpTime.)
- findStateOrder (Sets derivative information to states.)
- inlineArrayEqn (This module expands all array equations to scalar equations.)
- normalInlineFunction (Perform function inlining for function with annotation Inline=true.)
- inputDerivativesForDynOpt (Allowed derivatives of inputs in dyn. optimization.)
- introduceDerAlias (Adds for every der-call an alias equation e.g. dx = der(x).)

- removeEqualRHS (Detects equal expressions of the form a=<exp> and b=<exp> and substitutes them to get speed up.)
- removeProtectedParameters (Replace all parameters with protected=true in the system.)
- removeSimpleEquations (Performs alias elimination and removes constant variables from the DAE, replacing all occurrences of the old variable reference with the new value (constants) or variable reference (alias elimination).)
- removeUnusedParameter (Strips all parameter not present in the equations from the system.)
- removeUnusedVariables (Strips all variables not present in the equations from the system.)
- removeVerySimpleEquations ([Experimental] Like removeSimpleEquations, but less thorough. Note that this always uses the experimental new alias elimination, --removeSimpleEquations=new, which makes it unstable. In particular, MultiBody systems fail to translate correctly. It can be used for simple (but large) systems of equations.)
- replaceEdgeChange (Replace edge(b) = b and not pre(b) and change(b) = v <> pre(v).)
- residualForm (Transforms simple equations x=y to zero-sum equations 0=y-x.)
- resolveLoops (resolves linear equations in loops)
- simplifyAllExpressions (Does simplifications on all expressions.)
- simplifyIfEquations (Tries to simplify if equations by use of information from evaluated parameters.)
- sortEqnsVars (Heuristic sorting for equations and variables.)
- unitChecking (This module is no longer available and its use is deprecated. Use --unitChecking instead.)
- wrapFunctionCalls (This module introduces variables for each function call and substitutes all these calls with the newly introduced variables.)

*--cheapmatchingAlgorithm*

Sets the cheap matching algorithm to use. A cheap matching algorithm gives a jump start matching by heuristics.

Integer (default `3`). Valid options:

- 0 (No cheap matching.)
- 1 (Cheap matching, traverses all equations and match the first free variable.)
- 3 (Random Karp-Sipser: R. M. Karp and M. Sipser. Maximum matching in sparse random graphs.)

*--matchingAlgorithm*

Sets the matching algorithm to use. See *--help=optmodules* for more info.

String (default PFPlusExt). Valid options:

- BFSB (Breadth First Search based algorithm.)
- DFSB (Depth First Search based algorithm.)
- MC21A (Depth First Search based algorithm with look ahead feature.)
- PF (Depth First Search based algorithm with look ahead feature.)
- PFPlus (Depth First Search based algorithm with look ahead feature and fair row traversal.)
- HK (Combined BFS and DFS algorithm.)
- HKDW (Combined BFS and DFS algorithm.)
- ABMP (Combined BFS and DFS algorithm.)
- PR (Matching algorithm using push relabel mechanism.)
- DFSBExt (Depth First Search based Algorithm external c implementation.)
- BFSBExt (Breadth First Search based Algorithm external c implementation.)

- MC21AExt (Depth First Search based Algorithm with look ahead feature external c implementation.)
- PFExt (Depth First Search based Algorithm with look ahead feature external c implementation.)
- PFPlusExt (Depth First Search based Algorithm with look ahead feature and fair row traversal external c implementation.)
- HKExt (Combined BFS and DFS algorithm external c implementation.)
- HKDWExt (Combined BFS and DFS algorithm external c implementation.)
- ABMPExt (Combined BFS and DFS algorithm external c implementation.)
- PRExt (Matching algorithm using push relabel mechanism external c implementation.)
- BB (BBs try.)
- SBGraph (Set-Based Graph matching algorithm for efficient array handling.)
- pseudo (Pseudo array matching that uses scalar matching and reconstructs arrays afterwards as much as possible.)

*--indexReductionMethod*

Sets the index reduction method to use. See *--help=optmodules* for more info.

String (default dynamicStateSelection). Valid options:

- none (Skip index reduction)
- uode (Use the underlying ODE without the constraints.)
- dynamicStateSelection (Simple index reduction method, select (dynamic) dummy states based on analysis of the system.)
- dummyDerivatives (Simple index reduction method, select (static) dummy states based on heuristic.)

*--postOptModules*

Sets the post optimization modules to use in the back end. See *--help=optmodules* for more info.

String list (default lateInlineFunction,wrapFunctionCalls,inlineArrayEqn,constantLinearSystem,simplifysemiLinear,removeSimpleE
Valid options:

- addScaledVars_states (added var_norm = var/nominal, where var is state)
- addScaledVars_inputs (added var_norm = var/nominal, where var is input)
- addTimeAsState (Experimental feature: this replaces each occurrence of variable time with a new introduced state $time with equation der($time) = 1.0)
- calculateStateSetsJacobians (Generates analytical jacobian for dynamic state selection sets.)
- calculateStrongComponentJacobians (Generates analytical jacobian for torn linear and non-linear strong components. By default linear components and non-linear components with user-defined function calls are skipped. See also debug flags: LSanalyticJacobian, NLSanalyticJacobian and forceNLSanalyticJacobian)
- collapseArrayExpressions (Simplifies {x[1],x[2],x[3]} → x for arrays of whole variable references (simplifies code generation).)
- constantLinearSystem (Evaluates constant linear systems (a*x+b*y=c; d*x+e*y=f; a,b,c,d,e,f are constants) at compile-time.)
- countOperations (Count the mathematical operations of the system.)
- cseBinary (Common Sub-expression Elimination)
- dumpComponentsGraphStr (Dumps the assignment graph used to determine strong components to format suitable for Mathematica)
- dumpDAE (dumps the DAE representation of the current transformation state)
- dumpDAEXML (dumps the DAE as xml representation of the current transformation state)

- evaluateParameters (Evaluates parameters with annotation(Evaluate=true). Use '--evaluateFinalParameters=true' or '--evaluateProtectedParameters=true' to specify additional parameters to be evaluated. Use '--replaceEvaluatedParameters=true' if the evaluated parameters should be replaced in the DAE. To evaluate all parameters in the Frontend use -d=evaluateAllParameters.)
- extendDynamicOptimization (Move loops to constraints.)
- generateSymbolicLinearization (Generates symbolic linearization matrices A,B,C,D for linear model:$\dot{x} = Ax + Buy = Cx + Du$)
- generateSymbolicSensitivities (Generates symbolic Sensivities matrix, where der(x) is differentiated w.r.t. param.)
- inlineArrayEqn (This module expands all array equations to scalar equations.)
- inputDerivativesUsed (Checks if derivatives of inputs are need to calculate the model.)
- lateInlineFunction (Perform function inlining for function with annotation LateInline=true.)
- partlintornsystem (partitions linear torn systems.)
- recursiveTearing (inline and repeat tearing)
- reduceDynamicOptimization (Removes equations which are not needed for the calculations of cost and constraints. This module requires --postOptModules+=reduceDynamicOptimization.)
- relaxSystem (relaxation from gausian elemination)
- removeConstants (Remove all constants in the system.)
- removeEqualRHS (Detects equal function calls of the form a=f(b) and c=f(b) and substitutes them to get speed up.)
- removeSimpleEquations (Performs alias elimination and removes constant variables from the DAE, replacing all occurrences of the old variable reference with the new value (constants) or variable reference (alias elimination).)
- removeUnusedParameter (Strips all parameter not present in the equations from the system to get speed up for compilation of target code.)
- removeUnusedVariables (Strips all variables not present in the equations from the system to get speed up for compilation of target code.)
- reshufflePost (Reshuffles algebraic loops.)
- simplifyAllExpressions (Does simplifications on all expressions.)
- simplifyComplexFunction (Some simplifications on complex functions (complex refers to the internal data structure))
- simplifyConstraints (Rewrites nonlinear constraints into box constraints if possible. This module requires +gDynOpt.)
- simplifyLoops (Simplifies algebraic loops. This modules requires +simplifyLoops.)
- simplifyTimeIndepFuncCalls (Simplifies time independent built in function calls like pre(param) -> param, der(param) -> 0.0, change(param) -> false, edge(param) -> false.)
- simplifysemiLinear (Simplifies calls to semiLinear.)
- solveLinearSystem (solve linear system with newton step)
- solveSimpleEquations (Solves simple equations)
- symSolver (Rewrites the ode system for implicit Euler method. This module requires +symSolver.)
- symbolicJacobian (Detects the sparse pattern of the ODE system and calculates also the symbolic Jacobian if flag '--generateDynamicJacobian=symbolic'.)
- tearingSystem (For method selection use flag tearingMethod.)

- wrapFunctionCalls (This module introduces variables for each function call and substitutes all these calls with the newly introduced variables.)

*--simCodeTarget*

Sets the target language for the code generation.

String (default C). Valid options:

- None
- C
- C+Rust
- Cpp
- ExperimentalEmbeddedC
- ESP32
- JavaScript
- XML
- MidC
- wasm-jit
- wasm

*--orderConnections*

Orders connect equations alphabetically if set.

Boolean (default `true`).

*-t, --typeinfo*

Prints out extra type information if set.

Boolean (default `false`).

*-a, --keepArrays*

Sets whether to split arrays or not.

Boolean (default `false`).

*-m, --modelicaOutput*

Enables valid modelica output for flat modelica.

Boolean (default `false`).

*-q, --silent*

Turns on silent mode.

Boolean (default `false`).

*-n, --numProcs*

Sets the number of processors to use (0=default=auto).

Integer (default `0`).

*-i, --instClass*

Instantiate the class given by the fully qualified path.

String (default *empty*).

*-v, --vectorizationLimit*

Sets the vectorization limit, arrays and matrices larger than this will not be vectorized.

Integer (default `0`).

*-s, --simulationCg*

Turns on simulation code generation.

Boolean (default `false`).

*--evalAnnotationParams*

Sets whether to evaluate parameters in annotations or not.

Boolean (default `false`).

*--unitChecking*

Enable unit checking.

Boolean (default `false`).

*--generateLabeledSimCode*

Turns on labeled SimCode generation for reduction algorithms.

Boolean (default `false`).

*--reduceTerms*

Turns on reducing terms for reduction algorithms.

Boolean (default `false`).

*--reductionMethod*

Sets the reduction method to be used.

String (default deletion). Valid options:

- deletion
- substitution
- linearization

*--demoMode*

Disable Warning/Error Massages.

Boolean (default `false`).

*--locale*

Override the locale from the environment.

String (default *empty*).

*-o, --defaultOCLDevice*

**Sets the default OpenCL device to be used for parallel execution. 0 (the** default) picks a suitable device automatically.

Integer (default `0`).

*--maxTraversals*

Maximal traversals to find simple equations in the acausal system.

Integer (default `2`).

*--dumpTarget*

Redirect the dump to file. If the file ends with .html HTML code is generated.

String (default *empty*).

*--delayBreakLoop*

Enables (very) experimental code to break algebraic loops using the delay() operator. Probably messes with initialization.

Boolean (default `true`).

*--tearingMethod*

Sets the tearing method to use. Select no tearing or choose tearing method.

String (default cellier). Valid options:

- noTearing (Deprecated, use minimalTearing.)
- minimalTearing (Minimal tearing method to only tear discrete variables.)
- omcTearing (Tearing method developed by TU Dresden: Frenkel, Schubert.)
- cellier (Tearing based on Celliers method, revised by FH Bielefeld: Täuber, Patrick)
- guruTearing (Tearing based solely on TearingSelect annotation. Forces prefer/always variables to be iteration variables.)

*--tearingHeuristic*

Sets the tearing heuristic to use for Cellier-tearing.

String (default MC3). Valid options:

- MC1 (Original cellier with consideration of impossible assignments and discrete Vars.)
- MC2 (Modified cellier, drop first step.)
- MC11 (Modified MC1, new last step 'count impossible assignments'.)
- MC21 (Modified MC2, new last step 'count impossible assignments'.)
- MC12 (Modified MC1, step 'count impossible assignments' before last step.)
- MC22 (Modified MC2, step 'count impossible assignments' before last step.)
- MC13 (Modified MC1, build sum of impossible assignment and causalizable equations, choose var with biggest sum.)
- MC23 (Modified MC2, build sum of impossible assignment and causalizable equations, choose var with biggest sum.)
- MC231 (Modified MC23, Two rounds, choose better potentials-set.)
- MC3 (Modified cellier, build sum of impossible assignment and causalizable equations for all vars, choose var with biggest sum.)
- MC4 (Modified cellier, use all heuristics, choose var that occurs most in potential sets)

*--scalarizeMinMax*

Scalarizes the builtin min/max reduction operators if true.

Boolean (default `false`).

*--strict*

Enables stricter enforcement of Modelica language rules.

Boolean (default `false`).

*--scalarizeBindings*

Always scalarizes bindings if set.

Boolean (default `false`).

*--hpcomScheduler*

Sets the scheduler for task graph scheduling (list | listr | level | levelfix | ext | metis | mcp | taskdep | tds | bls | rand | none). Default: level.

String (default level).

*--hpcomCode*

Sets the code-type produced by hpcom (openmp | pthreads | pthreads_spin | tbb | mpi). Default: openmp.

String (default openmp).

*--rewriteRulesFile*

Activates user given rewrite rules for Absyn expressions. The rules are read from the given file and are of the form rewrite(fromExp, toExp);

String (default *empty*).

*--replaceHomotopy*

Replaces homotopy(actual, simplified) with the actual expression or the simplified expression. Good for debugging models which use homotopy. The default is to not replace homotopy.

String (default none). Valid options:

- none (Default, do not replace homotopy.)
- actual (Replace homotopy(actual, simplified) with actual.)
- simplified (Replace homotopy(actual, simplified) with simplified.)

*--generateDynamicJacobian*

Select how Jacobian matrix is generated, where der(x) is differentiated w.r.t. x.

String (default numeric). Valid options:

- none (Does not generate Jacobian. For use with explicit solvers.)
- numeric (Generates sparsity pattern for numeric Jacobian.)
- symbolic (Generates symbolic Jacobian. Used by dassl or ida solver with simulation flag '-jacobian'.)
- symbolicadjoint (Generates adjoint Jacobian symbolically.)
- bidirectional (Generates bidirectional Jacobian using star bicoloring (ColPack). Combines forward and adjoint modes.)

*--generateSymbolicLinearization*

**Generates symbolic linearization matrices A,B,C,D for linear model:**
$\dot{x} = Ax + Bu\ y = Cx + Du$

Boolean (default `false`).

*--resizableMaxPieces*

The number of pieces a connector array may be split into by the connections with --resizableArrays before it is given up on (default 300).

Integer (default `300`).

*--profiling*

Sets the profiling level to use. Profiled equations and functions record execution time and count for each time step taken by the integrator.

String (default none). Valid options:

- none (Generate code without profiling)
- blocks (Generate code for profiling function calls as well as linear and non-linear systems of equations)
- blocks+html (Like blocks, but also run xsltproc and gnuplot to generate an html report)
- all (Generate code for profiling of all functions and equations)

- all_perf (Generate code for profiling of all functions and equations with additional performance data using the papi-interface (cpp-runtime))
- all_stat (Generate code for profiling of all functions and equations with additional statistics (cpp-runtime))

*--reshuffle*

sets tolerance of reshuffling algorithm: 1: conservative, 2: more tolerant, 3 resolve all

Integer (default `1`).

*--gDynOpt*

Generate dynamic optimization problem based on annotation approach.

Boolean (default `false`).

*--maxSizeSolveLinearSystem*

Max size for solveLinearSystem.

Integer (default `0`).

*--cppFlags*

Sets extra flags for compilation with the C++ compiler (e.g. +cppFlags=-O3,-Wall)

String list (default ).

*--removeSimpleEquations*

Specifies method that removes simple equations.

String (default default). Valid options:

- none (Disables module)
- default (Performs alias elimination and removes constant variables. Default case uses in preOpt phase the fastAcausal and in postOpt phase the causal implementation.)
- causal (Performs alias elimination and removes constant variables. Causal implementation.)
- fastAcausal (Performs alias elimination and removes constant variables. fastImplementation fastAcausal.)
- allAcausal (Performs alias elimination and removes constant variables. Implementation allAcausal.)
- new (New implementation (experimental))

*--dynamicTearing*

Activates dynamic tearing (TearingSet can be changed automatically during runtime, strict set vs. casual set.)

String (default false). Valid options:

- false (No dynamic tearing.)
- true (Dynamic tearing for linear and nonlinear systems.)
- linear (Dynamic tearing only for linear systems.)
- nonlinear (Dynamic tearing only for nonlinear systems.)

*--symSolver*

Activates symbolic implicit solver (original system is not changed).

String (default none).

*--loop2con*

Specifies method that transform loops in constraints. hint: using initial guess from file!

String (default none). Valid options:

- none (Disables module)
- lin (linear loops --> constraints)

- noLin (no linear loops --> constraints)
- all (loops --> constraints)

*--forceTearing*

Use tearing set even if it is not smaller than the original component.

Boolean (default `false`).

*--simplifyLoops*

Simplify algebraic loops.

Integer (default `0`). Valid options:

- 0 (do nothing)
- 1 (special modification of residual expressions)
- 2 (special modification of residual expressions with helper variables)

*--recursiveTearing*

Inline and repeat tearing.

Integer (default `0`). Valid options:

- 0 (do nothing)
- 1 (linear tearing set of size 1)
- 2 (linear tearing)

*--flowThreshold*

Sets the minium threshold for stream flow rates

Real (default `1e-7`).

*--matrixFormat*

Sets the matrix format type in cpp runtime which should be used (dense | sparse ). Default: dense.

String (default dense).

*--partlintorn*

Sets the limit for partitionin of linear torn systems.

Integer (default `0`).

*--initOptModules*

Sets the initialization optimization modules to use in the back end. See *--help=optmodules* for more info.

String list (default simplifyComplexFunction,tearingSystem,solveSimpleEquations,calculateStrongComponentJacobians,simplifyAl
Valid options:

- calculateStrongComponentJacobians (Generates analytical jacobian for torn linear and non-linear strong components. By default linear components and non-linear components with user-defined function calls are skipped. See also debug flags: LSanalyticJacobian, NLSanalyticJacobian and forceNLSanalyticJacobian)
- collapseArrayExpressions (Simplifies {x[1],x[2],x[3]} → x for arrays of whole variable references (simplifies code generation).)
- inlineArrayEqn (This module expands all array equations to scalar equations.)
- constantLinearSystem (Evaluates constant linear systems (a*x+b*y=c; d*x+e*y=f; a,b,c,d,e,f are constants) at compile-time.)
- extendDynamicOptimization (Move loops to constraints.)
- generateHomotopyComponents (Finds the parts of the DAE that have to be handled by the homotopy solver and creates a strong component out of it.)

- inlineHomotopy (Experimental: Inlines the homotopy expression to allow symbolic simplifications.)
- inputDerivativesUsed (Checks if derivatives of inputs are need to calculate the model.)
- recursiveTearing (inline and repeat tearing)
- reduceDynamicOptimization (Removes equations which are not needed for the calculations of cost and constraints. This module requires --postOptModules+=reduceDynamicOptimization.)
- replaceHomotopyWithSimplified (Replaces the homotopy expression homotopy(actual, simplified) with the simplified part.)
- simplifyAllExpressions (Does simplifications on all expressions.)
- simplifyComplexFunction (Some simplifications on complex functions (complex refers to the internal data structure))
- simplifyConstraints (Rewrites nonlinear constraints into box constraints if possible. This module requires +gDynOpt.)
- simplifyLoops (Simplifies algebraic loops. This modules requires +simplifyLoops.)
- solveSimpleEquations (Solves simple equations)
- tearingSystem (For method selection use flag tearingMethod.)
- wrapFunctionCalls (This module introduces variables for each function call and substitutes all these calls with the newly introduced variables.)

*--maxMixedDeterminedIndex*

Sets the maximum mixed-determined index that is handled by the initialization.

Integer (default `10`).

*--useLocalDirection*

Keeps the input/output prefix for all variables in the flat model, not only top-level ones.

Boolean (default `false`).

*--defaultOptModulesOrdering*

If this is activated, then the specified pre-/post-/init-optimization modules will be rearranged to the recommended ordering.

Boolean (default `true`).

*--preOptModules+*

Enables additional pre-optimization modules, e.g. --preOptModules+=module1,module2 would additionally enable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--preOptModules-*

Disables a list of pre-optimization modules, e.g. --preOptModules-=module1,module2 would disable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--postOptModules+*

Enables additional post-optimization modules, e.g. --postOptModules+=module1,module2 would additionally enable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--postOptModules-*

Disables a list of post-optimization modules, e.g. --postOptModules-=module1,module2 would disable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--initOptModules+*

Enables additional init-optimization modules, e.g. --initOptModules+=module1,module2 would additionally enable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--initOptModules-*

Disables a list of init-optimization modules, e.g. --initOptModules-=module1,module2 would disable module1 and module2. See *--help=optmodules* for more info.

String list (default *empty*).

*--instCacheSize*

Sets the size of the internal hash table used for instantiation caching.

Integer (default `25343`).

*--maxSizeLinearTearing*

Sets the maximum system size for tearing of linear systems (default 200).

Integer (default `200`).

*--maxSizeNonlinearTearing*

Sets the maximum system size for tearing of nonlinear systems (default 10000).

Integer (default `10000`).

*--noTearingForComponent*

Deactivates tearing for the specified components. Use '-d=tearingdump' to find out the relevant indexes.

Unknown default valueFlags.FlagData.INT_LIST_FLAG(data = {NIL})

*--daeMode*

Generates code to simulate models in DAE mode. The whole system is passed directly to the DAE solver SUNDIALS/IDA and no algebraic solver is involved in the simulation process.

Boolean (default `false`).

*--inlineMethod*

Sets the inline method to use. replace : This method inlines by replacing in place all expressions. Might lead to very long expression. append : This method inlines by adding additional variables to the whole system. Might lead to much bigger system.

String (default replace).

*--setTearingVars*

Sets the tearing variables by its strong component indexes. Use '-d=tearingdump' to find out the relevant indexes. Use following format: '--setTearingVars=(sci,n,t1,...,tn)*', with sci = strong component index, n = number of tearing variables, t1,...tn = tearing variables. E.g.: '--setTearingVars=4,2,3,5' would select variables 3 and 5 in strong component 4.

Unknown default valueFlags.FlagData.INT_LIST_FLAG(data = {NIL})

*--setResidualEqns*

Sets the residual equations by its strong component indexes. Use '-d=tearingdump' to find out the relevant indexes for the collective equations. Use following format: '--setResidualEqns=(sci,n,r1,...,rn)*', with sci = strong component index, n = number of residual equations, r1,...rn = residual equations. E.g.: '--setResidualEqns=4,2,3,5' would select equations 3 and 5 in strong component 4. Only works in combination with 'setTearingVars'.

Unknown default valueFlags.FlagData.INT_LIST_FLAG(data = {NIL})

*--ignoreCommandLineOptionsAnnotation*

Ignores the command line options specified as annotation in the class.

Boolean (default `false`).

*--calculateSensitivities*

Generates sensitivities variables and matrices.

Boolean (default `false`).

*-r, --alarm*

Sets the number of seconds until omc times out. Used by the testing framework to terminate infinite running processes. The running command is first asked to stop, so that omc can still report how far it got; it exits outright a tenth of that time later (at least 5 and at most 60 seconds) if the command has no cancellation point to stop at.

Integer (default `0`).

*--totalTearing*

Activates total tearing (determination of all possible tearing sets) for the specified components. Use '-d=tearingdump' to find out the relevant indexes.

Unknown default valueFlags.FlagData.INT_LIST_FLAG(data = {NIL})

*--ignoreSimulationFlagsAnnotation*

Ignores the simulation flags specified as annotation in the class.

Boolean (default `false`).

*--dynamicTearingForInitialization*

Enable Dynamic Tearing also for the initialization system.

Boolean (default `false`).

*--preferTVarsWithStartValue*

Prefer tearing variables with start value for initialization.

Boolean (default `true`).

*--equationsPerFile*

Generate code for at most this many equations per C-file (partially implemented in the compiler).

Integer (default `500`).

*--evaluateFinalParameters*

Evaluates all the final parameters in addition to parameters with annotation(Evaluate=true).

Boolean (default `false`).

*--evaluateProtectedParameters*

Evaluates all the protected parameters in addition to parameters with annotation(Evaluate=true).

Boolean (default `false`).

*--replaceEvaluatedParameters*

Replaces all the evaluated parameters in the DAE.

Boolean (default `true`).

*--condenseArrays*

Sets whether array expressions containing function calls are condensed or not.

Boolean (default `true`).

*--wfcAdvanced*

wrapFunctionCalls ignores more then default cases, e.g. exp, sin, cos, log, (experimental flag)

Boolean (default `false`).

*--tearingStrictness*

Sets the strictness of the tearing method regarding the solvability restrictions.

String (default strict). Valid options:

- casual (Loose tearing rules using ExpressionSolve to determine the solvability instead of considering the partial derivative. Allows to solve for everything that is analytically possible. This could lead to singularities during simulation.)
- strict (Robust tearing rules by consideration of the partial derivative. Allows to divide by parameters that are not equal to or close to zero.)
- veryStrict (Very strict tearing rules that do not allow to divide by any parameter. Use this if you aim at overriding parameters after compilation with values equal to or close to zero.)

*--interactive*

Sets the interactive mode for omc.

String (default none). Valid options:

- none (do nothing)
- tcp (Starts omc as a server listening on the socket interface.)
- zmq (Starts omc as a ZeroMQ server listening on the socket interface.)

*-z, --zeroMQFileSuffix*

Sets the file suffix for zeroMQ port file if --interactive=zmq is used.

String (default *empty*).

*--homotopyApproach*

Sets the homotopy approach.

String (default equidistantGlobal). Valid options:

- equidistantLocal (Local homotopy approach with equidistant lambda steps. The homotopy parameter only effects the local strongly connected component.)
- adaptiveLocal (Local homotopy approach with adaptive lambda steps. The homotopy parameter only effects the local strongly connected component.)
- equidistantGlobal (Default, global homotopy approach with equidistant lambda steps. The homotopy parameter effects the entire initialization system.)
- adaptiveGlobal (Global homotopy approach with adaptive lambda steps. The homotopy parameter effects the entire initialization system.)

*--ignoreReplaceable*

Sets whether to ignore replaceability or not when redeclaring.

Boolean (default `false`).

*--postOptModulesDAE*

Sets the optimization modules for the DAEmode in the back end. See *--help=optmodules* for more info.

String list (default lateInlineFunction,wrapFunctionCalls,simplifysemiLinear,simplifyComplexFunction,removeConstants,simplifyT

*--evalLoopLimit*

The loop iteration limit used when evaluating constant function calls.

Integer (default `100000`).

*--evalRecursionLimit*

The recursion limit used when evaluating constant function calls.

Integer (default `256`).

*--singleInstanceAglSolver*

Sets to instantiate only one algebraic loop solver all algebraic loops

Boolean (default `false`).

*--showStructuralAnnotations*

Show annotations affecting the solution process in the flattened code.

Boolean (default `false`).

*--initialStateSelection*

Activates the state selection inside initialization to avoid singularities.

Boolean (default `false`).

*--linearizationDumpLanguage*

Sets the target language for the produced code of linearization.

String (default none). Valid options:

- none (Don't generate code for linearization.)
- modelica (Generate linearized Modelica model.)
- matlab (Generate matlab function that returns linearization matrices A,B,C,D.)
- julia (Generate julia function that returns linearization matrices A,B,C,D.)
- python (Generate python function that returns linearization matrices A,B,C,D.)

*--noASSC*

Disables analytical to structural singularity conversion.

Boolean (default `false`).

*--fullASSC*

Enables full equation replacement for BLT transformation from the ASSC algorithm.

Boolean (default `false`).

*--realASSC*

Enables the ASSC algorithm to evaluate real valued coefficients (usually only integers).

Boolean (default `false`).

*--initASSC*

Enables the ASSC algorithm for initialization.

Boolean (default `false`).

*--maxSizeASSC*

Sets the maximum system size for the analytical to structural conversion algorithm (default 200).

Integer (default `200`).

*-f, --baseModelica*

Outputs experimental Base Modelica.

Boolean (default `false`).

*--fmiFilter*

Specifies which model variables are exposed by the modelDescription.xml

String (default protected). Valid options:

- none (All variables are exposed, even variables introduced by the symbolic transformations. This is mainly for debugging purposes.)
- internal (All model variables are exposed, including protected ones. Variables introduced by the symbolic transformations are filtered out, with minor exceptions, e.g. for state sets.)
- protected (All public model variables are exposed. Internal and protected variables are filtered out, with small exceptions, e.g. for state sets.)
- blackBox (Only the interface is exposed. All other variables are hidden or exposed with concealed names.)

*--fmiSources*

Defines how much source code FMUs will be exported with. --fmiFilter=blackBox might override this, because black box FMUs do never contain their source code.

String (default false). Valid options:

- false (The FMU carries no sources at all [default].)
- true (Same as slim.)
- slim (The FMU carries the sources it was built from. Under --simCodeTarget=C+Rust that is a mix of C and Rust, and rebuilding needs cargo to fetch the Rust dependencies from crates.io.)
- full (As slim, plus a vendored copy of the Rust dependencies, so the FMU rebuilds without network access. Only differs from slim under --simCodeTarget=C+Rust.)

*--fmiFlags*

Add simulation flags to FMU. Will create <fmiPrefix>_flags.json in resources folder with given flags. Use --fmiFlags or --fmiFlags=none to disable [default]. Use --fmiFlags=default for the default simulation flags. To pass flags use e.g. --fmiFlags=s:cvode,nls:homotopy or --fmiFlags=path/to/yourFlags.json.

String list (default *empty*).

*--fmuCMakeBuild*

Deprecated and ignored. Source-code FMUs are always built with CMake.

Boolean (default `true`).

*--newBackend*

Activates experimental new backend for better array handling. This also activates the new frontend. [WIP]

Boolean (default `false`).

*--parmodauto*

Experimental: Enable parallelization of independent systems of equations in the translated model. Only works on Linux systems.

Boolean (default `false`).

*--interactivePort*

Sets the port used by the interactive server.

Integer (default `0`).

*--allowNonStandardModelica*

Flags to allow non-standard Modelica.

String list (default *empty*). Valid options:

- nonStdMultipleExternalDeclarations (Allow several external declarations in functions.See: https://specification.modelica.org/maint/3.5/functions.html#function-as-a-specialized-class)
- nonStdEnumerationAsIntegers (Allow enumeration as integer without casting via Integer(Enum).See: https://specification.modelica.org/maint/3.5/class-predefined-types-and-declarations.html#type-conversion-of-enumeration-values-to-string-or-integer)

- nonStdIntegersAsEnumeration (Allow integer as enumeration without casting via Enum(Integer).See: https://specification.modelica.org/maint/3.5/class-predefined-types-and-declarations.html#type-conversion-of-integer-to-enumeration-values)
- nonStdDifferentCaseFileVsClassName (Allow directory or file with different case in the name than the contained class name.See: https://specification.modelica.org/maint/3.5/packages.html#mapping-package-class-structures-to-a-hierarchical-file-system)
- nonStdTopLevelOuter (Allow top level outer.See: https://specification.modelica.org/maint/3.6/scoping-name-lookup-and-flattening.html#S4.p1)
- protectedAccess (Allow access of protected elements)
- reinitInAlgorithms (Allow reinit in algorithm sections)
- unbalancedModel (Allow models to be locally unbalanced and to have unbalanced connectors)
- implicitParameterStartAttribute (Allow fixed parameters with no binding or start attribute)
- initialSimplified (Allow use of experimental operator *initialSimplified()*)
- illegalConditionalContext (Allow use of components with false conditions in illegal contexts)

*--exportClocksInModelDescription*

exports clocks in modeldescription.xml for fmus, The default is false.

Boolean (default `false`).

*--linkType*

Sets the link type for the simulation executable. dynamic: libraries are dynamically linked; the executable is built very fast but is not portable because of DLL dependencies. static: libraries are statically linked; the executable is built more slowly but it is portable and dependency-free.

String (default dynamic).

*--tearingAlwaysDer*

Always choose state derivatives as iteration variables in strong components.

Boolean (default `false`).

*--dumpFlatModel*

Dumps the flat model at the given stages of the frontend.

String list (default all). Valid options:

- flatten (After flattening but before connection handling.)
- connections (After connection handling.)
- eval (After evaluating constants.)
- simplify (After model simplification.)
- scalarize (After scalarizing arrays.)
- translateResidualsDAE (Show the result of the translateResidualsDAE API.)

*-u, --simulate*

Simulates the last model in the given Modelica file.

Boolean (default `false`).

*--obfuscate*

Obfuscates identifiers in the simulation model

String (default none). Valid options:

- none (No obfuscation.)

- encrypted (Obfuscates protected variables in encrypted models)
- protected (Obfuscates protected variables in all models.)
- full (Obfuscates everything.)

*--fmuRuntimeDepends*

Defines if runtime library dependencies are included in the FMU.

String (default default). Valid options:

- default (Depending on CMake version. If CMake version >= 3.21 use "modelica", otherwise use "none")
- none (No runtime library dependencies are copied into the FMU.)
- modelica (All modelica runtime library dependencies are copied into the FMU.System librarys located in '/lib*', '/usr/lib*' and '/usr/local/lib*' are excluded.Needs CMake version >= 3.21.)
- all (All runtime library dependencies are copied into the FMU.System librarys are copied as well.Needs CMake version >= 3.21.)

*--frontendInline*

Enables inlining of functions in the frontend.

Boolean (default `false`).

*--exposeLocalIOs*

Introduces top-level inputs/outputs for unconnected input/output connectors at requested levels, provided they are public, 0 meaning top-level (standard Modelica), 1 inputs/outputs of top-level components, >1 going deeper. This flag is particularly useful for FMI export.

Integer (default `0`).

*--baseModelicaFormat*

Formatting options for Base Modelica

String list (default *empty*). Valid options:

- scalarized (Include subscripts in the quoted identifiers ('a[1].x[3]').)
- partiallyScalarized (Include subscripts in the quoted identifiers, except for the last name ('a[1].x'[3]).)
- nonScalarized (Don't include subscripts in the quoted identifiers ('a'[1].'x'[3]).)
- withRecords (Keep records and don't expand them.)
- withoutRecords (Expand records into separate components.)
- showConfidence (Add comments that show confidence numbers for binding equations.)

*--baseModelicaOptions*

Enables optional Base Modelica options.

String list (default *empty*). Valid options:

- moveBindings (Moves movable binding equations to normal equations.)
- scalarize (Fully scalarize the Base Modelica model.)
- inlineFunctions (Inline all functions.)

*--debugFollowEquations*

Takes a list of equation names and prints the corresponding equations after each stage of the backend process.

String list (default *empty*).

*--maxSizeLinearization*

Sets the maximum system size for which linearization code is generated.

Integer (default `1000`).

*--resizableArrays*

Assumes all arrays are resizable. Only works with the new backend --newBackend.

Boolean (default `false`).

*--evaluateStructuralParameters*

Sets which structural parameters are evaluated by the frontend.

String (default all). Valid options:

- all (Evaluates all structural parameters)
- strictlyNecessary (Evaluates only structural parameters strictly required by the frontend)

*--loadMissingLibraries*

Automatically try to load a matching library if a name can't be found during name lookup.

Boolean (default `true`).

*--causalizeDaeMode*

The system is partially causalized and simple assignments are generated for equations that can be solved explicitly. Only works with --daeMode.

Boolean (default `true`).

*--simCodeScalarize*

Scalarizes variables during simcode phase.

Boolean (default `true`).

*--cmd*

Executes the string argument as a script before any other operation.

String (default *empty*).

*--moo*

Generate code for dynamic optimization library MOO.

Boolean (default `false`).

*--fmiExtraAnnotations*

Export annotations matching the given regex to extra/org.openmodelica/modelAnnotations.json.

String (default *empty*).

*--interactiveDumpFormat*

Selects the format interactive API calls use to print result values. default : The OpenModelica textual value format. json : JSON, for programmatic consumers such as the web clients.

String (default default).

*--export-fmu*

Export the model as an FMU after loading. Combine with --fmuType and --fmuPlatforms to configure the export.

Boolean (default `false`).

*--fmuType*

FMI type for FMU export: me, cs, me_cs, se.

String list (default me).

*--fmuPlatforms*

Platforms for FMU export, comma-separated (e.g. static,dynamic).

String (default static).

*--fmiVersion*

FMI version for FMU export: 1.0, 2.0, 3.0.

String (default 2.0). Valid options:

- 1.0
- 2.0
- 3.0

*--tearingCostMargin*

How much cheaper solving a linear system untorn has to be estimated before its tearing set is dropped. Raise it to keep tearing systems the estimate would give up on, lower it towards 0 to tear less (default 2).

Real (default `2.0`).

*--tplOutputDir*

Directory the .mo generated from a Susan .tpl is written to. Empty (the default) writes it next to the .tpl, which is how the templates used to be generated into the source tree.

String (default *empty*).

*--fmuDirectory*

Write an exported FMU as an unzipped directory named <prefix>.fmu rather than a zip file. An importer that reads a directory (OpenModelica's own does) then pays neither the compression nor the extraction, which for a wasm FMU carrying a precompiled artifact is most of what packing it costs. wasm FMUs only.

Boolean (default `false`).

*--tplInterfaceDir*

Directory searched before the current one for the interface files a Susan .tpl imports with 'import interface'.

String (default *empty*).

## 37.2 Debug flags

The debug flag takes a comma-separated list of flags which are used by the compiler for debugging or experimental purposes. Flags prefixed with "-" or "no" will be disabled. The available flags are (+ are enabled by default, - are disabled):

***Cache*** **(default: on)**
: Turns off the instantiation cache.

***LSanalyticJacobian*** **(default: off)**
: Enables analytical jacobian for linear strong components. Defaults to false

***NLSanalyticJacobian*** **(default: on)**
: Enables analytical jacobian for non-linear strong components without user-defined function calls, for that see forceNLSanalyticJacobian

***acceptTooManyFields*** **(default: off)**
: Accepts passing records with more fields than expected to a function. This is not allowed, but is used in Fluid.Dissipation. See https://trac.modelica.org/Modelica/ticket/1245 for details.

***aliasConflicts*** **(default: off)**
: Dumps alias sets with different start or nominal values.

***arrayConnect*** **(default: off)**
: Use experimental array connection handler.

*backendKeepEnv* **(default: on)**
When enabled, the environment is kept when entering the backend, which enables CevalFunction (function interpretation) to work. This module not essential for the backend to function in most cases, but can improve simulation performance by evaluating functions. The drawback to keeping the environment graph in memory is that it is huge (~80% of the total memory in use when returning the frontend DAE).

*backendReduceDAE* **(default: off)**
Prints all Reduce DAE debug information.

*backenddaeinfo* **(default: off)**
Enables dumping of back-end information about system (Number of equations before back-end,...).

*bltdump* **(default: off)**
Dumps information from index reduction.

*bltmatrixdump* **(default: off)**
Dumps the blt matrix in html file. IE seems to be very good in displaying large matrices.

*buildExternalLibs* **(default: on)**
Use the autotools project in the Resources folder of the library to build missing external libraries.

*ceval* **(default: off)**
Prints extra information from Ceval.

*cgraph* **(default: off)**
Prints out connection graph information.

*cgraphGraphVizFile* **(default: off)**
Generates a graphviz file of the connection graph.

*cgraphGraphVizShow* **(default: off)**
Displays the connection graph with the GraphViz lefty tool.

*checkASUB* **(default: off)**
Prints out a warning if an ASUB is created from a CREF expression.

*checkBackendDae* **(default: off)**
Do some simple analyses on the datastructure from the frontend to check if it is consistent.

*checkDAECrefType* **(default: off)**
Enables extra type checking for cref expressions.

*checkDefUse* **(default: off)**
Warns about variables in functions that cannot statically be proven to be defined (given a value) before they are used, e.g. variables only assigned on some control flow paths. Per the Modelica specification using an uninitialized variable is an error.

*checkSimplify* **(default: off)**
Enables checks for expression simplification and prints a notification whenever an undesirable transformation has been performed.

*checkUsedElementsLookup* **(default: off)**
Checks the classes found by the lookup of getDefUseChains and getClassDiagram against the new frontend's lookup.

*combineSubscripts* **(default: off)**
Move all subscripts to the end of component references.

*constjac* **(default: off)**
solves linear systems with constant Jacobian and variable b-Vector symbolically

*countOperations* **(default: off)**
Count operations.

*daedumpgraphv* **(default: off)**
Dumps the DAE in graphviz format.

*dataReconciliation* **(default: off)**
Dumps all the dataReconciliation extraction algorithm procedure

*debugAdjoint* **(default: off)**
Dumps debug output for the adjoint differentiation process in the new backend.

*debugAlgebraicLoopsJacobian* **(default: off)**
Dumps debug output while creating symbolic jacobians for non-linear systems.

*debugAlias* **(default: off)**
Dumps some information about the process of removeSimpleEquations.

*debugDAEmode* **(default: off)**
Dump debug output for the DAEmode.

*debugDifferentiation* **(default: off)**
Dumps debug output for the differentiation process.

*debugDifferentiationVerbose* **(default: off)**
Dumps verbose debug output for the differentiation process.

*disableColoring* **(default: off)**
Disables coloring algorithm while spasity detection.

*disableDirectionalDerivatives* **(default: on)**
For FMI 2.0 only dependecy analysis will be perform.

*disableFMIDependency* **(default: off)**
Disables the dependency analysis and generation for FMI 2.0.

*disableJacsforSCC* **(default: off)**
Disables calculation of jacobians to detect if a SCC is linear or non-linear. By disabling all SCC will handled like non-linear.

*disableRecordConstructorOutput* **(default: off)**
Disables output of record constructors in the flat code.

*disableSingleFlowEq* **(default: off)**
Disables the generation of single flow equations.

*disableStartCalc* **(default: off)**
Deactivates the pre-calculation of start values during compile-time.

*disableWindowsPathCheckWarning* **(default: off)**
Disables warnings on Windows if OPENMODELICAHOME/MinGW is missing.

*discreteinfo* **(default: off)**
Enables dumping of discrete variables. Extends -d=backenddaeinfo.

*dummyselect* **(default: off)**
Dumps information from dummy state selection heuristic.

*dump* **(default: off)**
Dumps the absyn representation of a program.

*dumpASSC* **(default: off)**
Dumps the conversion process of analytical to structural singularities.

*dumpBackendClocks* **(default: off)**
Dumps times for each backend module (only new backend).

*dumpBackendInline* **(default: off)**
Dumps debug output while inline function.

*dumpBackendInlineVerbose* **(default: off)**
Dumps debug output while inline function.

*dumpBindings* **(default: off)**
Dumps information about the equations created from bindings.

*dumpCSE* **(default: off)**
Additional output for CSE module.

*dumpCSE_verbose* **(default: off)**
Additional output for CSE module.

*dumpCheckModel* **(default: off)**
Dumps the variables and equations found by checkModel.

*dumpConstrepl* **(default: off)**
Dump the found replacements for constants.

*dumpConversionRules* **(default: off)**
Dumps the rules when converting a package using a conversion script.

*dumpEArepl* **(default: off)**
Dump the found replacements for evaluate annotations (evaluate=true) parameters.

*dumpEncapsulateConditions* **(default: off)**
Dumps the results of the preOptModule encapsulateWhenConditions.

*dumpEqInUC* **(default: off)**
Dumps all equations handled by the unit checker.

*dumpEqUCStruct* **(default: off)**
Dumps all the equations handled by the unit checker as tree-structure.

*dumpEvents* **(default: off)**
Dumps information about the detected event functions.

*dumpExcludedSymJacExps* **(default: off)**
This flags dumps all expression that are excluded from differentiation of a symbolic Jacobian.

*dumpFPrepl* **(default: off)**
Dump the found replacements for final parameters.

*dumpFunctions* **(default: off)**
Add functions to backend dumps.

*dumpHomotopy* **(default: off)**
Dumps the results of the postOptModule optimizeHomotopyCalls.

*dumpInlineSolver* **(default: off)**
Dumps the inline solver equation system.

*dumpJL* **(default: off)**
Dumps the absyn representation of a program as a Julia representation

*dumpLoops* **(default: off)**
Dumps loop equation.

*dumpLoopsVerbose* **(default: off)**
Dumps loop equation and enhanced adjacency matrix.

*dumpPPrepl* **(default: off)**
Dump the found replacements for protected parameters.

*dumpParamrepl* **(default: off)**
Dump the found replacements for remove parameters.

*dumpRecursiveTearing* **(default: off)**
Dump between steps of recursiveTearing

*dumpResizable* **(default: off)**
Dumps information about resizable paremeter handling.

*dumpSCCGraphML* **(default: off)**
Dumps graphml files with the strongly connected components.

***dumpSetBasedGraphs*** **(default: off)**
Dumps information about set based graphs for efficient array handling (only new frontend and new backend).

***dumpSimCode*** **(default: off)**
Dumps the simCode model used for code generation.

***dumpSimplify*** **(default: off)**
Dumps expressions before and after simplification.

***dumpSimplifyLoops*** **(default: off)**
Dump between steps of simplifyLoops

***dumpSlice*** **(default: off)**
Dumps information about the slicing process (pseudo-array causalization).

***dumpSolve*** **(default: off)**
Dumps information about equation solving.

***dumpSortEqnsAndVars*** **(default: off)**
Dumps debug output for the modules sortEqnsVars.

***dumpSorting*** **(default: off)**
Dumps information about the process of sorting.

***dumpSparsePattern*** **(default: off)**
Dumps sparse pattern with coloring used for simulation.

***dumpSparsePatternVerbose*** **(default: off)**
Dumps in verbose mode sparse pattern with coloring used for simulation.

***dumpSynchronous*** **(default: off)**
Dumps information of the clock partitioning.

***dumpUnits*** **(default: off)**
Dumps all the calculated units.

***dumpdaelow*** **(default: off)**
Dumps the equation system at the beginning of the back end.

***dumpdgesv*** **(default: off)**
Enables dumping of the information whether DGESV is used to solve linear systems.

***dumpeqninorder*** **(default: off)**
Enables dumping of the equations in the order they are calculated.

***dumpindxdae*** **(default: off)**
Dumps the equation system after index reduction and optimization.

***dumpinitialsystem*** **(default: off)**
Dumps the initial equation system.

***dumprepl*** **(default: off)**
Dump the found replacements for simple equation removal.

***dynload*** **(default: off)**
Display debug information about dynamic loading of compiled functions.

***evalFuncDump*** **(default: off)**
dumps debug information about the function evaluation

***evalOutputOnly*** **(default: off)**
Generates equations to calculate top level outputs only.

***evalParameterDump*** **(default: off)**
Dumps information for evaluating parameters.

***evalfunc*** **(default: on)**
Turns on/off symbolic function evaluation.

*evaluateAllParameters* **(default: off)**
Evaluates all parameters if set, except the ones that have annotation(Evaluate = false).

*events* **(default: on)**
Turns on/off events handling.

*execHash* **(default: off)**
Measures the time it takes to hash all simcode variables before code generation.

*execstat* **(default: off)**
Prints out execution statistics for the compiler.

*execstatGCcollect* **(default: off)**
When running execstat, also perform an extra full garbage collection.

*experimentalReductions* **(default: off)**
Turns on custom reduction functions (OpenModelica extension).

*failtrace* **(default: off)**
Sets whether to print a failtrace or not.

*flowAliasElimination* **(default: off)**
Enables simple alias elimination of flow variables in stream connectors.

*fmuExperimental* **(default: off)**
Adds features to the FMI export that are considered experimental as of now: fmi2GetSpecificDerivatives, canGetSetFMUState, canSerializeFMUstate

*force-fmi-attributes* **(default: off)**
Force to export all fmi attributes to the modelDescription.xml, including those which have default values

*forceNLSanalyticJacobian* **(default: off)**
Forces calculation analytical jacobian also for non-linear strong components with user-defined functions.

*forceScalarize* **(default: off)**
Forces scalarization to be done when it would normally be automatically disabled.

*frontEndUnitCheck* **(default: off)**
Checks the consistency of units in equation.

*gcProfiling* **(default: off)**
Prints garbage collection stats to standard output.

*gen* **(default: off)**
Turns on/off dynamic loading of functions that are compiled during translation. Only enable this if external functions are needed to calculate structural parameters or constants.

*gendebugsymbols* **(default: off)**
Generate code with debugging symbols.

*generateCodeCheat* **(default: off)**
Used to generate code for the bootstrapped compiler.

*graphInst* **(default: off)**
Do graph based instantiation.

*graphInstGenGraph* **(default: off)**
Dumps a graph of the program. Use with -d=graphInst

*graphInstRunDep* **(default: off)**
Run scode dependency analysis. Use with -d=graphInst

*graphml* **(default: off)**
Dumps .graphml files for the bipartite graph after Index Reduction and a task graph for the SCCs. Can be displayed with yEd.

*graphviz* **(default: off)**
Dumps the absyn representation of a program in graphviz format.

*graphvizDump* **(default: off)**
Activates additional graphviz dumps (as .dot files). It can be used in addition to one of the following flags: {dumpdaelow|dumpinitialsystems|dumpindxdae}.

*hardcodedStartValues* **(default: off)**
Embed the start values of variables and parameters into the c++ code and do not read it from xml file.

*hpcom* **(default: off)**
Enables parallel calculation based on task-graphs.

*hpcomDump* **(default: off)**
Dumps additional information on the parallel execution with hpcom.

*hpcomMemoryOpt* **(default: off)**
Optimize the memory structure regarding the selected scheduler

*ignoreCycles* **(default: off)**
Ignores cycles between constant/parameter components.

*implOde* **(default: off)**
activates implicit codegen

*infoXmlOperations* **(default: off)**
Enables output of the operations in the _info.xml file when translating models.

*initialization* **(default: off)**
Shows additional information from the initialization process.

*inlineFunctions* **(default: on)**
Controls if function inlining should be performed.

*inlineSolver* **(default: off)**
Generates code for inline solver.

*instance* **(default: off)**
Prints extra failtrace from InstanceHierarchy.

*interactive* **(default: off)**
Starts omc as a server listening on the socket interface.

*interactivedump* **(default: off)**
Prints out debug information for the interactive server.

*iterationVars* **(default: off)**
Shows a list of all iteration variables.

*listAppendWrongOrder* **(default: on)**
Print notifications about bad usage of listAppend.

*lookup* **(default: off)**
Print extra failtrace from lookup.

*mergeAlgSections* **(default: off)**
Disables coloring algorithm while sparsity detection.

*mergeComponents* **(default: off)**
Enables automatic merging of components into arrays.

*metaModelicaRecordAllocWords* **(default: off)**
Instrument the source code to record memory allocations (requires run-time and generated files compiled with -DOMC_RECORD_ALLOC_WORDS).

*multirate* **(default: off)**
The solver can switch partitions in the system.

*newInst* **(default: on)**
Enables new instantiation phase.

*nfAPI* **(default: on)**
Enables experimental new instantiation use in the OMC API.

*nfAPIDynamicSelect* **(default: off)**
Show DynamicSelect(static, dynamic) in annotations. Default to false and will select the first (static) expression

*nfAPINoise* **(default: off)**
Enables error display for the experimental new instantiation use in the OMC API.

*nfEvalConstArgFuncs* **(default: on)**
Evaluate all functions with constant arguments in the new frontend.

*nfExpandFuncArgs* **(default: off)**
Expand all function arguments in the new frontend.

*nfExpandOperations* **(default: on)**
Expand all unary/binary operations to scalar expressions in the new frontend.

*nfScalarize* **(default: on)**
Run scalarization in NF, default true.

*oldFrontEndUnitCheck* **(default: off)**
Checks the consistency of units in equation (for the old front-end).

*omedit* **(default: off)**
Set by OMEdit, so the compiler can emit output only a GUI consumes.

*optdaedump* **(default: off)**
Dumps information from the optimization modules.

*parallelCodegen* **(default: on)**
Enables code generation in parallel (disable this if compiling a model causes you to run out of RAM).

*paramdlowdump* **(default: off)**
Enables dumping of the parameters in the order they are calculated.

*partitionInitialization* **(default: on)**
This flag controls if partitioning is applied to the initialization system.

*patternmAllInfo* **(default: off)**
Adds notifications of all pattern-matching optimizations that are performed.

*patternmDeadCodeElimination* **(default: on)**
Performs dead code elimination in match-expressions.

*patternmMoveLastExp* **(default: on)**
Optimization that moves the last assignment(s) into the result of a match-expression. For example: equation c = fn(b); then c; => then fn(b);

*patternmSkipFilterUnusedBindings* (default: off)

*printRecordTypes* **(default: off)**
Prints out record types as part of the flat code.

*printStructuralParameters* **(default: off)**
Prints the structural parameters identified by the front-end

*pthreads* **(default: off)**
Experimental: Unused parallelization.

*relidx* **(default: off)**
Prints out debug information about relations, that are used as zero crossings.

*relocatableFunctions* **(default: off)**
Generates relocatable code: all functions become function pointers and can be replaced at run-time.

*reportSerializedSize* **(default: off)**
Reports serialized sizes of various data structures used in the compiler.

***reshufflePost*** **(default: off)**
Reshuffles the systems of equations.

***resolveLoopsDump*** **(default: off)**
Debug Output for ResolveLoops Module.

***rml*** **(default: off)**
Converts Modelica-style arrays to lists.

***runtimeStaticLinking*** **(default: off)**
Use the static simulation runtime libraries (C++ simulation runtime).

***scodeDep*** **(default: on)**
Does scode dependency analysis prior to instantiation. Defaults to true.

***semiLinear*** **(default: off)**
Enables dumping of the optimization information when optimizing calls to semiLinear.

***shortOutput*** **(default: off)**
Enables short output of the simulate() command. Useful for tools like OMNotebook.

***showDaeGeneration*** **(default: off)**
Show the dae variable declarations as they happen.

***showEquationSource*** **(default: off)**
Display the element source information in the dumped DAE for easier debugging.

***showExpandableInfo*** **(default: off)**
Show information about expandable connector handling.

***showInstCacheInfo*** **(default: off)**
Prints information about instantiation cache hits and additions. Defaults to false.

***showStartOrigin*** **(default: off)**
Enables dumping of the DAE startOrigin attribute of the variables.

***showStatement*** **(default: off)**
Shows the statement that is currently being evaluated when evaluating a script.

***skipInputOutputSyntacticSugar*** **(default: off)**
Used when bootstrapping to preserve the input output parsing of the code output by the list command.

***stateselection*** **(default: off)**
Enables dumping of selected states. Extends -d=backenddaeinfo.

***static*** **(default: off)**
Enables extra debug output from the static elaboration.

***stripPrefix*** **(default: on)**
Strips the environment prefix from path/crefs. Defaults to true.

***susanDebug*** **(default: off)**
Makes Susan generate code using try/else to better debug which function broke the expected match semantics.

***symJacConstantSplit*** **(default: off)**
Generates all symbolic Jacobians with splitted constant parts.

***symjacdump*** **(default: off)**
Dumps information about symbolic Jacobians.

***symjacdumpverbose*** **(default: off)**
Dumps information in verbose mode about symbolic Jacobians.

***tail*** **(default: off)**
Prints out a notification if tail recursion optimization has been applied.

***tearingCost*** **(default: off)**
Dumps the estimated cost of every torn system against solving it untorn.

*tearingdump* **(default: off)**
Dumps tearing information.

*tearingdumpV* **(default: off)**
Dumps verbose tearing information.

*totaltearingdump* **(default: off)**
Dumps total tearing information.

*totaltearingdumpV* **(default: off)**
Dumps verbose total tearing information.

*tplPerfTimes* **(default: off)**
Enables output of template performance data for rendering text to file.

*transformsbeforedump* **(default: off)**
Applies transformations required for code generation before dumping flat code.

*types* **(default: off)**
Prints extra failtrace from Types.

*uncertainties* **(default: off)**
Enables dumping of status when calling modelEquationsUC.

*updmod* **(default: off)**
Prints information about modification updates.

*useMPI* **(default: off)**
Add MPI init and finalize to main method (CPPruntime).

*vectorize* **(default: off)**
Activates vectorization in the backend.

*vectorizeBindings* **(default: off)**
Turns on vectorization of bindings when scalarization is turned off.

*visxml* **(default: off)**
Outputs a xml-file that contains information for visualization.

*warnMinMax* **(default: on)**
Makes a warning assert from min/max variable attributes instead of error.

*warnNoNominal* **(default: off)**
Prints the iteration variables in the initialization and simulation DAE, which do not have a nominal value.

*writeToBuffer* **(default: off)**
Enables writing simulation results to buffer.

*zmqDangerousAcceptConnectionsFromAnywhere* **(default: off)**
When opening a zmq connection, listen on all interfaces instead of only connections from 127.0.0.1.

## 37.3 Flags for Optimization Modules

Flags that determine which symbolic methods are used to produce the causalized equation system.

The *--preOptModules* flag sets the optimization modules which are used before the matching and index reduction in the back end. These modules are specified as a comma-separated list.

The *--matchingAlgorithm* sets the method that is used for the matching algorithm, after the pre optimization modules.

The *--indexReductionMethod* sets the method that is used for the index reduction, after the pre optimization modules.

The *--initOptModules* then sets the optimization modules which are used after the index reduction to optimize the system for initialization, specified as a comma-separated list.

The *--postOptModules* then sets the optimization modules which are used after the index reduction to optimize the system for simulation, specified as a comma-separated list.

CHAPTER

# THIRTYEIGHT

# SIMULATION RUNTIME FLAGS

This chapter contains a *short overview of simulation flags* as well as additional details of the *numerical integration methods*.

## 38.1 C Runtime Simulation Flags

The simulation executable takes the following flags:

***-abortSlowSimulation***
Aborts if the simulation chatters: 1000 state events in a row within 1e-6 times the simulation interval, or 100 within 1e-9 times it, and within the step size.

***-alarm=value* *or* -alarm value**
Aborts after the given number of seconds (default=0 disables the alarm).

***-clock=value* *or* -clock value**
Selects the type of clock to use. Valid options include:

- RT (monotonic real-time clock)
- CYC (cpu cycles measured with RDTSC)
- CPU (process-based CPU-time)

***-cpu***
Dumps the cpu-time into the result file using the variable named $cpuTime.

***-csvOstep=value* *or* -csvOstep value**
Value specifies csv-files for debug values for optimizer step.

***-cvodeNonlinearSolverIteration=value* *or* -cvodeNonlinearSolverIteration value**
Nonlinear solver iteration for CVODE solver. Default: Depends on flag cvodeLinearMultistepMethod. Valid values

- **CV_ITER_NEWTON - Newton iteration.**
  Advised to use together with flag -cvodeLinearMultistepMethod=CV_BDF.
- **CV_ITER_FIXED_POINT - Fixed-Point iteration iteration.**
  Advised to use together with flag -cvodeLinearMultistepMethod=CV_ADAMS.

***-cvodeLinearMultistepMethod=value* *or* -cvodeLinearMultistepMethod value**
Linear multistep method for CVODE solver. Default: CV_BDF. Valid values

- **CV_BDF - BDF linear multistep method for stiff problems.**
  Use together with flag -cvodeNonlinearSolverIteration=CV_ITER_NEWTON or don't set cvodeNonlinearSolverIteration.
- **CV_ADAMS - Adams-Moulton linear multistep method for nonstiff problems.**
  Use together with flag -cvodeNonlinearSolverIteration=CV_ITER_FIXED_POINT or don't set cvodeNonlinearSolverIteration.

***-cx=value* *or* -cx value**
Value specifies an csv-file with inputs as correlation coefficient matrix Cx for DataReconciliation

*-daeMode*
Enables daeMode simulation if the model was compiled with the omc flag --daeMode and ida method is used.

*-deltaXLinearize=value* ***or*** **-deltaXLinearize value**
Value specifies the delta x value for numerical differentiation used by linearization. The default value is sqrt(DBL_EPSILON*2e1).

*-deltaXSolver=value* ***or*** **-deltaXSolver value**
Value specifies the delta x value for numerical differentiation used by integration method. The default values is sqrt(DBL_EPSILON).

*-embeddedServer=value* ***or*** **-embeddedServer value**
Enables an embedded server. Valid values:

- none - default, run without embedded server
- opc-da - [broken] run with embedded OPC DA server (WIN32 only, uses proprietary OPC SC interface)
- opc-ua - [experimental] run with embedded OPC UA server (TCP port 4841 for now; will have its own configuration option later)
- filename - path to a shared object implementing the embedded server interface (requires access to internal OMC data-structures if you want to read or write data)

*-embeddedServerPort=value* ***or*** **-embeddedServerPort value**
Value specifies the port number used by the embedded server. The default value is 4841.

*-mat_sync=value* ***or*** **-mat_sync value**
Syncs the mat file header after emitting every N time-points.

*-emit_protected*
Emits protected variables to the result-file.

*-eps=value* ***or*** **-eps value**
Value specifies the number of convergence iteration to be performed for DataReconciliation

*-f=value* ***or*** **-f value**
Value specifies a new setup XML file to the generated simulation code.

*-help=value* ***or*** **-help value**
Get detailed information that specifies the command-line flag

For example, -help=f prints detailed information for command-line flag f.

*-homAdaptBend=value* ***or*** **-homAdaptBend value**
Maximum trajectory bending to accept the homotopy step. Default: 0.5, which means the corrector vector has to be smaller than half of the predictor vector.

*-homBacktraceStrategy=value* ***or*** **-homBacktraceStrategy value**
Value specifies the backtrace strategy in the homotopy corrector step. Valid values:

- fix - default, go back to the path by fixing one coordinate
- orthogonal - go back to the path in an orthogonal direction to the tangent vector

*-homHEps=value* ***or*** **-homHEps value**
Tolerance respecting residuals for the homotopy H-function (default: 1e-5).

In the last step (lambda=1) newtonFTol is used as tolerance.

*-homMaxLambdaSteps=value* ***or*** **-homMaxLambdaSteps value**
Maximum lambda steps allowed to run the homotopy path (default: system size * 100).

*-homMaxNewtonSteps=value* ***or*** **-homMaxNewtonSteps value**
Maximum newton steps in the homotopy corrector step (default: 20).

*-homMaxTries=value* ***or*** **-homMaxTries value**
Maximum number of tries for one homotopy lambda step (default: 10).

*-homNegStartDir*
Start to run along the homotopy path in the negative direction.

If one direction fails, the other direction is always used as fallback option.

*-homotopyOnFirstTry*
If the model contains the homotopy operator, directly use the homotopy method to solve the initialization problem. This is already the default behaviour, this flag can be used to undo the effect of -noHomotopyOnFirstTry

*-noHomotopyOnFirstTry*
Disable the use of the homotopy method to solve the initialization problem. Without this flag, the solver tries to solve the initialization problem with homotopy if the model contains the homotopy-operator.

*-homTauDecFac=value* ***or*** **-homTauDecFac value**
Decrease homotopy step size tau by this factor if tau is too big in the homotopy corrector step (default: 10.0).

*-homTauDecFacPredictor=value* ***or*** **-homTauDecFacPredictor value**
Decrease homotopy step size tau by this factor if tau is too big in the homotopy predictor step (default: 2.0).

*-homTauIncFac=value* ***or*** **-homTauIncFac value**
Increase homotopy step size tau by this factor if tau can be increased after the homotopy corrector step (default: 2.0).

*-homTauIncThreshold=value* ***or*** **-homTauIncThreshold value**
Increase the homotopy step size tau if homAdaptBend/bend > homTauIncThreshold (default: 10).

*-homTauMax=value* ***or*** **-homTauMax value**
Maximum homotopy step size tau for the homotopy process (default: 10).

*-homTauMin=value* ***or*** **-homTauMin value**
Minimum homotopy step size tau for the homotopy process (default: 1e-4).

*-homTauStart=value* ***or*** **-homTauStart value**
Homotopy step size tau at the beginning of the homotopy process (default: 0.2).

*-idaMaxErrorTestFails=value* ***or*** **-idaMaxErrorTestFails value**
Value specifies the maximum number of error test failures in attempting one step. The default value is 7.

*-idaMaxNonLinIters=value* ***or*** **-idaMaxNonLinIters value**
Value specifies the maximum number of nonlinear solver iterations at one step. The default value is 3.

*-idaMaxConvFails=value* ***or*** **-idaMaxConvFails value**
Value specifies the maximum number of nonlinear solver convergence failures at one step. The default value is 10.

*-idaNonLinConvCoef=value* ***or*** **-idaNonLinConvCoef value**
Value specifies the safety factor in the nonlinear convergence test. The default value is 0.33.

*-idaLS=value* ***or*** **-idaLS value**
Value specifies the linear solver of the ida integration method. Valid values:

- dense (ida internal dense method.)
- klu (ida use sparse direct solver KLU. (default))
- spgmr (ida generalized minimal residual method. Iterative method)
- spbcg (ida Bi-CGStab. Iterative method)
- sptfqmr (ida TFQMR. Iterative method)

*-idaScaling*
Enable scaling of the IDA solver.

*-idaSensitivity*
Enables sensitivity analysis with respect to parameters if the model is compiled with omc flag --calculateSensitivities.

*-ignoreHideResult*
Emits also variables with HideResult=true annotation.

*-iif=value* ***or*** **-iif value**
Value specifies an external file for the initialization of the model.

*-iim=value* ***or*** **-iim value**
Value specifies the initialization method. Following options are available: 'symbolic' (default) and 'none'.

- none (sets all variables to their start values and skips the initialization process)
- symbolic (solves the initialization problem symbolically - default)

*-iit=value* ***or*** **-iit value**
Value [Real] specifies a time for the initialization of the model.

*-ils=value* ***or*** **-ils value**
Value specifies the number of steps for homotopy method (required: -iim=symbolic). The value is an Integer with default value 3.

*-initialStepSize=value* ***or*** **-initialStepSize value**
Value specifies an initial step size, used by the methods: dassl, ida, gbode

*-csvInput=value* ***or*** **-csvInput value**
Value specifies an csv-file with inputs for the simulation/optimization of the model

*-stateFile=value* ***or*** **-stateFile value**
Value specifies an file with states start values for the optimization of the model.

*-inputPath=value* ***or*** **-inputPath value**
Value specifies a path for reading the input files i.e., model_init.xml and model_info.json

*-ipopt_hesse=value* ***or*** **-ipopt_hesse value**
Value specifies the hessematrix for Ipopt(OMC, BFGS, const).

*-ipopt_init=value* ***or*** **-ipopt_init value**
Value specifies the initial guess for optimization (sim, const).

*-ipopt_jac=value* ***or*** **-ipopt_jac value**
Value specifies the Jacobian for Ipopt(SYM, NUM, NUMDENSE).

*-ipopt_max_iter=value* ***or*** **-ipopt_max_iter value**
Value specifies the max number of iteration for ipopt.

*-ipopt_warm_start=value* ***or*** **-ipopt_warm_start value**
Value specifies lvl for a warm start in ipopt: 1,2,3,...

*-jacobian=value* ***or*** **-jacobian value**
Select the calculation method for Jacobian used by the integration method:

- coloredNumerical (Colored numerical Jacobian, which is default for dassl and ida. Needs omc compiler flag --generateDynamicJacobian=numeric. With option -idaLS=klu a sparse matrix is used.)
- internalNumerical (Dense solver internal numerical Jacobian.)
- coloredSymbolical (Colored symbolical Jacobian. Needs omc compiler flag --generateDynamicJacobian=symbolic. With option -idaLS=klu a sparse matrix is used.)
- coloredSymbolicalAdjoint (Colored symbolical adjoint Jacobian. Needs omc compiler flags --newBackend and --generateDynamicJacobian=symbolicadjoint.)
- numerical (Dense numerical Jacobian.)
- symbolical (Dense symbolical Jacobian. Needs omc compiler flag --generateDynamicJacobian=symbolic.)
- bicoloredSymbolical (Bidirectional (star bicolored) symbolical Jacobian. Needs omc compiler flags --newBackend and --generateDynamicJacobian=bidirectional.)

***-jacobianNominalFactor=value* or -jacobianNominalFactor value**
The numerical Jacobian differences column i over

```
delta_h * max(|x[i]|, |h*x'[i]|)
```

and, where that is inside the variable's own absolute tolerance and so is no scale of its own, over delta_h*factor*nominal[i] instead. Lower the factor for a model that is non-smooth at that wider step; the value is a Double with default value 1.0.

***-l=value* or -l value**
Value specifies a time where the linearization of the model should be performed.

***-l_datarec***
Emit data recovery matrices with model linearization.

***-logFormat=value* or -logFormat value**
Value specifies the log format of the executable:

- text (default)
- xml
- xmltcp (required -port flag)

***-ls=value* or -ls value**
Value specifies the linear solver method

- lapack (method using LAPACK LU factorization)
- lis (method using iterative solver Lis)
- klu (method using KLU sparse linear solver)
- umfpack (method using UMFPACK sparse linear solver)
- totalpivot (method using a total pivoting LU factorization for underdetermination systems)
- default (default method - LAPACK with total pivoting as fallback)

***-ls_ipopt=value* or -ls_ipopt value**
Value specifies the linear solver method for Ipopt, default mumps. Note: Use if you build ipopt with other linear solver like ma27

***-lss=value* or -lss value**
Value specifies the linear sparse solver method

- default (the default sparse linear solver (or a dense solver if there is none available) )
- lis (method using iterative solver Lis)
- klu (method using klu sparse linear solver)
- umfpack (method using umfpack sparse linear solver)

***-lssMaxDensity=value* or -lssMaxDensity value**
Value specifies the maximum density for using a linear sparse solver. The value is a Double with default value 0.2.

***-lssMinSize=value* or -lssMinSize value**
Value specifies the minimum system size for using a linear sparse solver. The value is an Integer with default value 1000.

***-lv=value* or -lv value**
Value (a comma-separated String list) specifies which logging levels to enable. Multiple options can be enabled at the same time.

- LOG_STDOUT (this stream is always active, can be disabled with -lv=-LOG_STDOUT)
- LOG_ASSERT (this stream is always active, can be disabled with -lv=-LOG_ASSERT)
- LOG_DASSL (additional information about dassl solver)

- LOG_DASSL_STATES (outputs the states at every dassl call)
- LOG_DEBUG (additional debug information)
- LOG_DELAY (debug information for delay operator)
- LOG_DIVISION (Log division by zero)
- LOG_DSS (outputs information about dynamic state selection)
- LOG_DSS_JAC (outputs jacobian of the dynamic state selection)
- LOG_DT (additional information about dynamic tearing)
- LOG_DT_CONS (additional information about dynamic tearing (local and global constraints))
- LOG_EVENTS (additional information during event iteration)
- LOG_EVENTS_V (verbose logging of event system)
- LOG_GBODE (information about GBODE solver)
- LOG_GBODE_V (verbose information about GBODE solver)
- LOG_GBODE_NLS (log non-linear solver process of GBODE solver)
- LOG_GBODE_NLS_V (verbose log non-linear solver process of GBODE solver)
- LOG_GBODE_STATES (output states at every GBODE call)
- LOG_INIT (additional information during initialization)
- LOG_INIT_HOMOTOPY (log homotopy initialization)
- LOG_INIT_V (verbose information during initialization)
- LOG_IPOPT (information from Ipopt)
- LOG_IPOPT_FULL (more information from Ipopt)
- LOG_IPOPT_JAC (check jacobian matrix with Ipopt)
- LOG_IPOPT_HESSE (check hessian matrix with Ipopt)
- LOG_IPOPT_ERROR (print max error in the optimization)
- LOG_JAC (outputs the jacobian matrix used by ODE solvers)
- LOG_LS (logging for linear systems)
- LOG_LS_V (verbose logging of linear systems)
- LOG_MIXED (logging for mixed systems)
- LOG_MOO (logging for dynamic optimization library MOO)
- LOG_NLS (logging for nonlinear systems)
- LOG_NLS_V (verbose logging of nonlinear systems)
- LOG_NLS_HOMOTOPY (logging of homotopy solver for nonlinear systems)
- LOG_NLS_JAC (outputs the jacobian of nonlinear systems)
- LOG_NLS_JAC_TEST (tests the analytical jacobian of nonlinear systems)
- LOG_NLS_JAC_SUMS (tests the absolute sums of rows and cols in Kinsol Jacobian)
- LOG_NLS_NEWTON_DIAGNOSTICS (newton diagnostics (see: https://doi.org/10.1016/j.amc.2021.125991))
- LOG_NLS_DERIVATIVE_TEST (test derivatives in KINSOL nonlinear systems)
- LOG_NLS_SVD (perform a SVD analysis in KINSOL nonlinear systems)
- LOG_NLS_SVD_V (perform a SVD analysis in KINSOL nonlinear systems (verbose))

- LOG_NLS_RES (outputs every evaluation of the residual function)
- LOG_NLS_EXTRAPOLATE (outputs debug information about extrapolate process)
- LOG_RES_INIT (outputs residuals of the initialization)
- LOG_RT (additional information regarding real-time processes)
- LOG_SIMULATION (additional information about simulation process)
- LOG_SOLVER (additional information about solver process)
- LOG_SOLVER_V (verbose information about the integration process)
- LOG_SOLVER_CONTEXT (context information during the solver process)
- LOG_SOTI (final solution of the initialization)
- LOG_SPATIALDISTR (logging of internal operations for spatialDistribution)
- LOG_STATS (additional statistics about timer/events/solver)
- LOG_STATS_V (additional statistics for OMC_LOG_STATS)
- LOG_SUCCESS (this stream is always active, unless deactivated with -lv=-LOG_SUCCESS)
- LOG_SYNCHRONOUS (log clocks and sub-clocks for synchronous features)
- LOG_ZEROCROSSINGS (additional information about the zerocrossings)

***-lvMaxWarn=value* or -lvMaxWarn value**
Maximum number of times some repeating warnings are displayed. Default value 3.

***-lv_time=value* or -lv_time value**
Interval (a comma-separated Double list with two elements) specifies in which time interval logging is active. Doesn't affect LOG_STDOUT, LOG_ASSERT, and LOG_SUCCESS, LOG_STATS, LOG_STATS_V.

***-lv_system=value* or -lv_system value**
Value is a comma-separated list of equation indices (available in the transformational debugger) for which solver logs are shown (by default logs for all systems are shown)

***-mbi=value* or -mbi value**
Value specifies the maximum number of bisection iterations for state event detection or zero for default behavior

***-mei=value* or -mei value**
Value specifies the maximum number of event iterations. The value is an Integer with default value 20.

***-maxIntegrationOrder=value* or -maxIntegrationOrder value**
Value specifies maximum integration order, used by the methods: dassl, ida.

***-maxStepSize=value* or -maxStepSize value**
Value specifies maximum absolute step size, used by the methods: dassl, ida, gbode.

***-maxStepRetries=value* or -maxStepRetries value**
Value specifies how often a step is retried in a row, when evaluating the model at the end of the step failed, e.g. because of an assert or a non-linear system that could not be solved. Each retry halves the step size, which grows back to the output interval with the following steps. The value is a non-negative Integer with default value 20 for models without states and 1 otherwise.

***-minRetryStepSize=value* or -minRetryStepSize value**
Value specifies the minimum step size for retrying a failed step, see -maxStepRetries. The simulation is terminated instead of retrying a step with a smaller step size. The value is a positive Real with default value 1e-12.

***-measureTimePlotFormat=value* or -measureTimePlotFormat value**
Value specifies the output format of the measure time functionality:

- svg
- jpg

- ps
- gif
- ...

*-moo*
Perform dynamic optimization with MOO library

*-moo_l2bn_p1_it=value* ***or*** **-moo_l2bn_p1_it value**
Value specifies the number of phase I iterations (full bisections) for L2-Boundary-Norm mesh refinement in MOO

*-moo_l2bn_p2_it=value* ***or*** **-moo_l2bn_p2_it value**
Value specifies the number of phase II iterations (refinement) for L2-Boundary-Norm mesh refinement in MOO

*-moo_l2bn_p2_lvl=value* ***or*** **-moo_l2bn_p2_lvl value**
Value specifies the phase II refinement aggressiveness for L2-Boundary-Norm mesh refinement in MOO

*-newtonFTol=value* ***or*** **-newtonFTol value**
Tolerance respecting residuals for updating solution vector in Newton solver. Solution is accepted if the (scaled) 2-norm of the residuals is smaller than the tolerance newtonFTol and the (scaled) newton correction (delta_x) is smaller than the tolerance newtonXTol. The value is a Double with default value 1e-12.

*-newtonMaxSteps=value* ***or*** **-newtonMaxSteps value**
Maximum number of newton steps, used currently only by KINSOL in solver GBODE.

*-newtonMaxStepFactor=value* ***or*** **-newtonMaxStepFactor value**
Maximum newton step factor mxnewtstep = maxStepFactor * norm2(xScaling). Used currently only by KINSOL.

*-newtonXTol=value* ***or*** **-newtonXTol value**
Tolerance respecting newton correction (delta_x) for updating solution vector in Newton solver. Solution is accepted if the (scaled) 2-norm of the residuals is smaller than the tolerance newtonFTol and the (scaled) newton correction (delta_x) is smaller than the tolerance newtonXTol. The value is a Double with default value 1e-12.

*-newtonJacUpdates=value* ***or*** **-newtonJacUpdates value**
Number of steps before Jacobian is recomputed. If zero is chosen, the corresponding solution phase is skipped.

*-newton=value* ***or*** **-newton value**
Value specifies the damping strategy for the newton solver.

- damped (Newton with a damping strategy)
- damped2 (Newton with a damping strategy 2)
- damped_ls (Newton with a damping line search)
- damped_bt (Newton with a damping backtracking and a minimum search via golden ratio method)
- pure (Newton without damping strategy)

*-nls=value* ***or*** **-nls value**
Value specifies the nonlinear solver:

- hybrid (Modification of the Powell hybrid method from minpack - former default solver)
- kinsol (SUNDIALS/KINSOL includes an interface to the sparse direct solver, KLU. See simulation option -nlsLS for more information.)
- experimental-kinsol (SUNDIALS/KINSOL (with internal scaling) includes an interface to the sparse direct solver, KLU. See simulation option -nlsLS for more information.)
- newton (Newton Raphson - prototype implementation)
- mixed (Mixed strategy. First the homotopy solver is tried and then as fallback the hybrid solver.)

- homotopy (Damped Newton solver if failing case fixed-point and Newton homotopies are tried.)

*-nlsInfo*
Outputs detailed information about solving process of non-linear systems into csv files.

*-nlsLS=value* ***or*** **-nlsLS value**
Value specifies the linear solver used by the non-linear solver:

- default (chooses the nls linear solver based on which nls is being used.)
- totalpivot (internal total pivot implementation. Solve in some case even under-determined systems.)
- lapack (use external LAPACK implementation.)
- klu (use KLU direct sparse solver. Only with KINSOL available.)

*-nlssMaxDensity=value* ***or*** **-nlssMaxDensity value**
Value specifies the maximum density for using a non-linear sparse solver. The value is a Double with default value 0.1.

*-nlssMinSize=value* ***or*** **-nlssMinSize value**
Value specifies the minimum system size for using a non-linear sparse solver. The value is an Integer with default value 1000.

*-nlsJacTestATol=value* ***or*** **-nlsJacTestATol value**
Value specifies the absolute tolerance for the Jacobian derivative test.

*-nlsJacTestRTol=value* ***or*** **-nlsJacTestRTol value**
Value specifies the relative tolerance for the Jacobian derivative test.

*-noemit*
Do not emit any results to the result file.

*-noEquidistantTimeGrid*
Output the internal steps given by dassl/ida instead of interpolating results into an equidistant time grid as given by stepSize or numberOfIntervals.

*-noEquidistantOutputFrequency=value* ***or*** **-noEquidistantOutputFrequency value**
Integer value n controls the output frequency in noEquidistantTimeGrid mode and outputs every n-th time step

*-noEquidistantOutputTime=value* ***or*** **-noEquidistantOutputTime value**
Real value timeValue controls the output time point in noEquidistantOutputTime mode and outputs every time>=k*timeValue, where k is an integer

*-noEventEmit*
Do not emit event points to the result file.

*-noRestart*
Disables the restart of the integration method after an event is performed, used by the methods: dassl, ida

*-noRootFinding*
Disables the internal root finding procedure of methods: dassl and ida.

*-noScaling*
Disables scaling for the variables and the residuals in the algebraic nonlinear solver KINSOL.

*-noSuppressAlg*
Flag to not suppress algebraic variables in the local error test of the ida solver in daeMode. In general, the use of this option is discouraged when solving DAE systems of index 1, whereas it is generally encouraged for systems of index 2 or more.

*-optDebugJac=value* ***or*** **-optDebugJac value**
Value specifies the number of iterations from the dynamic optimization, which will be debugged, creating .csv and .py files.

*-optimizerNP=value* ***or*** **-optimizerNP value**
Value specifies the number of points in a subinterval. Currently supports numbers 1 and 3.

*-optimizerTimeGrid=value* ***or*** **-optimizerTimeGrid value**
Value specifies external file with time points.

*-output=value* ***or*** **-output value**
Output the variables a, b and c at the end of the simulation to the standard output: time = value, a = value, b = value, c = value

*-outputFormat=value* ***or*** **-outputFormat value**
Sets file format of the result file.

*-outputPath=value* ***or*** **-outputPath value**
Value specifies a path for writing the output files i.e., model_res.mat, model_prof.intdata, model_prof.realdata etc.

*-override=value* ***or*** **-override value**
Override the variables in the XML setup file For example: var1=start1,var2=start2,par3=start3

*-overrideFile=value* ***or*** **-overrideFile value**
Will override the variables in the XML setup file with the values from the file. Note that: -overrideFile CANNOT be used with -override. Use when variables for -override are too many. overrideFileName contains lines of the form: var=start

*-port=value* ***or*** **-port value**
Value specifies the port for simulation status (default disabled).

*-r=value* ***or*** **-r value**
Value specifies the name of the output result file. The default file-name is based on the model name and output format. For example: Model_res.mat.

*-reconcile*
Run the Data Reconciliation numerical computation algorithm for constrained equations

*-reconcileBoundaryConditions*
Run the Data Reconciliation numerical computation algorithm for boundary condition equations

*-reconcileState*
Run the State Estimation numerical computation algorithm for constrained equations

*-gbm=value* ***or*** **-gbm value**
Value specifies the chosen solver of solver gbode (single-rate, slow states integrator).

- adams (Implicit multistep method of type Adams-Moulton (order 2))
- expl_euler (Explizit Runge-Kutta Euler method (order 1))
- impl_euler (Implizit Runge-Kutta Euler method (order 1, L-stable))
- trapezoid (Implicit Runge-Kutta trapezoid method (order 2, A-stable))
- sdirk2 (Singly-diagonal implicit Runge-Kutta (order 2, L-stable))
- sdirk3 (Singly-diagonal implicit Runge-Kutta (order 3, L-stable))
- sdirk4 (Singly-diagonal implicit Runge-Kutta (order 4, L-stable))
- esdirk2 (Explicit singly-diagonal implicit Runge-Kutta (order 2, L-stable))
- esdirk3 (Explicit singly-diagonal implicit Runge-Kutta (order 3, L-stable))
- esdirk4 (Explicit singly-diagonal implicit Runge-Kutta (order 4, L-stable, 6 stages))
- esdirk4s7 (Explicit singly-diagonal implicit Runge-Kutta (order 4, L-stable, 7 stages))
- sirk3l (Singly-implicit Runge-Kutta SIRK3(2)3L[2]SA (order 3, L-stable))
- sirk3 (Singly-implicit Runge-Kutta SIRK3(2)4L[3]SA (order 3, L-stable))
- sirk3s5 (Singly-implicit Runge-Kutta SIRK3(2)5L[3]SA (order 3, L-stable))
- sirk4lag (Singly-implicit Runge-Kutta SIRK4(3) Laguerre (order 4, A(89.548*)-stable))
- sirk4 (Singly-implicit Runge-Kutta SIRK4(3)5L[3]SA (order 4, L-stable))

- sirk5 (Singly-implicit Runge-Kutta SIRK5(4)5L[3]SA (order 5, L-stable))
- sirk4s6 (Singly-implicit Runge-Kutta SIRK4(3)6L[4]SA (order 4, L-stable))
- sirk5s6 (Singly-implicit Runge-Kutta SIRK5(4)6L[4]SA (order 5, L-stable))
- sirk5s7 (Singly-implicit Runge-Kutta SIRK5(4)7L[4]SA (order 5, L-stable))
- sirk6s7 (Singly-implicit Runge-Kutta SIRK6(5)7L[4]SA (order 6, L-stable))
- sirk6s8 (Singly-implicit Runge-Kutta SIRK6(5)8L[4]SA (order 6, L-stable))
- sirk5s7l5 (Singly-implicit Runge-Kutta SIRK5(4)7L[5]SA (order 5, L-stable))
- firk7 (Fully-implicit Runge-Kutta FIRK7(6TS)5L[4]SA (order 7, L-stable))
- radauIA2 (Implicit Runge-Kutta method of Radau family IA (order 3, L-stable))
- radauIA3 (Implicit Runge-Kutta method of Radau family IA (order 5, L-stable))
- radauIA4 (Implicit Runge-Kutta method of Radau family IA (order 7, L-stable))
- radauIIA2 (Implicit Runge-Kutta method of Radau family IIA (order 3, L-stable))
- radauIIA3 (Implicit Runge-Kutta method of Radau family IIA (order 5, L-stable))
- radauIIA4 (Implicit Runge-Kutta method of Radau family IIA (order 7, L-stable))
- radauIIA5 (Implicit Runge-Kutta method of Radau family IIA (order 9, L-stable))
- radauIIA6 (Implicit Runge-Kutta method of Radau family IIA (order 11, L-stable))
- radauIIA7 (Implicit Runge-Kutta method of Radau family IIA (order 13, L-stable))
- lobattoIIIA3 (Implicit Runge-Kutta method of Lobatto family IIIA (order 4, A-stable))
- lobattoIIIA4 (Implicit Runge-Kutta method of Lobatto family IIIA (order 6, A-stable))
- lobattoIIIB3 (Implicit Runge-Kutta method of Lobatto family IIIB (order 4, A-stable))
- lobattoIIIB4 (Implicit Runge-Kutta method of Lobatto family IIIB (order 6, A-stable))
- lobattoIIIC3 (Implicit Runge-Kutta method of Lobatto family IIIC (order 4, L-stable))
- lobattoIIIC4 (Implicit Runge-Kutta method of Lobatto family IIIC (order 6, L-stable))
- gauss2 (Implicit Runge-Kutta method of Gauss (order 4, A-stable))
- gauss3 (Implicit Runge-Kutta method of Gauss (order 6, A-stable))
- gauss4 (Implicit Runge-Kutta method of Gauss (order 8, A-stable))
- gauss5 (Implicit Runge-Kutta method of Gauss (order 10, A-stable))
- gauss6 (Implicit Runge-Kutta method of Gauss (order 12, A-stable))
- merson (Explicit Runge-Kutta Merson method (order 4))
- mersonSsc1 (Explicit Runge-Kutta Merson method with large stability region (order 1))
- mersonSsc2 (Explicit Runge-Kutta Merson method with large stability region (order 2))
- heun (Explicit Runge-Kutta Heun method (order 2))
- fehlberg12 (Explicit Runge-Kutta Fehlberg method (order 2))
- fehlberg45 (Explicit Runge-Kutta Fehlberg method (order 5))
- fehlberg78 (Explicit Runge-Kutta Fehlberg method (order 8))
- fehlbergSsc1 (Explicit Runge-Kutta Fehlberg method with large stability region (order 1))
- fehlbergSsc2 (Explicit Runge-Kutta Fehlberg method with large stability region (order 2))
- rk810 (Explicit 8-10 Runge-Kutta method (order 10))
- rk1012 (Explicit 10-12 Runge-Kutta method (order 12))

- rk1214 (Explicit 12-14 Runge-Kutta method (order 14))
- dopri45 (Explicit Runge-Kutta method Dormand-Prince (order 5))
- dopriSsc1 (Explicit Runge-Kutta method Dormand-Prince with large stability region (order 1))
- dopriSsc2 (Explicit Runge-Kutta method Dormand-Prince with large stability region (order 2))
- tsit5 (Explicit Runge-Kutta method from Tsitouras (order 5))
- rungekutta (Explicit classical Runge-Kutta method (order 4))
- rungekuttaSsc (Explicit Runge-Kutta method with large stabiliy region (order 1))

***-gbctrl=value* or -gbctrl value**
Step size control of solver gbode (single-rate, slow states integrator).

- i (I controller for step size (beta=1/k, k RK error order))
- pi_33 (PI controller for step size (beta1=0.7/k, beta2=-0.4/k))
- pi_34 (PI controller for step size (beta1=2./3./k, beta2=-1./3./k))
- pi_42 (PI controller for step size (beta1=0.6/k, beta2=-0.2/k))
- pid_h312 (PID controller for step size (alpha1=1./18./k, alpha2=1./9./k, alpha3=1./18./k))
- pid_soederlind (PID controller for step size (alpha1=0.1/k, alpha2=0.2/k, alpha3=0.1/k))
- pid_stiff (PID controller for step size (alpha1=0.58/k, alpha2=0.21/k, alpha3=0.21/k))
- pc (Standard PI Predictive controller (beta1=2/k, beta2=-1/k, ratio=1))
- pc_hybrid (Hybrid I / PI Predictive controller: min(PI Predictive, I))
- pi_h211 (PI Predictive controller (beta1=0.25/k, beta2=0.25/k, ratio=-0.25))
- pi_h0_211 (PI Predictive controller (beta1=0.5/k, beta2=0.5/k, ratio=-0.5))
- pid_h0_312 (PID Predictive controller (alpha1=0.25/k, alpha2=0.5/k, alpha3=0.25/k, ratio1=-0.75, ratio2=-0.25))
- pid_h0_321 (PID Predictive controller (alpha1=1.25/k, alpha2=0.5/k, alpha3=-0.75/k, ratio1=0.25, ratio2=0.75))
- ppid (PID Predictive controller (alpha1=6./20/k, alpha2=1./20/k, alpha3=-5./20/k, ratio1=1.0, ratio2=0.0))
- const (Constant step size)

***-gbctrl_evnt_reinit***
Reset step size using standard inital step size selection after an event (default false)

***-gbctrl_filter=value* or -gbctrl_filter value**
Applies exponential smoothing to the step size factor; gbctrl_filter = 0 yields constant step size, gbctrl_filter = 1 uses full adaptation without averaging.

***-gbctrl_fhr***
Applies adaptive damping to the step size factor using Führer's approach, scaling it by `h_fac *= (h_n / h_n1)^gamma` to penalize repeated rejections or reward successful step acceptance.

***-gberr=value* or -gberr value**
Error estimation method for solver gbode (single-rate, slow states integrator) Possible values:

- default - depending on the Runge-Kutta method
- richardson - Richardson extrapolation
- embedded - Embedded scheme
- two_step - Two-step estimator, if available
- contractive_defect - Contractive defect estimator, if available

- contractive_filter - Contractive filter applied to the embedded estimator, if available

***-gbint=value* or -gbint value**
Interpolation method of solver gbode (single-rate, slow states integrator).

- linear (Linear interpolation (1st order))
- hermite (Hermite interpolation (3rd order))
- hermite_a (Hermite interpolation (only for left hand side))
- hermite_b (Hermite interpolation (only for right hand side))
- hermite_errctrl (Hermite interpolation with error control)
- dense_output (use dense output formula for interpolation)
- dense_output_errctrl (use dense output fomular with error control)

***-gbnls=value* or -gbnls value**
Non-linear solver method of solver gbode (single-rate, slow states integrator).

- newton (Newton method, dense)
- kinsol (SUNDIALS KINSOL: Inexact Newton, sparse)
- experimental-kinsol (experimental kinsol)
- internal (simplified Newton with decoupling transformation (uses KLU))

***-gbnls_internal_damping=value* or -gbnls_internal_damping value**
Value specifies damping applied to the estimated convergence rate in the first Newton iteration (0 <= value <= 1; 0 = conservative, 1 = optimistic). Only valid for -gbnls=internal. Since no history is available in the first Newton iteration, the convergence rate is taken from the previous solve and raised to the power of this value.

***-gbnls_internal_jackeep=value* or -gbnls_internal_jackeep value**
Value specifies how often the ODE Jacobian is recalculated (0 <= value < 1). Only valid for -gbnls=internal. The Jacobian is kept, if the linear convergence rate || dz_k || / || dz_{k-1} || of the Newton iteration is smaller than the specified value. Small values result in more Jacobian callbacks.

***-gbfm=value* or -gbfm value**
Value specifies the chosen solver of solver gbode (multi-rate, fast states integrator). Current Restriction: Fully implicit (Gauss, Radau, Lobatto) RK methods are not supported, yet.

- adams (Implicit multistep method of type Adams-Moulton (order 2))
- expl_euler (Explizit Runge-Kutta Euler method (order 1))
- impl_euler (Implizit Runge-Kutta Euler method (order 1, L-stable))
- trapezoid (Implicit Runge-Kutta trapezoid method (order 2, A-stable))
- sdirk2 (Singly-diagonal implicit Runge-Kutta (order 2, L-stable))
- sdirk3 (Singly-diagonal implicit Runge-Kutta (order 3, L-stable))
- sdirk4 (Singly-diagonal implicit Runge-Kutta (order 4, L-stable))
- esdirk2 (Explicit singly-diagonal implicit Runge-Kutta (order 2, L-stable))
- esdirk3 (Explicit singly-diagonal implicit Runge-Kutta (order 3, L-stable))
- esdirk4 (Explicit singly-diagonal implicit Runge-Kutta (order 4, L-stable, 6 stages))
- esdirk4s7 (Explicit singly-diagonal implicit Runge-Kutta (order 4, L-stable, 7 stages))
- sirk3l (Singly-implicit Runge-Kutta SIRK3(2)3L[2]SA (order 3, L-stable))
- sirk3 (Singly-implicit Runge-Kutta SIRK3(2)4L[3]SA (order 3, L-stable))
- sirk3s5 (Singly-implicit Runge-Kutta SIRK3(2)5L[3]SA (order 3, L-stable))
- sirk4lag (Singly-implicit Runge-Kutta SIRK4(3) Laguerre (order 4, A(89.548*)-stable))

- sirk4 (Singly-implicit Runge-Kutta SIRK4(3)5L[3]SA (order 4, L-stable))
- sirk5 (Singly-implicit Runge-Kutta SIRK5(4)5L[3]SA (order 5, L-stable))
- sirk4s6 (Singly-implicit Runge-Kutta SIRK4(3)6L[4]SA (order 4, L-stable))
- sirk5s6 (Singly-implicit Runge-Kutta SIRK5(4)6L[4]SA (order 5, L-stable))
- sirk5s7 (Singly-implicit Runge-Kutta SIRK5(4)7L[4]SA (order 5, L-stable))
- sirk6s7 (Singly-implicit Runge-Kutta SIRK6(5)7L[4]SA (order 6, L-stable))
- sirk6s8 (Singly-implicit Runge-Kutta SIRK6(5)8L[4]SA (order 6, L-stable))
- sirk5s7l5 (Singly-implicit Runge-Kutta SIRK5(4)7L[5]SA (order 5, L-stable))
- firk7 (Fully-implicit Runge-Kutta FIRK7(6TS)5L[4]SA (order 7, L-stable))
- radauIA2 (Implicit Runge-Kutta method of Radau family IA (order 3, L-stable))
- radauIA3 (Implicit Runge-Kutta method of Radau family IA (order 5, L-stable))
- radauIA4 (Implicit Runge-Kutta method of Radau family IA (order 7, L-stable))
- radauIIA2 (Implicit Runge-Kutta method of Radau family IIA (order 3, L-stable))
- radauIIA3 (Implicit Runge-Kutta method of Radau family IIA (order 5, L-stable))
- radauIIA4 (Implicit Runge-Kutta method of Radau family IIA (order 7, L-stable))
- radauIIA5 (Implicit Runge-Kutta method of Radau family IIA (order 9, L-stable))
- radauIIA6 (Implicit Runge-Kutta method of Radau family IIA (order 11, L-stable))
- radauIIA7 (Implicit Runge-Kutta method of Radau family IIA (order 13, L-stable))
- lobattoIIIA3 (Implicit Runge-Kutta method of Lobatto family IIIA (order 4, A-stable))
- lobattoIIIA4 (Implicit Runge-Kutta method of Lobatto family IIIA (order 6, A-stable))
- lobattoIIIB3 (Implicit Runge-Kutta method of Lobatto family IIIB (order 4, A-stable))
- lobattoIIIB4 (Implicit Runge-Kutta method of Lobatto family IIIB (order 6, A-stable))
- lobattoIIIC3 (Implicit Runge-Kutta method of Lobatto family IIIC (order 4, L-stable))
- lobattoIIIC4 (Implicit Runge-Kutta method of Lobatto family IIIC (order 6, L-stable))
- gauss2 (Implicit Runge-Kutta method of Gauss (order 4, A-stable))
- gauss3 (Implicit Runge-Kutta method of Gauss (order 6, A-stable))
- gauss4 (Implicit Runge-Kutta method of Gauss (order 8, A-stable))
- gauss5 (Implicit Runge-Kutta method of Gauss (order 10, A-stable))
- gauss6 (Implicit Runge-Kutta method of Gauss (order 12, A-stable))
- merson (Explicit Runge-Kutta Merson method (order 4))
- mersonSsc1 (Explicit Runge-Kutta Merson method with large stability region (order 1))
- mersonSsc2 (Explicit Runge-Kutta Merson method with large stability region (order 2))
- heun (Explicit Runge-Kutta Heun method (order 2))
- fehlberg12 (Explicit Runge-Kutta Fehlberg method (order 2))
- fehlberg45 (Explicit Runge-Kutta Fehlberg method (order 5))
- fehlberg78 (Explicit Runge-Kutta Fehlberg method (order 8))
- fehlbergSsc1 (Explicit Runge-Kutta Fehlberg method with large stability region (order 1))
- fehlbergSsc2 (Explicit Runge-Kutta Fehlberg method with large stability region (order 2))
- rk810 (Explicit 8-10 Runge-Kutta method (order 10))

- rk1012 (Explicit 10-12 Runge-Kutta method (order 12))
- rk1214 (Explicit 12-14 Runge-Kutta method (order 14))
- dopri45 (Explicit Runge-Kutta method Dormand-Prince (order 5))
- dopriSsc1 (Explicit Runge-Kutta method Dormand-Prince with large stability region (order 1))
- dopriSsc2 (Explicit Runge-Kutta method Dormand-Prince with large stability region (order 2))
- tsit5 (Explicit Runge-Kutta method from Tsitouras (order 5))
- rungekutta (Explicit classical Runge-Kutta method (order 4))
- rungekuttaSsc (Explicit Runge-Kutta method with large stabiliy region (order 1))

***-gbfctrl=value* or -gbfctrl value**
Step size control of solver gbode (multi-rate, fast states integrator).

- i (I controller for step size (beta=1/k, k RK error order))
- pi_33 (PI controller for step size (beta1=0.7/k, beta2=-0.4/k))
- pi_34 (PI controller for step size (beta1=2./3./k, beta2=-1./3./k))
- pi_42 (PI controller for step size (beta1=0.6/k, beta2=-0.2/k))
- pid_h312 (PID controller for step size (alpha1=1./18./k, alpha2=1./9./k, alpha3=1./18./k))
- pid_soederlind (PID controller for step size (alpha1=0.1/k, alpha2=0.2/k, alpha3=0.1/k))
- pid_stiff (PID controller for step size (alpha1=0.58/k, alpha2=0.21/k, alpha3=0.21/k))
- pc (Standard PI Predictive controller (beta1=2/k, beta2=-1/k, ratio=1))
- pc_hybrid (Hybrid I / PI Predictive controller: min(PI Predictive, I))
- pi_h211 (PI Predictive controller (beta1=0.25/k, beta2=0.25/k, ratio=-0.25))
- pi_h0_211 (PI Predictive controller (beta1=0.5/k, beta2=0.5/k, ratio=-0.5))
- pid_h0_312 (PID Predictive controller (alpha1=0.25/k, alpha2=0.5/k, alpha3=0.25/k, ratio1=-0.75, ratio2=-0.25))
- pid_h0_321 (PID Predictive controller (alpha1=1.25/k, alpha2=0.5/k, alpha3=-0.75/k, ratio1=0.25, ratio2=0.75))
- ppid (PID Predictive controller (alpha1=6./20/k, alpha2=1./20/k, alpha3=-5./20/k, ratio1=1.0, ratio2=0.0))
- const (Constant step size)

***-gbferr=value* or -gbferr value**
Error estimation method for solver gbode (multi-rate, fast states integrator) Possible values:

- default - depending on the Runge-Kutta method
- richardson - Richardson extrapolation
- embedded - Embedded scheme
- two_step - Two-step estimator, if available
- contractive_defect - Contractive defect estimator, if available
- contractive_filter - Contractive filter applied to the embedded estimator, if available

***-gbfint=value* or -gbfint value**
Interpolation method of solver gbode (multi-rate, fast states integrator).

- linear (Linear interpolation (1st order))
- hermite (Hermite interpolation (3rd order))
- hermite_a (Hermite interpolation (only for left hand side))

- hermite_b (Hermite interpolation (only for right hand side))
- hermite_errctrl (Hermite interpolation with error control)
- dense_output (use dense output formula for interpolation)
- dense_output_errctrl (use dense output fomular with error control)

***-gbfnls=value* *or* -gbfnls value**
Non-linear solver method of solver gbode (multi-rate, fast states integrator).

- newton (Newton method, dense)
- kinsol (SUNDIALS KINSOL: Inexact Newton, sparse)
- experimental-kinsol (experimental kinsol)
- internal (simplified Newton with decoupling transformation (uses KLU))

***-gbratio=value* *or* -gbratio value**
Define percentage of states for the fast states selection of solver gbode (values from 0 to 1).

***-rt=value* *or* -rt value**
Value specifies the scaling factor for real-time synchronization (0 disables). A value > 1 means the simulation takes a longer time to simulate.

***-s=value* *or* -s value**
Value specifies the integration method. For additional information see the *User's Guide*

- dassl (default) - BDF method - implicit (dense solver), variable step size control, adaptive order 1-5, event location
- ida - SUNDIALS IDA solver - BDF method - implicit (sparse/dense solver, default sparse) variable step size control, adaptive order 1-5, event location - additional simulation flags: -idaMaxErrorTestFails -idaMaxNonLinIters -idaMaxConvFails -idaNonLinConvCoef -idaLS -idaScaling -idaSensitivity
- cvode - SUNDIALS CVODE solver - BDF or Adams-Moulton solver - implicit (dense solver), variable step-size control, adaptive order 1-12, event location - additional simulation flags -cvodeLinearMultistepMethod -cvodeNonlinearSolverIteration
- gbode - generic Runge-Kutta ODE solver - implicit (sparse solver)/explicit, fixed/variable step size control, order 1-14, event location, optional bi-rate integration - additional simulation flags -gbm -gbctrl -gbratio - additional advanced flags -gbctrl_filter -gbctrl_fhr -gberr -gbint -gbnls -gbfm -gbfctrl -gbferr -gbfint -gbfnls
- euler - explicit Euler, fixed step size, order 1
- rungekutta - classical Runge-Kutta - explicit, fixed step, order 4
- symSolver - symbolic inline Solver [compiler flag '--symSolver' needed] - fixed step size, order 1
- symSolverSsc - symbolic implicit Euler with step size control [compiler flag '--symSolver' needed] - step size control, order 1
- qss - A QSS solver [experimental]
- optimization - Special solver for dynamic optimization

***-saveInitialGuess_system=value* *or* -saveInitialGuess_system value**
Debug flag that performs standard initialization until the specified system is reached, computes only the torn part and saves the results obtained so far to a .mat file

***-single***
Output results in single precision (mat-format only).

***-steps***
Dumps the number of integration steps into the result file.

***-startTime=value* *or* -startTime value**
Sets startTime for the simulation.

*-steadyState*
Aborts the simulation if steady state is reached.

*-steadyStateTol=value* ***or*** **-steadyStateTol value**
This relative tolerance is used to detect steady state: `max(|d(x_i)/dt|/nominal(x_i)) < steadyStateTol`

*-stepSize=value* ***or*** **-stepSize value**
Sets stepSize for the simulation.

*-stopAtSystem=value* ***or*** **-stopAtSystem value**
Performs standard initialization until the specified system is reached, then aborts the simulation.

*-stopTime=value* ***or*** **-stopTime value**
Sets stopTime for the simulation.

*-svdCount=value* ***or*** **-svdCount value**
Number of extremal singular values and vectors computed for LOG_NLS_SVD (0 disables).

*-svdSigma=value* ***or*** **-svdSigma value**
Estimated smallest singular value for the preconditioner in SVD analysis.

*-svdTol=value* ***or*** **-svdTol value**
Convergence tolerance of the sparse SVD analysis: PRIMME stops at ||r|| <= svdTol*||A||. The normal equations it uses resolve no singular value below sqrt(DBL_EPSILON)*||A||, so tightening it past that buys nothing.

*-sx=value* ***or*** **-sx value**
Value specifies an csv-file with inputs as covariance matrix Sx for DataReconciliation

*-tolerance=value* ***or*** **-tolerance value**
Specifies solver tolerance.

*-keepHessian=value* ***or*** **-keepHessian value**
Value specifies the number of steps, which keep Hessian matrix constant.

*-variableFilter=value* ***or*** **-variableFilter value**
Specifies which variables should be present in the result-file using POSIX Extended Regular Expressions. The given expression must match the full variable name.

*-w*
Shows all warnings even if a related log-stream is inactive.

*-parmodNumThreads=value* ***or*** **-parmodNumThreads value**
Value specifies the number of threads for simulation using parmodauto. If not specified (or is 0) it will use the systems max number of threads. Note that this option is ignored if the model is not compiled with --parmodauto

*-parmodScheduler=value* ***or*** **-parmodScheduler value**
Selects the parmodauto scheduler: 'flow' (default) or 'level'. Switchable at run time without recompiling the simulator.

*-parmodClustering=value* ***or*** **-parmodClustering value**
Selects the parmodauto clustering strategy: 'default' (merge-based), 'fixed_width_min_height', or 'none'.

*-parmodClustersPerLevel=value* ***or*** **-parmodClustersPerLevel value**
Sets the maximum number of clusters per level used by the default clustering.

*-parmodExportTaskGraph=value* ***or*** **-parmodExportTaskGraph value**
Exports the parmodauto task graph (tasks, dependencies) and the resulting clustering to the given json file, keyed by equation index.

*-parmodImportClustering=value* ***or*** **-parmodImportClustering value**
Imports a clustering (groups of equation indices) from the given json file instead of computing one. The simulation aborts if the clustering is invalid (forms a cycle or references unknown equations).

*-parmodDumpStages=value or* **-parmodDumpStages value**

Exports the parmodauto task graph and clustering before and after each clustering optimization to a series of json files named <prefix>.NN.<stage>.json, so the effect of each optimization can be inspected.

CHAPTER

# THIRTYNINE

# TECHNICAL DETAILS

This chapter gives an overview of some implementation details that might be interesting when building tools around OpenModelica.

## 39.1 The MATv4 Result File Format

The default result-file format of OpenModelica is based on MATLAB level 4 MAT-files as described in the MATLAB documentation. This format can be read by tools such as MATLAB, Octave, Scilab, and SciPy. OpenModelica will write the result-files in a particular way that can be read by tools such as DyMat and Dymola (OpenModelica can also read files generated by Dymola since the used format is the same).

The variables stored in the MAT-file are (in the order required by OpenModelica):

**Aclass**

- `Aclass(1,:)` is always `Atrajectory`
- `Aclass(2,:)` is `1.1` in OpenModelica
- `Aclass(3,:)` is empty
- `Aclass(4,:)` is either `binTrans` or `binNormal`

The most important part of the variable is `Aclass(4,:)` since there are two main ways the result-file is stored: transposed or not. For efficiency, the result-file is written time-step by time-step during simulation. But the best way to read the data for a single variable is if the variables are stored variable by variable. If `Aclass(4,:)` is `binTrans`, all matrices need to be transposed since the file was not transposed for efficient reading of the file. Note that this affects all matrices, even matrices that do not change during simulation (such as name and description).

**name**
Is an n x m character (int8) matrix, where n is the number of variables stored in the result-file (including time). m is the length of the longest variable. OpenModelica stores the trailing part of the name as NIL bytes (0) whereas other tools use spaces for the trailing part.

**description**
Is an n x m character (int8) matrix containing the comment-string corresponding to the variable in the name matrix.

**dataInfo**
Is an n x 4 integer matrix containing information for each variable (in the same order as the name and description matrices).

- `dataInfo(i,1)` is `1` or `2`, saying if variable i is stored in the data_1 or data_2 matrix. If it is `0`, it is the abscissa (time variable).
- `dataInfo(i,2)` contains the index in the data_1 or data_2 matrix. The index is 1-based and may contain several variables pointing to the same row (alias variables). A negative value means that the variable is a negated alias variable.
- `dataInfo(i,3)` is 0 to signify linear interpolation. In other tools the value is the number of times differentiable this variable is, which may improve plotting.

- `dataInfo(i,4)` is `-1` in OpenModelica to signify that the value is not defined outside the time range. `0` keeps the first/last value when going outside the time range and `1` performs linear interpolation on the first/last two points.

**data_1**
: If it is an n x 1 matrix it contains the values of parameters. If it is an n x 2 matrix, the first and second column signify start and stop-values.

**data_2**
: Each row contains the values of a variable at the sampled times. The corresponding time stamps are stored in `data_2(1,:)`. `data_2(2,1)` is the value of some variable at time `data_2(1,1)`. The simulation flag `-single` stores `data_1` and `data_2` in single precision (matrix type 10, 4-byte elements) instead of double.

## 39.2 The Arrow Result File Format

`outputFormat="arrow"` (the simulation flag `-outputFormat=arrow`) writes the result as Apache Arrow IPC.

Compared to the MATv4 file it stores each variable as a typed column, so one variable is read without striding through the others; it carries the unit, description and type of every variable inside the file; it stores a variable that changes only at events only where it changes; and it can hold `String` variables, which the MATv4 file cannot.

The format is specified in `OMCompiler/SimulationRuntime/rust/openmodelica_arrow_writer/SPECIFICATION.md`. Nothing in it is specific to OpenModelica: it is meant to carry a Modelica result or an FMI one, and to be readable by any Arrow implementation without a Modelica tool in the loop.

Under `-mat_sync=N` a batch holds at most `N` rows and reaches the file as soon as it is complete, so the file can be read while the simulation runs.

CHAPTER

FORTY

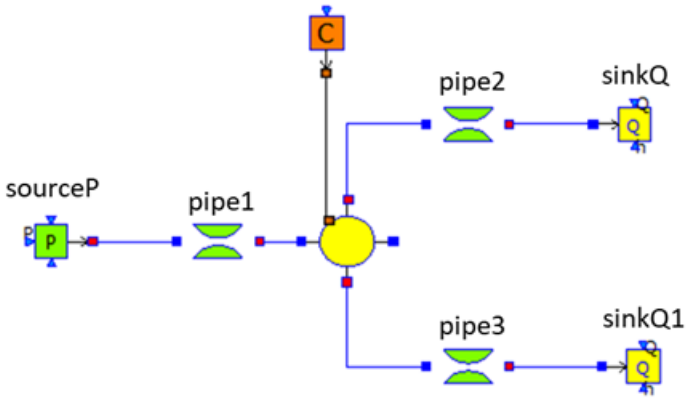
# DATA RECONCILIATION

## 40.1 Objective of Data Reconciliation

The objective of data reconciliation is to use physical models to reduce the impact of measurement errors by decreasing measurement uncertainties and detecting faulty sensors. Data reconciliation is possible only when redundant measurements are available. Redundancy can be achieved by linking together the measured variables of interest using the physical laws that constrain them. This can be done with static Modelica models (models featuring algebraic equations only, no differential equations).

## 40.2 Defining the Data Reconciliation Problem in OpenModelica

Let us take the example of the Modelica model of a splitter.




Water flows from left to right, from the source to the sinks. The model is made of five different model components.

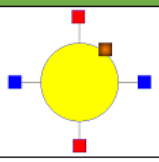
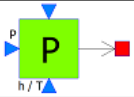
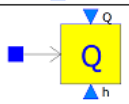
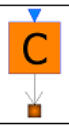
**To perform data reconciliation, two kinds of variables must be declared:**

1. The boundary conditions (which represent assumptions on the environment);
2. The variables of interest to be reconciled.

**These two kinds of variables must be manually declared in the source code**

1. With annotations for the boundary conditions;
2. With modifiers for the variables of interest.

The boundary conditions are declared with the annotation: annotation(__OpenModelica_BoundaryCondition = true). For the pressure source, the boundary conditions are the pressure P0, and the specific enthalpy h0 or the temperature T0 of the source (depending on the option chosen by the user).

| Component name | Component icon | Component type | Component internal state variables |
|---|---|---|---|
| Volume |  | Component | P: pressure [Pa]<br>T: temperature [K] |
| Pressure loss |  | Component | Q: mass flow rate [kg/s]<br>Pm: mean pressure [Pa]<br>T: temperature [K] |
| Pressure source |  | Boundary condition | P0: pressure [Pa]<br>T0: temperature [K] |
| Mass flow rate sink |  | Boundary condition | Q0: mass flow rate [kg] |
| Heat source |  | Boundary condition | |

```
model SourceP "Water/steam source with fixed pressure"
  parameter Modelica.SIunits.AbsolutePressure P0=300000 "Source pressure" annotation(_
↪_OpenModelica_BoundaryCondition = true);
  parameter Modelica.SIunits.Temperature T0=290 "Source temperature (active if option_
↪temperature=1" annotation(__OpenModelica_BoundaryCondition = true);
  parameter Modelica.SIunits.SpecificEnthalpy h0=100000
    "Source specific enthalpy (active if option_temperature=2)" annotation(__
↪OpenModelica_BoundaryCondition = true);
  parameter Integer option_temperature=1 "1:temperature fixed - 2:specific enthalpy␣
↪fixed";

  Modelica.SIunits.AbsolutePressure P "Fluid pressure";
  Modelica.SIunits.MassFlowRate Q "Mass flow rate";
  Modelica.SIunits.Temperature T "Fluid temperature";
  Modelica.SIunits.SpecificEnthalpy h "Fluid enthalpy";
equation
  P = P0;
  if (option_temperature == 1) then
    T = T0;
     h = f(T);
  else
    h = h0;
    T = g(h);
  end if;
end SourceP;
```

Boundary conditions are declared with annotations so that libraries can be modified to accomodate data reconciliation, and still can be used with tools that do not support data reconciliation (because annotations not recognized by a tool are ignored by that tool). The variables of interest are declared with the modifier "uncertain = Uncertainty.refine"

A modifier is used instead of an annotation so that checks can be performed to detect errors such as declaring a variable that does not exist to be a variable to be reconciled. The drawback is that tools that do not support data reconciliation will produce an error. To avoid this problem, variables of interest should be declared in a separate

model (Splitter_DR in the example below) that instantiates the orginal model (Splitter), so that the original model (Splitter) is not modified and can still be used with tools that do not support data reconciliation.

```
model Splitter_DR
  Splitter splitter(
     pipe1(Q(uncertain = Uncertainty.refine)),
     pipe2(Q(uncertain = Uncertainty.refine)),
     pipe3(Q(uncertain = Uncertainty.refine)),
     pipe1(Pm(uncertain = Uncertainty.refine)),
     pipe2(Pm(uncertain = Uncertainty.refine)),
     pipe3(Pm(uncertain = Uncertainty.refine)),
     pipe1(T(uncertain = Uncertainty.refine)),
     pipe2(T(uncertain = Uncertainty.refine)),
     pipe3(T(uncertain = Uncertainty.refine)));
end Splitter_DR;
```

**In addition to declaring boundary conditions and variables of interest, one must provide two input files:**

1. The measurement input file (mandatory).
2. The correlation matrix input file (optional).

**The measurement input file is a csv file with three columns:**

1. One column for the variable names [ident]
2. One column for measured values [positive floating point number]
3. One column for the half-width confidence intervals [positive floating point number].The half-with confidence interval for variable $x_i$ is defined as $wi = \lambda_{95\%}\sigma_i$, where $\sigma_i$ is the standard deviation of $x_i$ and $\lambda_{95\%} = 1.96$

**The header of the file is the row**

Variable Names; Measured Value-x; Half Width Confidence Interval

**It is possible to insert comments with // at the beginning of a row**

// Measurement input file for the Splitter model.
Variable Name;Measured Value;Half Width Confidence Interval
splitter.pipe1.Q; 2.50; 0.196
splitter.pipe2.Q; 1.15; 0.196
splitter.pipe3.Q; 1.25; 0.196
splitter.pipe1.Pm; 6.1e5; 0.392e5
splitter.pipe2.Pm; 2.55e5; 0.392e5
splitter.pipe3.Pm; 2.45e5; 0.392e5
splitter.pipe1.T; 292; 1.96
splitter.pipe2.T; 386; 1.91
splitter.pipe3.T; 388; 1.91

The above file can be more easily visualized in matrix form:

The correlation matrix file is a csv file that contains the off-diagonal lower triangular correlation coefficients of the variables of interest:

1. The first row contains names of variables of interest [ident].
2. The first column contains names of variables of interest [ident].
3. The names in the first row and first column must be identical in the same order.
4. The first cell in the first row (which is also the first cell in the first column) must not be empty, but can contain any character string (except column separators).

| Variable Name | Measured Value | Half Width Confidence Interval |
|---|---|---|
| splitter.pipe1.Q | 2.50 | 0.196 |
| splitter.pipe2.Q | 1.15 | 0.196 |
| splitter.pipe3.Q | 1.25 | 0.196 |
| splitter.pipe1.Pm | 6.1e5 | 0.392e5 |
| splitter.pipe2.Pm | 2.55e5 | 0.392e5 |
| splitter.pipe3.Pm | 2.45e5 | 0.392e5 |
| splitter.pipe1.T | 292 | 1.96 |
| splitter.pipe2.T | 386 | 1.91 |
| splitter.pipe3.T | 388 | 1.91 |

5. The off-diagonal lower triangular matrix cells contain the correlation coefficients [positive or nul floating point number]. The correlation coefficients $r_{ij}$ are defined such that $s_{ij} = r_{ij}\sigma_i\sigma_j$ where $\sigma_i$ and $\sigma_j$ are respectively the standard deviations of variables $x_i$ and $x_j$, and $s_{ij}$ is the covariance matrix. $r_{ii} = 1$ because $s_{ii} = \sigma_i^2 |r_{ij}| <= 1$
6. The upper triangular and diagonal cells are ignored because the correlation matrix is symmetric $r_{ji} = r_{ij}$, and its diagonal is $r_{ii} = 1$
7. Only variables of interest with positive correlation coefficients must appear in the matrix. Unfilled cells are equal to zero. Variables of interest that do not appear in the matrix have correlation coefficients equal to zero. Therefore, if all correlation coefficients are equal to zero, the matrix can be empty and the correlation matrix file is not needed

The following correlation file is drawn from the VDI2048 standard example of a heat circuit of a steam turbine plant.

```
Sxy;mV;mHK;mSPLL;mSPL;mFDKELL;mFDKEL
mV
mHK
mSPLL
mSPL;;;0.39951
mFDKELL;;;0;0
mFDKEL;;;0;0;0.2
```

The above file can be more easily visualized in matrix form:

| Sxy | mV | mHK | mSPLL | mSPL | mFDKELL | mFDKEL |
|---|---|---|---|---|---|---|
| mV | | | | | | |
| mHK | | | | | | |
| mSPLL | | | | | | |
| mSPL | | | 0.39951 | | | |
| mFDKELL | | | 0 | | 0 | |
| mFDKEL | | | 0 | | 0 | 0.2 |

The variables mV and mHK could have been omitted because they do not have any positive correlation coefficients.

## 40.3 Data Reconciliation Support in OMEdit

**The data reconciliation setup is done by:**

1. Opening the Modelica model with the data reconciliation modifiers in OMEdit.
2. Selecting Data Reconciliation > Calculate Data Reconciliation.
3. Selecting the Data Reconciliation algorithm.
4. **Filling the Data Reconciliation form with**
    a. The name of the Measurement Input File (mandatory);
    b. The name of the Correlation Matrix Input file (optional). The default is the identity matrix (i.e. measurements are independent of each other);
    c. The value of Epsilon (optional). The default value is 1.e-10. Epsilon is the stopping criteria of the data reconciliation numerical iterations.
5. Clicking on Save Settings to save the above settings in the Modelica model.
6. Clicking on Calculate to launch the calculation

**The data reconciliation computation is performed in three main steps:**

1. **Static analysis is performed on the model to extract the equations that are necessary for data reconciliation. There are two groups of extracted equations:**
    a. The auxiliary conditions that constrain the variables of interest.
    b. The intermediate equations that solve the intermediate variables from the variables of interest (this is the numeric way of eliminating the intermediate variables).

    The auxiliary and intermediate equations are interchangeable: denoting r the number of auxiliary conditions, there are as many possibilities to construct the set of auxiliary conditions as to choose r equations among the set that contains both the auxiliary and the intermediate equations.

    **Any error in the posing of the data reconciliation problem is detected at this step. The possible errors are:**
    a. The number r of auxiliary equations is not strictly less than the number of variables of interest.
    b. The number r of auxiliary equations is zero.

    Both errors occur when there are too many boundary conditions related to the variables of interest. Variables of interest that are not involved in any of the auxiliary conditions or intermediate equations are not reconciled.
2. The model is simulated to compute the Jacobian matrices and eliminate numerically the intermediate variables. At this step, numerical simulation errors can occur, such as divisions by zero, non-convergence, etc. They can be corrected by improving the model or providing better start values.
3. **The input files are read, the data reconciliation calculation is performed, and the results are displayed. Errors can occur:**
    a. If input files do not exist.
    b. **If there is a mismatch between the variables of interest declared in the model and in the input files:**
        i. All variables of interest declared in the model should be declared in the measurement input file and reciprocally.
        ii. All variables of interest declared in the correlation matrix file should be declared in the model (the converse is not true).
    c. If a variable of interest has multiple entries in an input file.
    d. If the first row and the first column are different in the correlation matrix file.

e. If the numerical cells of the matrices are not positive real numbers.

**The results are displayed:**

1. In an html file with the title: Data Reconciliation Report. This file automatically pops up when the calculation is completed.
2. **In two csv output files:**
    a. One that contains the reconciled values and the reconciled half-width confidence intervals.
    b. The other that contains the reconciled covariance matrix.

**These files do not pop up automatically when the calculation is completed. The names of the files are respectively**

<working directory>\<model name>\< model name>_Outputs.csv

**and**

<working directory>\<model name>\< model name>_Reconciled_Sx.csv,

where <model name> denotes the full name of the model, including its path. The name of the working directory can be read with the command Tools > Options.

The Data Reconciliation Report has three sections:

1. **Overview, with the following information:**
    a. Model file: name of the Modelica model file
    b. Model name: name of the Modelica model
    c. Model directory: name of the directory of the Modelica model file
    d. Measurement input file: name of the measurement input file
    e. Correlation matrix input file: name of the correlation matrix file (if any)
    f. Generated: date and time of the generation of the data reconciliation report
2. **Analysis, with the following information:**
    a. Number of auxiliary conditions, denoted r in the sequel.
    b. Number of variables to be reconciled.
    c. Number of related boundary conditions: number of boundary conditions related to the variables to be reconciled. This number should be strictly less than the number of variables to be reconciled, otherwise the data reconciliation problem is ill-posed and data reconciliation cannot be performed.
    d. Number of iterations to convergence: number of iterations of the data reconciliation numerical loop.
    e. Final value of J*/r: final value of the data reconciliation iteration loop. This value is smaller than epsilon when the iterations are completed (cf. below).
    f. Epsilon: stopping criteria of the data reconciliation iteration loop. The recommended value by VDI 2048 is 1.e-10.
    g. Final value of the objective function J*: is equal to J*/r multiplied by r, where r is the number of auxiliary conditions.
    h. Chi-square value: value of the chi-square distribution for r degrees of freedom and statistical certainty of probability of 95%.
    i. Result of global test: true if J* is less than the chi-square value, false otherwise. If false, the results for the reconciled values should be rejected because the vector of contradictions (i.e. the discrepancy between the measured values and the reconciled values) is too large.
    j. Auxiliary conditions: set of the auxiliary conditions (i.e., the equations that constrain the variables of interest).

k. Intermediate equations: set of the intermediate equations (i.e., the equations that compute the intermediate variables from the variables of interest). This set can be empty if there are no intermediate variables.

l. Debug log: log of the numerical iteration loop.

3. **Results, which is a table with the following columns:**

   a. Variables to be Reconciled: the names of the variables of interest.

   b. Initial Measured Values: the measured values entered in the measurement input file.

   c. Reconciled Values: the reconciled values computed by the data reconciliation algorithm.

   d. Initial Half-width Confidence Intervals: the half-width confidence intervals entered in the measurement input file.

   e. Reconciled Half-width Confidence Intervals: the reconciled half-width confidence intervals computed by the data reconciliation algorithm.

   f. Results of Local Tests: true if the values of local tests (cf. below) are less than the quantile of normal distribution with probability 95% ($\lambda_{95\%}$), false otherwise.

   g. Values of Local Tests: values of the improvements (i.e., the difference between the initial and the reconciled values) divided by the square root of the diagonal element of the covariance matrix of the improvements.

   h. Margin to Correctness: $\lambda_{95\%}$ minus the values of local tests.

The data reconciliation report for the the VDI2048 standard example of a heat circuit of a steam turbine plant is given below.

### 40.3.1 Overview:

Model file: VDI2048Example.mo
Model name: NewDataReconciliationSimpleTests.VDI2048Example
Model directory: NewDataReconciliationSimpleTests
Measurement input file: VDI2048Example_Inputs.csv
Correlation matrix input file: VDI2048Example_Correlation.csv
Generated: Thu Jan 20 18:41:45 2022by OpenModelica v1.19.0-dev-500-g6c3a4e429f (64-bit)

### 40.3.2 Analysis:

Number of auxiliary conditions: 3
Number of variables to be reconciled: 11
Number of related boundary conditions: 0
Number of iterations to convergence: 2
Final value of (J*/r) : 4.56744e-28
Epsilon : 1e-10
Final value of the objective function (J*) : 1.37023e-27
Chi-square value : 7.81473
Result of global test : TRUE

### 40.3.3 Auxiliary conditions

1. (1): 0.0 = mHDANZ - mHDNK
2. (1): mFD3 = mHK + mA7 + mA6 + mA5 + 0.4 * mV
3. (1): mFD1 = mFDKEL + mFDKELL + (-0.2) * mV

### 40.3.4 Intermediate equations

1. (1): mHDANZ = mA7 + mA6 + mA5
2. (1): mFD2 = mSPL + mSPLL + (-0.6) * mV
3. (1): 0.0 = mFD2 - mFD3
4. (1): 0.0 = mFD1 - mFD2

### 40.3.5 Debug log

### 40.3.6 Results

| Variables to be Reconciled | Initial Measured Values | Reconciled Values | Initial Half-width Confidence Intervals | Reconciled Half-width Confidence Intervals | Results of Local Tests | Values of Local Tests | Margin to Correctness |
|---|---|---|---|---|---|---|---|
| mFDKEL | 46.241 | 44.6959 | 2.5 | 1.61062 | TRUE | 1.58381 | 0.376194 |
| mFDKELL | 45.668 | 44.1229 | 2.5 | 1.61062 | TRUE | 1.58381 | 0.376194 |
| mSPL | 44.575 | 44.6426 | 0.535 | 0.425429 | TRUE | 0.40853 | 1.55147 |
| mSPLL | 44.319 | 44.3861 | 0.532 | 0.423635 | TRUE | 0.40853 | 1.55147 |
| mV | 0.525 | 0.524499 | 0.105 | 0.104627 | TRUE | 0.0295873 | 1.93041 |
| mHK | 69.978 | 70.0049 | 0.854 | 0.615089 | TRUE | 0.08913 | 1.87087 |
| mA7 | 10.364 | 10.3642 | 0.168 | 0.133112 | TRUE | 0.00387312 | 1.95613 |
| mA6 | 3.744 | 3.74402 | 0.058 | 0.0566989 | TRUE | 0.00257972 | 1.95742 |
| mA5 | 4.391 | 4.39102 | 0.058 | 0.0566989 | TRUE | 0.00257972 | 1.95742 |
| mHDNK | 18.498 | 18.4993 | 0.205 | 0.137264 | TRUE | 0.0161013 | 1.9439 |
| mD | 2.092 | Not reconciled | 0.272 | Not reconciled | Not reconciled | Not reconciled | Not reconciled |

mD is not reconciled because it does not appear in any of the auxiliary conditions or intermediate equations.

**For the VDI2048 example, the name of the csv output file is**

> <working directory>\NewDataReconciliationSimpleTests.VDI2048Example\NewDataReconciliationSimpleTests.VDI2048Example_Output

**and the name of the reconciled covariance matrix csv file is**

> <working directory>\NewDataReconciliationSimpleTests.VDI2048Example\NewDataReconciliationSimpleTests.VDI2048Example_Reconciled_Sx.csv

The Modelica model of the VDI2048 example is given below.

```
model VDI2048Example
  Real mFDKEL(uncertain=Uncertainty.refine)=46.241;
  Real mFDKELL(uncertain=Uncertainty.refine)=45.668;
  Real mSPL(uncertain=Uncertainty.refine)=44.575;
  Real mSPLL(uncertain=Uncertainty.refine)=44.319;
  Real mV(uncertain=Uncertainty.refine);
  Real mHK(uncertain=Uncertainty.refine)=69.978;
  Real mA7(uncertain=Uncertainty.refine)=10.364;
  Real mA6(uncertain=Uncertainty.refine)=3.744;
  Real mA5(uncertain=Uncertainty.refine);
  Real mHDNK(uncertain=Uncertainty.refine);
  Real mD(uncertain=Uncertainty.refine)=2.092;
```

(continues on next page)

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```
  Real mFD1;
  Real mFD2;
  Real mFD3;
  Real mHDANZ;
equation
  mFD1 = mFDKEL + mFDKELL - 0.2*mV;
  mFD2 = mSPL + mSPLL - 0.6*mV;
  mFD3 = mHK + mA7 + mA6 + mA5 + 0.4*mV;
  mHDANZ = mA7 + mA6 + mA5;

  0 = mFD1 - mFD2;
  0 = mFD2 - mFD3;
  0 = mHDANZ - mHDNK;
end VDI2048Example;
```

Note that the binding equations that assign fixed values to the variables have been automatically eliminated by the extraction algorithm. These equations are necessary to have a valid square Modelica model, but must be eliminated for data reconciliation.

The table below compares the results obtained with OpenModelica with those given by the VDI2048 standard.

| Variables to be Reconciled | Initial Measured Values | Reconciled Values with OpenModelica | Reconciled Values from VDI2048 | Initial Half-width Confidence Intervals | Reconciled Half-width Confidence Intervals with OpenModelica | Reconciled Half-width Confidence Intervals from VDI2048 |
|---|---|---|---|---|---|---|
| mFDKEL | 46.241 | 44.6959 | 44.696 | 2.5 | 1.61062 | 1.611 |
| mFDKELL | 45.668 | 44.1229 | 44.123 | 2.5 | 1.61062 | 1.611 |
| mSPL | 44.575 | 44.6426 | 44.643 | 0.535 | 0.425429 | 0.425 |
| mSPLL | 44.319 | 44.3861 | 44.386 | 0.532 | 0.423635 | 0.424 |
| mV | 0.525 | 0.524499 | 0.524 | 0.105 | 0.104627 | 0.105 |
| mHK | 69.978 | 70.0049 | 70.005 | 0.854 | 0.615089 | 0.615 |
| mA7 | 10.364 | 10.3642 | 10.364 | 0.168 | 0.133112 | 0.133 |
| mA6 | 3.744 | 3.74402 | 3.744 | 0.058 | 0.0566989 | 0.057 |
| mA5 | 4.391 | 4.39102 | 4.391 | 0.058 | 0.0566989 | 0.057 |
| mHDNK | 18.498 | 18.4993 | 18.499 | 0.205 | 0.137264 | 0.137 |
| mD | 2.092 | Not reconciled | 2.092 | 0.272 | Not reconciled | 0.272 |

The value of mD is left unchanged after reconciliation. This is indicated by 'Not reconciled' in OpenModelica, and by repeating the initial measured values in VDI2048. In order to compute the reconciled values of mFD1, mFD2, mFD3 and mHDANZ, which have no measurements, it is possible to consider them as variables of interest with very large half-width confidence, e.g., 1e4, and assign them arbitrary measured values, e.g. 0. The result is

For the splitter, the results are the following:

## 40.4 Computing the Boundary Conditions from the Reconciled Values

**The values and uncertainties of the boundary conditions that correspond to the reconciled values of the variables of interest can be computed by:**

1. Selecting Data Reconciliation > Calculate Data Reconciliation

| Variables to be Reconciled | Initial Measured Values | Reconciled Values with OpenModelica | Reconciled Values from VDI2048 | Initial Half-width Confidence Intervals | Reconciled Half-width Confidence Intervals with OpenModelica | Reconciled Half-width Confidence Intervals fror VDI2048 |
|---|---|---|---|---|---|---|
| mFDKEL | 46.241 | 44.6959 | 44.696 | 2.5 | 1.61062 | 1.611 |
| mFDKELL | 45.668 | 44.1229 | 44.123 | 2.5 | 1.61062 | 1.611 |
| mSPL | 44.575 | 44.6426 | 44.643 | 0.535 | 0.425428 | 0.425 |
| mSPLL | 44.319 | 44.3861 | 44.386 | 0.532 | 0.423634 | 0.424 |
| mV | 0.525 | 0.524499 | 0.524 | 0.105 | 0.104627 | 0.105 |
| mHK | 69.978 | 70.0049 | 70.005 | 0.854 | 0.61509 | 0.615 |
| mA7 | 10.364 | 10.3642 | 10.364 | 0.168 | 0.133112 | 0.133 |
| mA6 | 3.744 | 3.74402 | 3.744 | 0.058 | 0.0566989 | 0.057 |
| mA5 | 4.391 | 4.39102 | 4.391 | 0.058 | 0.0566989 | 0.057 |
| mHDNK | 18.498 | 18.4993 | 18.499 | 0.205 | 0.137264 | 0.137 |
| mD | 2.092 | Not reconciled | 2.092 | 0.272 | Not reconciled | 0.272 |
| mFD1 | *** | 88.714 | 88.714 | *** | 0.613429 | 0.613 |
| mFD2 | *** | 88.714 | 88.714 | *** | 0.613429 | 0.613 |
| mFD3 | *** | 88.714 | 88.714 | *** | 0.613429 | 0.613 |
| mHDANZ | *** | 18.4993 | 18.499 | *** | 0.137264 | 0.137 |

| Variables to be Reconciled | Initial Measured Values | Reconciled Values | Initial Half-width Confidence Intervals | Reconciled Half-width Confidence Intervals | Results of Local Tests | Values of Local Tests | Margin to Correctnes |
|---|---|---|---|---|---|---|---|
| splitter.pipe1.Q | 2.5 | 2.43767 | 0.196 | 0.108462 | TRUE | 0.748276 | 1.21172 |
| splitter.pipe1.Pm | 610000 | 617668 | 39200 | 31584.6 | TRUE | 0.647353 | 1.31265 |
| splitter.pipe1.T | 292 | 290.015 | 14 | 8.25849 | TRUE | 0.344207 | 1.61579 |
| splitter.pipe2.Q | 1.15 | 1.17158 | 0.196 | 0.130814 | TRUE | 0.289819 | 1.67018 |
| splitter.pipe2.Pm | 255000 | 251925 | 39200 | 28890.4 | TRUE | 0.227449 | 1.73255 |
| splitter.pipe2.T | 386 | 387.853 | 13 | 7.79403 | TRUE | 0.349125 | 1.61087 |
| splitter.pipe3.Q | 1.25 | 1.26609 | 0.196 | 0.129549 | TRUE | 0.214432 | 1.74557 |
| splitter.pipe3.Pm | 245000 | 240406 | 39200 | 29129.9 | TRUE | 0.34324 | 1.61676 |
| splitter.pipe3.T | 388 | 387.859 | 13 | 7.79402 | TRUE | 0.026654 | 1.93335 |

2. Selecting the Boundary Conditions algorithm.
3. **Filling the Data Reconciliation form with**
    a. The name of the Reconciled Measurement File (mandatory). It is the name of the csv output file produced by the data reconciliation algorithm.
    b. The name of the Reconciled Correlation Matrix file (mandatory). It is the name of the correlation matrix csv file produced by the data reconciliation algorithm.
4. Clicking on Save Settings to save the above settings in the Modelica model.
5. Clicking on Calculate to launch the calculation.

**At least one boundary condition must be declared in the model, otherwise the computation fails with a difficult to interpret error message such as**

Cannot Compute Jacobian Matrix F.

A better error message will be posted in a future version.

**The computation of the boundary conditions is performed in three main steps:**

1. **Static analysis is performed on the model to extract the equations that compute the boundary conditions from the variables of interest. This corresponds to automatically inverting the original model. There are two groups of extracted equations:**
    a. The boundary conditions that are the equations that compute the boundary conditions.
    b. The intermediate equations that solve the intermediate variables from the variables of interest (this is the numeric way of eliminating the intermediate variables).

2. The model is simulated to compute the Jacobian matrices and eliminate numerically the intermediate equations. At this step, numerical simulation errors can occur, such as divisions by zero, non-convergence, etc. They can be corrected by improving the model or providing better start values.

3. The input files are read, the numerical calculations are performed, and the results are displayed. The half-width confidence intervals for the boundary conditions are calculated by propagating the reconciled uncertainties on the variables of interest through the inverted model.

**The results are displayed:**

1. In an html file with the title: Boundary Condition Report. This file pops up automatically when the calculation is completed.

2. In a csv output file. The name of the csv output file is <working directory>\<model name>\< model name>_ BoundaryConditions_Outputs.csv

The Boundary Condition Report has three sections:

### 40.4.1 Overview

a. Model file: name of the Modelica model file
b. Model name: name of the Modelica model
c. Model directory: name of the directory of the Modelica model file
d. Reconciled values input file: name of the csv output file produced by the data reconciliation algorithm
e. Reconciled covariance matrix input file: name of the correlation matrix csv file produced by the data reconciliation algorithm
f. Generated: date and time of the generation of the boundary condition report

### 40.4.2 Analysis

a. Number of boundary conditions.

b. Number of reconciled variables.

c. Boundary conditions: set of the boundary conditions (i.e., the equations that compute the boundary conditions).

d. Intermediate equations: set of the intermediate equations (i.e., the equations that compute the intermediate variables from the variables of interest).

### 40.4.3 Debug log

Log of the numerical iteration loop

### 40.4.4 Results

**A table with the following columns**

a. Boundary Conditions: the names of the boundary conditions.

b. Values: the computed values of the boundary conditions.

c. Reconciled Half-width Confidence Intervals: the half-with confidence intervals for the boundary conditions.

The results for the splitter are:

| Boundary conditions | Values | Reconciled Half-width Confidence Intervals |
|---|---|---|
| splitter.sinkQ1.Q0 | 1.26609 | 0.129549 |
| splitter.sourceP.P0 | 914780 | 53492.5 |
| splitter.sinkQ.Q0 | 1.17158 | 0.130814 |
| splitter.sourceP.T0 | 290.087 | 8.2886 |

## 40.5 Contacts

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## 40.6 References

Bouskela, D., Jardin, A., Palanisamy, A., Ochel, L., & Pop, A. (2021). New Method to Perform Data Reconciliation with OpenModelica and ThermoSysPro. Proceedings of 14th Modelica Conference 2021, Linköping, Sweden, September 20-24, 2021.

VDI - Verein Deutscher Ingenieure. (2000). Uncertainty of measurement during acceptance tests on energy-conversion and power plants - Part 1: Fundamentals. VDI 2048 Blatt 1, October 2000.

CHAPTER

# FORTYONE

# FREQUENTLY ASKED QUESTIONS (FAQ)

Below are some frequently asked questions in three areas, with associated answers.

## 41.1 OpenModelica General

- **Q: OpenModelica does not read the MODELICAPATH environment variable,**
  even though this is part of the Modelica Language Specification.
- **A: Use the OPENMODELICALIBRARY environment variable instead. We have**
  switched to this variable, in order not to interfere with other Modelica tools which might be installed on the same system. MODELICAPATH is not read at all: OPENMODELICALIBRARY does not extend or override it. Like MODELICAPATH, it is a list of directories, separated by colon (:) on all operating systems except Windows, which uses semicolon (;). If it is not set, OpenModelica defaults to OPENMODELICAHOME/lib/omlibrary/ and ~/.openmodelica/libraries/ (on Windows '~' is %APPDATA%). In the future, we might switch to a solution with a settings file, that also allows the user to turn on the MODELICAPATH functionality if desired.
- **Q: How do I enter multi-line models into OMShell since it evaluates**
  when typing the Enter/Return key?
- **A: There are basically three methods: 1) load the model from a file**
  using the pull-down menu or the loadModel command. 2) Enter the model/function as one (possibly long) line. 3) Type in the model in another editor, where using multiple lines is no problem, and copy/paste the model into OMShell as one operation, then push Enter. Another option is to use OMNotebook instead to enter and evaluate models.

## 41.2 OMNotebook

- Q: OMNotebook hangs, what to do?
- **A: It is probably waiting for the omc.exe (compiler) process. (Under**
  windows): Kill the processes omc.exe, g++.exe (C-compiler), as.exe (assembler), if present. If OMNotebook then asks whether to restart OMC, answer yes. If not, kill the process OMNotebook.exe and restart manually.
- **Q: After a previous session, when starting OMNotebook again, I get a**
  strange message.
- **A: You probably quit the previous OpenModelica session in the wrong**
  way, which left the process omc.exe running. Kill that process, and try starting OMNotebook again.
- **Q: I copy and paste a graphic figure from Word or some other**
  application into OMNotebook, but the graphic does not appear. What is wrong?
- **A: OMNotebook supports the graphic picture formats supported by Qt,**
  including the .png, .bmp (bitmap) formats, but not for example the gif format. Try to convert your picture into one of the supported formats, (e.g. in Word, first do paste as bitmap format), and then copy the converted version into a text cell in OMNotebook.

- **Q: I select a cell, copy it (e.g. Ctrl-C), and try to paste it at**
  another place in the notebook. However, this does not work. Instead some other text that I earlier put on the clipboard is pasted into the nearest text cell.
- **A: The problem is wrong choice of cursor mode, which can be text**
  insertion or cell insertion. If you click inside a cell, the cursor become vertical, and OMNotebook expects you to paste text inside the cell. To paste a cell, you must be in cell insertion mode, i.e., click between two cells (or after a cell), you will get a vertical line. Place the cursor carefully on that vertical line until you see a small horizontal cursor. Then you should past the cell.
- **Q: I am trying to click in cells to place the vertical character**
  cursor, but it does not seem to react.
- **A: This seems to be a Qt feature. You have probably made a selection**
  (e.g. for copying) in the output section of an evaluation cell. This seems to block cursor position. Click again in the output section to disable the selection. After that it will work normally.
- **Q: I have copied a text cell and start writing at the beginning of**
  the cell. Strangely enough, the font becomes much smaller than it should be.
- **A: This seems to be a Qt feature. Keep some of the old text and start**
  writing the new stuff inside the text, i.e., at least one character position to the right. Afterwards, delete the old text at the beginning of the cell.

CHAPTER

FORTYTWO

# MAJOR OPENMODELICA RELEASES

This Appendix lists the most important OpenModelica releases and a brief description of their contents. Right now versions from 1.3.1 to v1.27.1 are described.

## 42.1 Release Notes for nightly

## 42.2 Release Notes for OpenModelica 1.27.1

## 42.3 Patch release for 1.27.0.

- OMEdit can now re-simulate a model from compiled artifacts without requiring the Modelica source code and without the need of recompiling it #14111.
- Improved handling of parameter menus for instances of replaceable models #16248
- Many fixes to OMEdit, including some causing the GUI to crash.
- Fixed bug in the implementation of `spatialDistribution()`

Here is the complete list of closed issues.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.27.0...v1.27.1

## 42.4 Release Notes for OpenModelica 1.27.0

## 42.5 2026 summer release of OpenModelica version 1.27.0.

### 42.5.1 Main highlights:

- Experimental MCP server in OMEdit for interaction with AI agents.
- OMEdit now uses Qt6 instead of Qt5, better rendering on high-resolution monitors.
- State machines are now supported by the new frontend.
- Reverse model lookup.
- The Modifiers tab in the parameter dialog now collects all the modifiers applied to a component instance that were not previously displayed in the Parameters dialog.
- Improved formatting of parameter input dialogs.
- More responsive editing of diagrams in OMEdit.
- 60 Hz framerate animations of Multibody systems.
- Improved simulation of systems with implicit equations including if clauses.
- Previously compiled models can be re-simulated in a new session.
- Declarative equation-based debugger now handles models with more than 10.000 equations efficiently.

- FMU memory leaks fixed.
- Applying library conversion scripts preserves the original formatting.

### 42.5.2 OpenModelica Compiler (OMC)

#### Frontend

The new front end has been further improved with 29 issues resolved.

State machines ar now supported by the new frontend, see #8162; since there are basically no open-source libraries using them for testing, the implementation may still be buggy or incomplete, testing by OpenModelica users is very welcome.

Base Modelica export was improved, including alias simplification of flow variables in stream connectors for efficient mixed-integer optimization of thermo-fluid system models, -d=flowAliasElimination.

The use of equality among Reals outside functions, which is prohibited by the Modelica Language Specification for good numerical reasons, is now deprecated, see #14940. It will not be accepted by future versions of the compiler, unless specifically required by a `--allowNonStandardModelica` flag.

#### Backend and Code Generation

A bug in the resolveLoops module causing completely wrong results to be computed was fixed, see #13292. Overall, 8 issues were fixed in the currently used backend.

The work on the development of the new backend continued, with substantial improvements and over 80 pull requests. 41% of the Modelica Standard Library and 48% of the models of the Buildings library are now simulated successfully. 11 issues were closed.

Recall that the new backend, which is a lot more efficient than the currently used one, in particular when handling arrays, is still under development and experimentally available with the `--newBackend <https://openmodelica.org/doc/OpenModelicaUersGuide/latest/omchelptext.html#omcflag-newbackend>`__ compiler flag.

The experimental `initialSimplified()` operator was introduced in the new backend, see #11272. Its use and rationale are described in a paper submitted to the 2026 Asian Modelica Conference.

5 issues regarding code generation were also fixed.

#### C runtime

Several improvements were added to the internal nonlinear solver of GBODE, further improving its efficiency, which now can exceed multi-step methods such as DASSL and IDA for systems with many events. This can be activated with flags `-gbnls=internal`, `-gberr=embedded`.

A bug in the implementation of nonlinear solvers for systems including if-equations was fixed, drastically improving the speed and robustness of the solution for such systems, in particular piecewise-linear electrical circuit models, see #15718 for more details.

Overall 12 issues regarding the runtime were addressed.

### 42.5.3 Graphical Editor OMEdit

OMEdit 1.27.0 provides many new features and improvements:

- Qt6 is used instead of Qt5, leading to improved graphical rendering on wide high-resolution displays.
- Reverse model lookup: by right-clicking on a class in the Libraries Browser and selecting Find Usage, it is possible to get a list of all usages of that class in all the loaded model, see #12915.
- The whole list of modifiers added to an instantiated model which are not already represented in the General and custom parameter tabs are now visible in the Modifiers tab, see #14372. This includes:
  - binding equations for variables and input variables;
  - min/max/nominal attribute modifiers;

  - modifiers and redeclares applied to sub-components, possibly by the Show Element feature, which are now visible in the parameter dialog, tab Modifiers, of the top-level component.
- The formatting of input and text fields of parameter input dialogs was further improved.
- Many diagram editing operations that were previously very slow are now much faster, see #14804.
- It is now possible to re-simulate a model that fails when simulating for the first time; previously, one had to recompile it, see #5472.
- It is now possible to re-simulate a model that was compiled in a previous session, see #14111.
- Multibody animations now run at 60 Hz framerate, see #14851.
- The declarative equation-based debugger can now handle large models over 10,000 equations, see #9977.
- Applying conversion scripts for newer versions of the used libraries preserves the original formatting, see #13447.

Many OMEdit bugs were also fixed in this release. Overall, 52 issues were addressed.

### 42.5.4 FMI export

Some bugs causing FMU memory leaks and eventually leading to out-of-memory errors were fixed, see #12225, #13488, and #14509. A bug causing failure when exporting FMUs with directional derivatives was also fixed, see #15537.

Overall, 12 issues regarding FMI export were addressed.

### 42.5.5 Experimental MCP server in OMEdit for interaction with AI agents

An experimental MCP server was implemented in OMEdit to allow AI agents to interact with OMEdit by writing, modifying, and running models, and then by analyzing the plotted results. See #15385 and follow up #15854. This server is switched off by default and can be activated by following these instructions. You are welcome to contribute to the discussion proposing ideas and requesting features in #15854.

### 42.5.6 List of tickets closed in 1.27.0

List of closed tickets in the 1.27.0 release. Over 160 issues were addressed and resolved.

### 42.5.7 Next releases

The next release 1.28.0 is planned to be released at the end of 2026.

A major milestone in 1.28.0 will be FMI3 support. We are also planning to include much improved handling of conditional connectors and further improvements to the GUI such as a restructured Simulation Setup dialog, faster editing of large models in OMEdit, better plotting of clocked variables, support of the Figure annotation, etc.

We are also actively experimenting the option of running OMEdit in the browser, using local hardware resources through Wasm technology. A mature enough version should become available when 1.28.0 is released.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.9...v1.27.0

## 42.6 Release Notes for v1.26.9

### 42.6.1 What's Changed

- Fix for #15808 parameter value width by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15828

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.8...v1.26.9

## 42.7 Release Notes for v1.28.0-dev

## 42.8 Release Notes for OpenModelica v1.26.8

### 42.8.1 What's Changed

- nothing changed, just fixing some github actions

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.7...v1.26.8

## 42.9 Release Notes for OpenModelica v1.26.7

### 42.9.1 What's Changed

- nothing changed, just fixing some github actions
- fix copy-paste error by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15474

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.6...v1.26.7

## 42.10 Release Notes for OpenModelica 1.26.6

### 42.10.1 What's Changed

Nothing has changed since v1.26.4. Release 1.26.5 and 1.26.6 are made just to tests our github actions.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.5...v1.26.6

## 42.11 Release Notes for OpenModelica 1.26.5

### 42.11.1 What's Changed

- add the workflows from master by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15454
- remove the wip workflow by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15457

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.4...v1.26.5

## 42.12 Release Notes for OpenModelica 1.26.4

## 42.13 Patch release for 1.26.3.

### 42.13.1 What's Changed

- Check for Expression.isNull() (#15116) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/15138
- update 3rdParty to build on resolute by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15421
- force qt6 on resolute by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15422
- Fix compilation on clang 21.1.8 by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15426
- fix for #15300 - filter on discrete variables (#15302) by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/15429

Here is the complete list of closed issues.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.3...v1.26.4

## 42.14 Release Notes for OpenModelica 1.26.3

## 42.15 Patch release for 1.26.2.

Fixes this bug: #15080 - Regression: start value not displayed

Here is the complete list of closed issues.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.2...v1.26.3

## 42.16 Release Notes for OpenModelica 1.26.2

## 42.17 Patch release for 1.26.1.

Fixes three bugs:

- #14810 was fixed in 1.26.1 but introduced a regression in the C++ runtime. This is now fixed.
- #14926 units were changed when the decimal dot was inserted in parameter editing fields. This is now fixed.
- #14894 supporting the double y-axis introduced a regression on the size of new plot windows. This is now fixed.

Here is the complete list of closed issues.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.1...v1.26.2

## 42.18 Release Notes for OpenModelica 1.26.1

## 42.19 Patch release for 1.26.0.

Fixes two critical bugs introduced in 1.26.0.

- #14848 was due to PR #14819, which resolved #10145. The bug caused OMEdit 1.26.0 to crash while typing non-trivial expressions in parameter input fields, if the currently displayed expression was invalid, e.g., when starting to type a string constant " or an array {.
- #14861 was due to PR #14774 which resolved #11721. The bug caused wrong redeclare clauses to be generated when using drop-down menus to redeclare replaceable classes, e.g. replaceable Medium models from Modelica.Media

Here is the complete list of closed issues.

Windows beta releases available here

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.0...v1.26.1

## 42.20 Release Notes for OpenModelica 1.26.1 Beta 2

## 42.21 Patch release for 1.26.0.

Fixes two critical bugs introduced in 1.26.0.

- #14848 was due to PR #14819, which resolved #10145. The bug caused OMEdit 1.26.0 to crash while typing non-trivial expressions in parameter input fields, if the currently displayed expression was invalid, e.g., when starting to type a string constant " or an array {.
- #14861 was due to PR #14774 which resolved #11721. The bug caused wrong redeclare clauses to be generated when using drop-down menus to redeclare replaceable classes, e.g. replaceable Medium models from Modelica.Media

Here is the complete list of closed issues.

Windows beta releases available here

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.26.0...v1.26.1-dev.beta.2

## 42.22 Release Notes for OpenModelica 1.26.0

## 42.23 2025 Winter release of OpenModelica version 1.26.0.

### 42.23.1 Main highlights:

- OMEdit now allows to **load and save** models and packages with **syntax errors**.
- **Improved sizing of parameter editing dialogs** in OMEdit.
- OpenModelica now allows to **use ``break`` to** remove modifiers **and for** selective model extension.
- OpenModelica now implements **less restrictive rules for the use of conditional components**, as specified in the draft of the next Modelica Language Specification.
- **Improved operation of debugging features in OMEdit**: the generation of Equation Operations in the Equation-Based Debugger is now activated by default and it is also possible to activate profiling at runtime after running a model for the first time.
- Improved handling of **large result files** in OMEdit.
- Old **deprecated and poorly supported solvers were removed from the runtime** - gbode should be used instead.

### 42.23.2 OpenModelica Compiler (OMC)

Selective model extension was introduced in #11381.

New, less restrictive rules that are now defined for conditional components in the draft version of Modelica 3.7 were implemented in #12888; basically, it is now possible to refer to conditionally defined components outside of connect statements, as long as they are actually defined.

The new front end has been further improved with 25 issues resolved.

Regarding backend work, 12 issues were fixed in the currently used backend.

The work on the development of the new backend continued, with 31 issues fixed. Recall that the new backend, which is a lot more efficient in particular when handling arrays, is still under development and experimentally available with the `--newBackend <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omchelptext.html#omcflag-newbackend>`__ compiler flag.

13 issues regarding code generation were also fixed.

Regarding the C runtime, a new solver strategy was implemented in GBODE, which drastically reduces the number of iterations of the nonlinear solver in the implicit integration methods at each stage, while preserving the same accuracy of the solution; see also the discussion in #14089, #14022. This can be activated with flags `-gbnls=internal`, `-gberr=embedded`; only works with single-rate at the moment, but will be extended to multi-rate integration in the next release.

Old poorly supported and deprecated solvers (see #9191) were finally removed from the runtime. They are replaced by better implemented algorithm available within the GBODE solver.

Overall 21 issues regarding the runtime were addressed.

### 42.23.3 Graphical Editor OMEdit

OMEdit 1.26.0 provides several new features:

- It is now possible load and save models and packages with syntax errors. Until all errors are fixed, the code can be edited in text mode, with a direct mapping on the file system; then, it can be saved and re-loaded with the standard Modelica view, see #13663.
- Much better sizing of parameter input dialogs. Lenghty comments in drop-down menus are now displayed in tooltips, avoiding the need of excessively wide parameter input windows, see #11721.
- Improved operation of debugging features: the generation of Equation Operations in the Equation-Based Debugger is now activated by default and it is also possible to activate profiling at runtime after running a model for the first time.
- Loading large result files in OMEdit is now much faster and more reliable.

Many OMEdit bugs were also fixed in this release. Overall, 39 issues were addressed.

### 42.23.4 FMI export

CMAKE FMU export is now the default option. A critical bug was resolved about changes in discrete input variables, which did not generate events in FMI ME, see #13822. Overall, 10 issues regarding FMI export were addressed.

### 42.23.5 OMPython

OMPython 4.0.0 was released on Oct 20, 2025. See the release notes.

### 42.23.6 List of tickets closed in 1.26.0

List of closed tickets in the 1.26.0 release. Overall, 170 issues were addressed and resolved.

### 42.23.7 Next releases

The next release is planned to be released in spring 2026. It should include much improved handling of conditional connectors and further improvements to the GUI such as a restructured Simulation Setup dialog, faster editing of large models in OMEdit, better plotting of clocked variables, support of the Figure annotation, etc. Further improvements in FMI export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.25.7...v1.26.0

## 42.24 Release Notes for OpenModelica 1.26.0-dev.beta.1

### 42.24.1 2025 winter release of OpenModelica 1.26.0 Beta 1 version.

Main highlights:

- OMEdit now allows to **load and save** models and packages with **syntax errors**.
- **Improved sizing of parameter editing dialogs** in OMEdit.
- OpenModelica now allows to **use ``break`` to** remove modifiers **and for** selective model extension.
- OpenModelica now implements **less restrictive rules for the use of conditional components**, as specified in the draft of the next Modelica Language Specification.
- **Improved operation of debugging features in OMEdit**: the generation of Equation Operations in the Equation-Based Debugger is now activated by default and it is also possible to activate profiling at runtime after running a model for the first time.
- Improved handling of **large result files** in OMEdit.
- Old **deprecated and poorly supported solvers were removed from the runtime** - gbode should be used instead.

### 42.24.2 OpenModelica Compiler (OMC)

Selective model extension was introduced in #11381.

New, less restrictive rules that are now defined for conditional components in the draft version of Modelica 3.7 were implemented in #12888; basically, it is now possible to refer to conditionally defined components outside of connect statements, as long as they are actually defined.

The new front end has been further improved with 25 issues resolved.

Regarding backend work, 12 issues were fixed in the currently used backend.

The work on the development of the new backend continued, with 29 issues fixed. Recall that the new backend, which is a lot more efficient in particular when handling arrays, is still under development and experimentally available with the `--newBackend <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omchelptext.html#omcflag-newbackend>`__ compiler flag.

13 issues regarding code generation were also fixed.

Regarding the C runtime, a new solver strategy was implemented in GBODE, which drastically reduces the number of iterations of the nonlinear solver in the implicit integration methods at each stage, while preserving the same accuracy of the solution; see also the discussion in #14089, #14022. This can be activated with flags `-gbnls=internal`, `-gberr=embedded`; only works with single-rate at the moment, but will be extended to multi-rate integration in the next release.

Old poorly supported and deprecated solvers (see #9191) were finally removed from the runtime. They are replaced by better implemented algorithm available within the GBODE solver.

Overall 20 issues regarding the runtime were addressed.

### 42.24.3 Graphical Editor OMEdit

OMEdit 1.26.0 provides several a few new features:

- It is now possible load and save models and packages with syntax errors. Until all errors are fixed, the code can be edited in text mode, with a direct mapping on the file system; then, it can be saved and re-loaded with the standard Modelica view, see #13663.
- Much better sizing of parameter input dialogs. Lenghty comments in drop-down menus are now displayed in tooltips, avoiding the need of excessively wide parameter input windows, see #11721.
- Improved operation of debugging features: the generation of Equation Operations in the Equation-Based Debugger is now activated by default and it is also possible to activate profiling at runtime after running a model for the first time.
- Loading large result files in OMEdit is now much faster and more reliable.

Many OMEdit bugs were also fixed in this release. Overall, 35+ issues were addressed.

### 42.24.4 FMI export

CMAKE FMU export is now the default option. A critical bug was resolved about changes in discrete input variables, which did not generate events in FMI ME, see #13822. Overall, 10 issues regarding FMI export were addressed.

### 42.24.5 OMPython

OMPython 4.0.0 was released on Oct 20, 2025. See the release notes.

### 42.24.6 List of tickets closed in 1.26.0

List of closed tickets in the 1.26.0 release. Over 160 issues were addressed and resolved.

### 42.24.7 Next releases

The next release is planned to be released in spring 2026. It should include much improved handling of conditional connectors and further improvements to the GUI such as a restructured Simulation Setup dialog, faster editing of large models in OMEdit, better plotting of clocked variables, support of the Figure annotation, etc. Further improvements in FMI export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.25.7...v1.26.0-dev.beta.1

## 42.25 Release Notes for OpenModelica 1.25.7

Patch release of 1.25.6. Fixes a bug introduced in 1.25.6 that caused OMEdit to crash.

## 42.26 Release Notes for OpenModelica 1.25.6

Patch release of 1.25.5.

Fixes 6 issues of the OMEdit GUI, regarding animations with CAD files, OMEdit crashes, hierarchical editing. Also fixes a regression that caused slow loading of large result files.

## 42.27 Release Notes for OpenModelica 1.25.5

Patch release of 1.25.4. Fixes a couple of issues with FMI export, including a regression introduced in 1.25.4, as well as a couple of bugs in OMEdit.

Here is a complete list of the fixed issues.

## 42.28 Release Notes for OpenModelica 1.25.4

### 42.28.1 What's Changed

- Construct the qualified path of variable (#14341) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/14342
- Clear the hash (#14344) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/14345

This is bug fix release that fixes a regression with the plotting in OMEdit introduced in v1.25.3.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.25.3...v1.25.4

## 42.29 Release Notes for OpenModelica 1.25.3

Patch release of 1.25.2. Fixes 4 issues, concerning the GUI, inlining, and FMI export.

In particular, #14192 significantly improves the peformance and reliability of OMEdit when browsing simulation results of models of non-trivial size.

## 42.30 Release Notes for OpenModelica 1.25.2

Patch release of 1.25.1. Fixes 4 issues with the GUI that were found in 1.25.1.

Activates building using qt6 webengine by default on Linux Debian Trixie LTS, since qt6 webkit is no longer available.

## 42.31 Release Notes for OpenModelica 1.25.1

Patch release of 1.25.0. Fixes 17 issues that were found in 1.25.0, mostly involving the GUI.

Please use this version of OMC if you plan on installing the Modelica Standard Library version 4.1.0, as it contains a critical fix regarding version management in the class loader.

## 42.32 Release Notes for OpenModelica 1.25.0

This is the final release of the regular early-spring release of OpenModelica, version 1.25.0.

Main highlights: OMEdit now supports **hierarchical parameter editing** in structured models, a **Reload package** feature, and an **Open Class in text view** feature.

### 42.32.1 OpenModelica Compiler (OMC)

The new front end has been further improved with 20+ issues solved. Three fixes regarding the new experimental Base Modelica flat output.

Regarding backend work, 9 issues were fixed in the currently used backend. In particular, #13187 fixed a long-standing issue that caused unexplicable divisions by zero in the Buildings library. Additionally, 18 issues were address in the new backend, which is still under development and experimentally available with the `--newBackend <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omchelptext.html#omcflag-newbackend>`__ compiler flag.

Regarding the C runtime, 15 issues were addressed. In particular, #5709 fixed an old problem that caused equidistant time grid simulation result outputs to miss some time steps if the saving of results at events was disabled - this now allows to obtain fully periodic sampling times in simulation outputs with equidistant time grid in that case.

A new experimental feature, the Newton Diagnostics, was added to the C runtime. This feature can be activated by the simulation flag `-lv=LOG_NEWTON_DIAGNOSTICS <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/simulationflags.html#simflag-lv>`__; this computes and displays a ranking of the most likely start attributes responsible for the failure of Newton-Raphson iterations on nonlinear implicit systems during initialization. As such, it can be an invaluable tool for troubleshooting initialization failures due to convergence issues caused by badly chosen start attributes. For more details see the paper by F. Casella and B. Bachmann on this topic (here is an open-access preprint on ArXiv) and the presentation at the 2025 OpenModelica Workshop for more details. The current implementation is still incomplete, as it doesn't work yet with symbolic jacobians and does not perform residual scaling, so it is not going to work well yet when applied to systems of equations that are badly scaled due to the use of SI units. A full implementation will be available in the next release.

### 42.32.2 Graphical Editor OMEdit

OMEdit 1.25.0 provides several, long awaited-for features.

The first is hierarchical editing of model parameters #2891: you can now change parameters not only for top-level components, but also for its sub-components. This feature is available by right-clicking over component icons and selecting Show Element; this can be done recursively to set parameters of sub-sub-components, etc.. Replaceable components and classes can be handled in the same way. Previously, this was only possible by switching to the textual input mode and by manually adding the corresponding nested modifiers and redeclare clauses to the top-level component instances.

The Reload feature was implemented #5664: if you right-click on a top-level package, the whole package is unloaded from memory and reloaded from the file system, *while preserving the status of the already opened sub-packages in the Library browser*. Previously, you had to first select Unload, then re-open the package, and then navigate again through the sub-package hierarchy to reach the model(s) of your interest. This feature is very convenient when working with multiple Modelica tools in parallel, or when editing some parts of a library with textual editors, because it allows to update the loaded package to the updated version on the file system with a single mouse click.

When browsing the code of a class in the textual view, it is now possible to open any class mentioned in the source code by just right-clicking on it and selecting Open Class, or just by the ctrl-click shortcut #8854.

It is now possible to select a part of a model diagram by dragging a selection window, then copy and paste all the selected components either in the same model, or into a new model #12687.

OMEdit now automatically adds the `each` prefix when providing scalar parameter values to parameter arrays, avoiding the common error of forgetting to add it manually #13636.

The new instance-based infrastructure of OMEdit is now fully mature and far superior to the old graphical editing mode from all points of view. Hence, starting from version 1.25.0, support of the old graphical editing mode is dropped #13257.

Many OMEdit bugs were also fixed in this release. Overall, 40+ issues were addressed.

### 42.32.3 FMI export

Several issues regarding FMI export were addressed.

A serious bug #13582 affecting co-simulation FMUs using the CVODE stiff solver was solved, allowing to use FMI-CS on stiff models.

### 42.32.4 API documentation

The online documentation of the interactive environment API was significantly improved in terms of completeness and readability.

### 42.32.5 List of tickets closed in 1.25.0

List of closed tickets in the 1.25.0 release. 140 issues were addressed and resolved.

### 42.32.6 Next releases

The next release is planned to be released towards the end of 2025. It should include further improvements to the GUI such as a restructured Simulation Setup dialog, faster editing of large models in OMEdit, etc. Further improvements in FMI 2.0.x export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.24.5...v1.25.0

## 42.33 Release Notes for OpenModelica 1.24.5

Added flag to avoid non-strictly necessary compile-time evaluations, see #13570.

Required by RTE to compile Dynawo code on 1.24.x using C11 instead of C17.

## 42.34 Release Notes for OpenModelica 1.24.4

Some more patches for the 1.24.x, see list.

## 42.35 Release Notes for OpenModelica 1.24.3

Patch release for 1.24.2

Fixes 6 issues, most importantly a regression involving start attributes for state variables not showing up in the parameter input dialog.

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.24.2...v1.24.3

## 42.36 Release Notes for OpenModelica 1.24.2

Patch release of 1.24.0, fixes issues with the OMEdit GUI. Replaces the previously planned 1.24.1 which was skipped.

A list of the fixed issues is available here.

### 42.36.1 What's Changed

- Hide the start and fixed attributes based on final modifier (#13007) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/13008
- Add context to `Inst.expand` (#12962) by @perost in https://github.com/OpenModelica/OpenModelica/pull/13023
- OMEdit fixes by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/13081
- Fixes 1.24.1 by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/13100
- Cpp FMI: don't check clockSubactive in firstTick of simulation code by @rfranke in https://github.com/OpenModelica/OpenModelica/pull/13120
- Fix the icon display if the component does not have annotation by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/13200
- Draw a default grey box if the model doesn't have an icon by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/13216
- Cherry-pick instance API fixes by @perost in https://github.com/OpenModelica/OpenModelica/pull/13218

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.24.0...v1.24.2

## 42.37 Release Notes for OpenModelica 1.24.0

The release date of 1.24.0 was anticipated with respect to the traditional summer release and winter release date. The main motivation is that a major update of the OMEdit source code was made on the master branch to make it compatible with both Qt5 and Qt6. This makes it hard to back-port crucial fixes to the GUI in patch releases before the formerly scheduled release date of Jan-Feb 2025. The current development version on the master branch is quite stable and there are no major complaints, which allow us to anticipate the next official release to September 2024.

### 42.37.1 OpenModelica Compiler (OMC)

The new front end has been further improved with about 25 issues solved, here is a complete list. Nine of those issues regarded fixes to the new experimental Base Modelica flat output.

A new compiler flag --exposeLocalIOs was added to automatically add the outputs of a model components to the outputs of an FMU, instead of only adding the top-level outputs. This can easily provide monitoring information in an FMU without the need of painstakingly bring all those outputs to the top level in the original Modelica model.

Besides #12730, the work on the backend was mostly focused on developing the new backend, with 14 issues being fixed.

One small fix was made to the C runtime.

### 42.37.2 Graphical Editor OMEdit

The OMEdit source code was adapted to use both Qt5 and Qt6, see pull request #12485.

The quality of the OMEdit GUI was further improved over the previous version 1.23.1, with about 15 issues fixed, see the complete list.

An important improvement regarding the usability of the GUI concerns the reaction time when editing diagrams, which used to be very slow when adding or removing components and connections in large models; these operations are now much faster, while changing parameters can still be quite slow. See #11920 for more details.

### 42.37.3 FMI export

A few issues were addressed regarding FMI export.

### 42.37.4 List of tickets closed in 1.24.0

List of closed tickets in 1.24.0. Over 65 issues were addressed and resolved.

### 42.37.5 Next releases

The next release 1.25.0 is planned to be released in January/February 2025, with a first beta release possibly before the end of the year. It should include further improvements to the GUI such as parameter editing in hierarchically structured model, restructured Simulation Setup dialog, Rename feature with refactoring, faster editing of large models in OMEdit, etc. Further improvements in FMI 2.0.x export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.23.1...v1.24.0

## 42.38 Release Notes for OpenModelica 1.23.1

This is a minor release with fixes to OMEdit and omc to avoid crashes.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.23.0...v1.23.1

## 42.39 Release Notes for OpenModelica 1.23.0

Version 1.23.0 of OpenModelica was released on 6 June 2024. It has many improvements and bug fixes compared to 1.22.3 (1.22.4 for Linux), plus some new useful features, in particular regarding the OMEdit GUI and the FMI export feature.

### 42.39.1 Proper rounding of decimal numbers

Real parameter values returned by the front-end when flattening models often had bad rounding, such as `499.99999999999` instead of `500` or `1.00000000000012` instead of `1.0`. Also, bad rounding used to plague parameter values with unit conversions driven by `displayUnit` attributes in the OMEdit GUI. In some cases, very long decimal outputs such as `1200000000.0` were displayed, instead of the more easily understood `1.2e9`.

This issue was tackled systematically and resolved thanks to rounding algorithms based on the Ryu library, see #8865 for a comprehensive list of all improvements. Now all Real values numbers that are expected to be represented as round decimal numbers are actually represented as such; additionally, decimal vs. scientific format is chosen according to heuristic rules, to ensure good readability by humans in all cases, without significant loss of precision.

### 42.39.2 OpenModelica Compiler (OMC)

The new front end has been further improved with about 25 issues solved, here is a complete list.

The front end can now provide clean BaseModelica flat output from the command line; experimental array-preserving flat output can also be obtained. See the User's Guide for more information.

The draft MLS 3.7 Sect. 7.1 now explicitly requires annotations at the end of a class to be carried over when extending model; this includes experiment annotations. This behaviour is now implemented in the frontend, so it is no longer necessary to re-add the experiment annotation when extending a class, see #10386.

Most of the work on the backend is still focused on developing the new backend; about 10 fixes were made to the current backend. Two notable improvements are worth mentioning:

- the non-standard `annotation(tearingSelect)` was deprecated and replaced by `annotation(__OpenModelica_tearingSelect)`

- according to the Modelica Language Specification Sect. 8.6 parameters with no binding and no explicitly set value now cause the compilation to fail, see #10386. This may cause some old models to fail during compilation, but it is the required behaviour by the specification, to guard against parameters that are accidentally left without a meaningful value. The fix is to provide the modifier for the parameters without bindings, or to add an explicit `start = 0` modifier in the library model.

About 10 bug fixes were made to the C runtime.

### 42.39.3 Graphical Editor OMEdit

The quality of the OMEdit GUI was further improved over the previous version 1.22.3, with about 55 issues fixed, see the complete list. Most of them are bug fixes, but there are also some new features:

- Duplicate class feature now works correctly also when the class is duplicated in another scope #5346
- Top-level model parameters can now be edited with the GUI #4408
- Further optimization of the editor's response time when deleting components and adding/deleting connections #11920
- All rounding issues in the GUI resolved #8865

### 42.39.4 FMI export

14 issues were addressed regarding FMI export, further improving the quality of that feature. We are currently testing over 80 libraries from the Package Manager collection by exporting FMI-CS FMUs with OMC and simulating them with CVODE using the FMPy tool; test reports can be reached from this page.

### 42.39.5 List of tickets closed in 1.23.0

List of closed tickets in 1.23.0. Over 140 issues were resolved.

### 42.39.6 Next releases

The next release 1.24.0 is planned to be released in Q4 2024. It should include further improvements to the GUI such as parameter editing in hierarchically structured model, restructured Simulation Setup dialog, Rename feature with refactoring, faster editing of large models in OMEdit, etc. Further improvements in FMI 2.0.x export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.22.3...v1.23.0

## 42.40 Release Notes for OpenModelica 1.22.3

This patch release contains several fixes and improvements to the OMEdit GUI. See the full list of the closed issues here.

## 42.41 Release Notes for OpenModelica 1.22.2

This patch release contains several fixes and improvements, mostly to the OMEdit GUI

- a critical bug when handling connections that causes OMEdit to crash when editing them was fixed
- moving components around in diagrams in OMEdit is now much faster and responsive
- several fixes to diagram visualization and parameter inputs in OMEdit
- much faster FMU code export thanks to the clang compiler and parallel C source code compilation

A full list of closed issues can be found here.

## 42.42 Release Notes for OpenModelica 1.22.1

This patch release contains several improvements to the OMEdit GUI:

- It is now possible to handle 'each' and 'final' prefixes in parameter input dialogs
- It is possible to close the Message Browser window if one wants to maximize the real estate for result plots. Only the status bar is displayed also over multiple re-runs or re-compilations, unless warnings or errors pop up
- Some fixes to visualization glitches and OMEdit unexpected crashes

For the full list of improvements, see here.

## 42.43 Release Notes for OpenModelica 1.22.0

The main highlight of the 1.22.0 release of OpenModelica is a significant improvement of the OMEdit GUI, made possible by the new instance-based architecture for the interaction between the OMEdit GUI and the underlying OMC compiler, which is now activated by default; see below for further details. Many bugs were also fixed, leading to a much improved user experience, compared to the previous 1.21.0 release.

### 42.43.1 OpenModelica Compiler (OMC)

The new front end has been further improved with about 25 bug fixes, here is a complete list. The conversion from Integer to Enumeration, which was introduced in Modelica 3.4, is now supported by OMC.

Most of the work on the backend is currently focused on developing the new backend; a few fixes were made to the current backend. The `--tearingMethod=noTearing <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omchelptext.html#omcflag-tearingmethod>`__ was deprecated, because it breaks models with discrete variables involved in algebraic loops, `--tearingMethod=minimalTearing <https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omchelptext.html#omcflag-tearingmethod>`__ should be used instead. A few bug fixes were also made to the code generation process.

Several bug fixes and improvements were made to the C runtime. A new simulation flag `-lv_system <https://openmodelica.org/doc/OpenModelicaUsersGuide/1.22/simulationflags.html#simflag-lv-system>`__ was added, to enable logging of solver behaviour for selected systems; together with `-lv_time <https://openmodelica.org/doc/OpenModelicaUsersGuide/1.22/simulationflags.html#simflag-lv-time>`__, this allows to avoid huge log files when debugging solver issues taking place at some point in time with some specific system of equations.

Several improvements were made to the C++ runtime:

- support for ExternalMedia library (fix record inputs of external functions and bindings of records to scalar variables)
- support for ThermofluidStream library (fix array dimensions of created temporary variables)
- preliminary support for DAE mode
- fixed issue with start attributes for iteration variables of implicit nonlinear systems, which were previously lost

### 42.43.2 Graphical Editor OMEdit

As mentioned above, the new instance-based infrastructure for model editing is now firmly in place and is activated by default. This supports long awaited-for features, namely conditional connectors and parameter input dialogs activated by boolean variables, replaceable classes and models with parameter editing. It also improves the support of the DynamicSelect annotation. In case of remaining issues, it is still possible to de-activate the new infrastructure and fall back to the old one, using the checkbox *Tools* | *Options* | *General* | *Optional Features* | *Disable new instance-based graphical editing of models*.

Connection handling and rendering is also much improved:

- it is no longer possible to make connections between incompatible connectors (that previously only failed later on when trying to compile the model);

- connection lines are drawn with a white background that allows to reveal bogus connections that were previously hidden by the component itself (e.g., inadvertently short-circuiting a resistor or capacitor). It also show clearly that two apparently crossing connection lines have no actual connection to each other;
- connection lines spanning a connection set with more than one connector are now rendered with dot-like branching points, increasing readability.

Over 70 issues were successfully addressed in the OMEdit graphical editor. About 35 issues concerned the debugging and fine-tuning of the new instance-based infrastructure.

### 42.43.3 Scripting interfaces

Improvement made to the OMMatlab concening the efficiency of the `linearize()` API function call were ported to OMPython and OMJulia. The updated implementation avoids recompiling the model from scratch every time when multiple calls to `linearize()` are made on the same model, resulting in dramatic performance improvement.

### 42.43.4 FMI support

Further development work was carried out to support source-code FMI export across all operating systems using CMAKE, see closed tickets, in addition to the old workflow that was based on GNU makefiles and only worked in POSIX environments. This functionality, documented here, is now mostly in place, though it requires more testing to become fully usable. To get the latest developments in FMI export support, consider trying the 1.23.0-dev nightly builds.

A new flag --nonStandardExposeLocalIOs was introduced to export input/output connectors of sub-models, like sources, sinks and sensors. The default value 0 expose the top-level public inputs and outputs, the value 1 also exposes public inputs and outputs of components, the value 2 also exposes public inputs and outputs of components within components, and so on.

### 42.43.5 List of tickets closed in 1.22.0

List of closed tickets in 1.22.0. 140 issues were resolved.

### 42.43.6 Next releases

The next release 1.23.0 is planned to be release in Q2 2024. It should include further improvements to the GUI such as parameter editing in hiearchically structured model, fully functional Duplicate feature, restructured Simulation Setup dialog, etc. Further improvements in FMI 2.0.x export are also planned.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.21.0...v1.22.0

## 42.44 Release Notes for OpenModelica 1.21.0

The 1.21.0 release of OpenModelica doesn't contain any major new feature, but it contains many improvements and bugfixes that significantly improved the quality of the software with respect to the previous 1.20.0 release.

The new single-step gbode solver has been further developed and can now be used as a serious alternative to the more established dassl, ida, and cvode solvers. A full-fledged GUI for its configuration is still not available and will be added in future versions. Currently, the method defaults to esdirk4, a general-purpose 4-th order implicit method. Other methods can be set with the -gbm simulation flag, and each method now automatically selects the best advanced options. All solvers use variable step-size with error control by default, but they can be turned to fixed time step by adding the -gbctrl=const simulation flag.

A completely overhauled architecture for the interaction between the OMEdit GUI and the underlying OMC compiler is now experimentally available in 1.21.0. It relies on the new frontend to instantiate the classes being edited, rather than trying to re-do it from scratch on the GUI side. This architecture provides faster user interaction and allowed to fix many shortcomings of the GUI, e.g. lack of proper support for replaceable classes with parameters, conditional connectors and parameter dialog activation depending on parameters, etc.

### 42.44.1 OpenModelica Compiler (OMC)

The new front end has been further improved with about 20 bug fixes, here is a complete list. Major development work went into supporting the development and fine-tuning a new API for the the OMEdit GUI, see tickets.

Several fixes were made to the current backend, although development work is now mostly focused on the new backend, which includes array-preserving code generation features. The new backend is still not capable of running most models from mainstream libraries. However, it is starting to show interesting results on selected large-scale test models, with size up to a million equations. These models can now be handled with reasonable amounts of time required to build and compile the simulation code. The new backend can be activated with the `--newBackend` compiler flag.

Several bug fixes were made to the code generation process. The new CMake-based build infrastructure has been further developed and is now nearly complete, including support for FMI generation.

Many bug fixes and improvements were made to the C runtime, mostly regarding the new gbode solver. This solver is fast reaching production quality and can now be used as a serious alternative to the mainstream dassl, ida, and cvode solvers; it also replaces deprecated obsolete solvers such as impeuler, trapezoid, imprungekutta, etc., that will be removed in future versions.

### 42.44.2 Graphical Editor OMEdit

About 60 issues were successfully addressed in the OMEdit graphical editor. Most notably, the performance of the GUI support for replaceable classes has been improved dramatically; therefore that option, which is required to use Modelica.Media and Modelica.Fluid, is no longer optional but always active by default.

About half of the addressed issues concern the development and fine tuning of the new instance-based interface, that is going to be much faster than the existing one and to address long-standing issues such as supporting conditional connectors and replaceable classes with parameter modifiers.

This new interface can be activated with the *Tools* | *Options* | *General* | *Enable instance API* option. It is mostly in place now, but it still requires further testing and debugging before it can replace the existing one for good. If you want to experiment with it, we suggest you to use the latest 1.22.0-dev nightly build version, that incorporates the latest developments and bug fixes. Please try that one before reporting issues on the bug tracker.

### 42.44.3 Scripting interfaces

The OMMatlab interface was significantly improved in this version, see tickets. In particular, it is now possible to linearize a system in many different conditions without recompiling it each time, which is useful model-based control design.

### 42.44.4 List of tickets closed in 1.21.0

List of closed tickets in 1.21.0. Over 130 issues were resolved.

### 42.44.5 Next releases

The next release 1.22.0 is planned to be release in Q4 2023. It will include the new instance-based editing in OMEdit, featuring support of conditional connectors, parameter-depending dialog annotation, hierarchical editing of models, and faster rendering of complex diagrams.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.20.0...v1.21.0

## 42.45 Release Notes for OpenModelica 1.20.0

The first most notable feature of this release is the automatic installation of the Modelica Standard Library (MSL), which is now fully integrated with the Package Manager. Every time any tool of the OpenModelica suite (e.g. OMEdit, OMNotebook, OMShell, etc.) attempts to load a version of the MSL, it checks if it has already been installed in the user's set of system libraries, which is handled by the Package Manager and is located in the user's .openmodelica directory. If that directory is empty, either because of a fresh install, or because it has been deleted,

then the MSL is automatically installed in the user's system libraries from cached zip files in the OpenModelica installation directory; in fact, both MSL 3.2.3 (which is backwards compatible with 3.2.2 and 3.2.1) and 4.0.0 are installed, so that any library created during the last ten years can run out of the box.

This automatic installation does not require any Internet connection, so it also works behind corporate firewalls or in situations with limited available bandwidth. This solution uses the same package manager that is also used to install other system libraries, contrary to the solution implemented in versions 1.18.0 and 1.19.x, which used two different directories in the MODELICAPATH, one for the package manager and one for the preinstalled MSL, leading to slightly confusing duplicate installations of MSL.

OMEdit loads MSL 4.0.0 by default in the Libraries Browswer. However, if one then loads a package using MSL 3.2.3, it is possible to unload MSL 4.0.0 and load MSL 3.2.3 just with a click of a button.

The second most notable feature is that a new general purpose ODE solver, named `gbode`, was introduced. This solver is a fully configurable single-step solver, supporting many different integration methods, both explicit and implicit, using either fixed time step or variable time step with error control, handling event detection and dense output for accurate resampling over a regular time grid. Implemented methods include Euler, Heun, Dormand-Prince, Gauss, Radau, Lobatto, Adams-Moulton, Fehlberg, SDIRK, ESDIRK, etc. Adaptive multi-rate algorithms are also available within this solver, although this feature is still experimental. This solver replaces previously available solvers like `euler`, `impeuler`, `trapezoid`, etc., which are now deprecated and will be removed in future versions of the tool.

The solver is currently only available via simulation flags, which can be set in OMEdit under Simulation Setup | Simulation Flags | Additional Simulation Flags (optional). It will be supported via drop-down menus in future releases. See the User's Guide under Solving Modelica Models for further information.

### 42.45.1 OpenModelica Compiler (OMC)

The new front end has been further improved, with over a dozen bug fixes.

Some issues were fixed in the current backend, although most of the development work is now focused on the new backend, which can be optionally activated with the `--newBackend` compiler flag, and will become the default choice in a future release.

Regarding code generation several issues were fixed, including one that affected the ExternalMedia library, which is now fully supported by OpenModelica.

### 42.45.2 C Runtime

Besides introducing the new `gbode` solver, some other issues were fixed. The support for external input from CSV files was improved and better documented. See here for a full list of closed issues.

### 42.45.3 Graphical Editor OMEdit

Besides improved support of the Modelica Standard Library with the package manager, over a dozen issues were fixed, see the full list.

### 42.45.4 FMI

Main highlights: - The FMI import feature allows to import an FMU as a block in a Modelica model. This feature was broken in versions 1.18.0 and 1.19.0, it is now functional again, with some limitations, see the User's Guide for further information. Support for this feature must be explicitly activated with the Enable FMU Import checkbox in the Tools | Options | Simulation | Translation Flags tab of OMEdit. - Support of FMI code generation using CMake, see the documentation in the User's Guide.

- Bug fixes.

See here for a full list of closed FMI issues.

### 42.45.5 List of tickets closed in 1.20.0

List of closed tickets in 1.20.0. Over 80 issues were resolved.

### 42.45.6 Next releases

A 1.20.1 bugfix version may be released if critical bugs are identified and resolved before January 2023. The next release 1.21.0 is planned to be beta-released in February 2023, and released in March 2023; it should include a completely restructured handling of model editing in OMEdit, including long awaited-for features like support of conditional connectors, parameter-depending dialog annotation, and faster rendering of complex diagrams.

Download it from: https://openmodelica.org

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.19.0...v1.20.0

## 42.46 Release Notes for OpenModelica 1.19.2

Version 1.19.2 is a bugfix release, where some critical bugs that were present in 1.19.0 got fixed.

The most important one is #8772: parameter dependencies were not handled correctly in some cases, leading to some parameters being wrongly evaluated to zero, which also impacted multibody system animations, see #8938.

Some further remaining issues with directory names containing accented letters were fixed in #8777. A problem with the delay operator was also fixed, see #9116.

Here is the complete list of bug fixes in release 1.19.2.

Download it from: https://www.openmodelica.org

## 42.47 Release Notes for OpenModelica 1.19.0

### 42.47.1 OpenModelica Compiler (OMC)

The new front end has been further improved, with over 40 bug fixes.

Several issues were fixed in the backend, most notably problems affecting event generation and issues involving algorithms and arrays, which led to a wrong diagnosis of under-determined system of equations. Overall, over 15 issues were addressed.

Regarding code generation 5 issues were fixed, mostly concerning corner cases that involved arrays, record, and slicing operators.

### 42.47.2 C Runtime

Remaining issues concerning Clock variables were resolved; so, starting from this version, the synchronous features of the Modelica language, in particular the Modelica.Clocked library, are now fully supported. The configuration of runtime and external libraries on Windows was substantially improved. A bug was fixed in daeMode that prevented correct event handling in state-less models, which now run correctly. Overall about 20 issues were fixed.

### 42.47.3 Graphical Editor OMEdit

The most important new feature in 1.19.0 is the fully integrated package management and conversion script support in the GUI. We suggest you to read the Package Management section of the user's guide for an introduction to the basic concepts.

The package management functionality is now available under the File | Manage Libraries menu. It is possible to install supported (or experimental) open-source libraries from the internet, and upgrade them when newer versions are released; all the required dependencies are installed automatically. The Windows installer by default also installs the basic versions of the Modelica standard library, as a fallback in case internet connection is not available, e.g. in corporate environments. All other libraries are no longer supplied with the installer and must be installed via the package manager. Off-line use of the package manager will be improved in future versions.

When right-clicking on a library in the libraries browser, a new context menu item "Convert to Newer versions of used libraries" is available. This allows you to convert your library to newer versions of its dependencies, once you have installed them. If the newer version of the used library is backwards compatible with the previous one, this just changes the uses annotation, otherwise, the conversion script is run automatically. The most common use of this feature is to upgrade models or libraries that you developed using the Modelica library 3.2.3 to use Modelica 4.0.0. We recommend that you use this functionality on your own libraries only; for libraries that you download from the internet, it is best to wait for the developers to perform the conversion and release new versions of their libraries, that you can then get through the package manager.

Support of the dynamicSelect annotation has been improved, although it is still not 100% functional in all cases.

The plotting of results has been significantly improved; appropriate prefixes are now automatically selected to avoid getting very large or very small numbers on the Y-axis.

Overall, over 40 issues were fixed since the previous 1.18.1 release.

Work is on going to provide full support of parameter-depending conditional connectors, parameter-depending dialog annotations, and editing of parameter modifiers in redeclared classes. Implementing these features requires a fundamental re-design of the way OMEdit interacts with the OMC environment to get the required information. These features should become available, at least experimentally, in the future 1.20.0 release.

### 42.47.4 FMI Export

- Introduced support for interpolation in CS-FMUs by setting "canInterpolateInputs=true" in modeldescription.xml - Introduced support for getting partial derivatives in ME-FMUs by setting "providesDirectionalDerivative=true" - Lots of improvements to OpenModelica FMU export configurations (black box as well as source code FMUs). - Added source-code nonlinear solver CMINPACK to source-code FMUs
- Basic source-code FMU compilation with CMake; cross compilation with Docker now available on Windows.

About 10 issues fixed.

### 42.47.5 OMSimulator

- Support of importing and exporting Units and UnitDefinitions to SSP files. - Support for getting directional derivative in OMSimulator using both Symbolic Jacobians and numerical approximation using KINSOL solver.

### 42.47.6 List of tickets closed in 1.19.0

List of closed tickets in 1.19.0. About 180 issues were resolved.

### 42.47.7 Next releases

A 1.19.1 bugfix version may be released if critical bugs are identified and resolved before July 2022. The next release 1.20.0 is planned to be beta-released in July 2022, and release in September 2022. On-going work to further improve the level of support of the Buildings library should ensure a significant improvement in the level of support of most Modelica libraries in that upcoming release.

Download it from: https://www.openmodelica.org

## 42.48 Release Notes for OpenModelica 1.18.0

### 42.48.1 OpenModelica Compiler (OMC)

The development of the new front end continued further, after becoming the default in the previous version. The compiler can now successfully flatten 100% of the models of the Modelica Standard Library 3.2.3 and 4.0.0 that have an experiment annotation. It can also successfully flatten 100% of many other open-source Modelica libraries, such as Chemical, HelmholtzMedia, IBPSA, ModelicaTest, OpenIPSL, PNLib, PhotoVoltaics, PlanarMechanics, PowerGrids, PowerSysPro, PowerSystems, SystemDynamics, TAeZoSysPro, ThermofluidStream. The success

ratio when flattening the models of the Buildings library is currently at 96%, on-going work aims at reaching 100% by the end of 2021. Overall, 20 front end issues were fixed since the last official release.

Regarding symbolic analysis and code generation, the handling of index reduction in non-trivial cases where the state constraints are spread among many equations has been improved by the introduction of the ASCC algorithm, coupled with the existing reshuffle loop algorithm; this had beneficial effects in particular on three-phase circuit models. Some bugs in the generation of symbolic jacobians for nonlinear systems were also fixed. Overall, 11 issues were resolved.

### 42.48.2 C Runtime

Full support of the spatialDistribution() operator was introduced, including accurate handling of events. Several low-level issues were resolved, involving memory leaks and segmentation faults.

### 42.48.3 C++ Runtime

The C++ runtime was improved to handle more Modelica language features that are used by the new frontend. The previously release OMC 1.17 had worse coverage for the C++ runtime since it used the new frontend by default without supporting it in the C++ code generator. With these improvements, the coverage of libraries improved significantly, also compared to previous versions of OpenModelica with the old frontend, since the new frontend handles more models correctly than the old one, see the regression report, column "Compilation".

### 42.48.4 Graphical Editor OMEdit

Several new features were added to the plotting functionality of OMEdit, in particular: - a "Fit to Diagram" button was added close to the zoom buttons to automatically adjust the extent of a model diagram to its actual content; - the sign of plotted variables can now be toggled by means of the context menu on the variable legends, to compare directly variables that are opposite in sign; - appropriate multiples of SI units (e.g. mW, W, kW, MW, GW for power) are automatically selected for display based on the order of magnitude of the variable, to avoid very large or very small numbers on the plot axes; - the rendering of plots and parameter windows on large and/or high-resolution screens was further improved.

Several bugs were also fixed; in total, 27 issues were addressed.

### 42.48.5 FMI Support and OMSimulator

FMI 2.0 export was further improved. OMSimulator development continues, over 30 issues were fixed.

### 42.48.6 Data reconciliation

The operation of power plants requires a good quality of the process data obtained through sensor measurements. Unfortunately, sensor measurements such as flow rates, temperatures, and pressures are subject to errors that lead to uncertainties in the assessment of the system's state. Operational margins are therefore set to take into account uncertainties on the system's state. Their effect is to decrease production because safety regulations put stringent limits on the thermal power of the plants. It is therefore important to compute the best estimates of the measurement uncertainties in order to increase power production by reducing operational margins as much as possible while still preserving system safety.

The best estimates can be obtained by combining data statistics with a knowledge a priori of the system in the form of a physical model. Data reconciliation is a technique that has been conceived in the process industry for that purpose. It is fully described in the VDI 2048 standard for the control and quality improvement of process data and their uncertainties by means of correction calculation for operation and acceptance tests".

An extension of Modelica to perform data reconciliation on Modelica models was developed together with EDF and is now fully implemented and integrated with the OMEdit GUI. The basic ideas are explained in this presentation, and a section DataReconciliation was added to the User's Guide, explaing how to use it step-by-step.

### 42.48.7 List of tickets closed in 1.18.0

We are currently transitioning from the old trac issue tracker to the GitHub issue tracker, which is fully integrated with the GitHub revision control and continuous integration framework that we use for the development of OpenModelica. Eventually, the old trac tickets will be migrated onto the GitHub issue tracker. For the time being, old tickets are still managed on trac, while new ones are on GitHub. Overall, about 80 issues were addressed successfully since the 1.17.0 release.

- older tickets
- newer tickets

### 42.48.8 Next releases

A 1.18.1 bugfix release is planned later this year with some critical bug fixes that have been identified and partially addressed, but need some more testing. The next release 1.19.0 is planned to be released in February 2022, close to the OpenModelica Workshop and Annual Meeting.

Version 1.19.0 is expected to contain a GUI integrated in OMEdit for library handling and conversions. It is also planned to successfully run 100% or close to 100% of the Buildings 7.0.1 library. This will be a major milestone, given the broad extent and complexity of that library.

Download it from: https://www.openmodelica.org

## 42.49 Release Notes for OpenModelica 1.17.0

### 42.49.1 OpenModelica Compiler (OMC)

The new frontend has been further improved, and is now the default choice for all the OpenModelica tools. The `-d=newInst` flag no longer needs to be set in scripts. The old frontend is no longer maintained and will progressively be replaced also for the API interface used by OMEdit. 21 tickets were fixed since the previous 1.16.5 release.

Some issues were fixed in the backend, in particular regarding `homotopy` during initialization. Some improvements to code generation, in particular enhancing the support of the HelmholtzMedia library.

The MSYS environment used on Windows was updated to a more recent version, with several benefits: - clang is now also available on Windows and used by default instead of gcc for the compilation of the generated C code, providing much faster C compile time on Windows; - dynamic linking is used instead of static linking, further reducing the overall compilation time on Windows; - a more recent version of the QT library is used, which solves some issues with the rendering of features in OMEdit.

The Sundials solvers and basic linear algebra library KLU were upgraded to the most recent available versions, with benefits in performance and roubustness at runtime.

### 42.49.2 Supported versions of Modelica Standard Library (MSL)

OpenModelica now supports both currently maintained versions of the Modelica Standard Library, MSL 3.2.3 and MSL 4.0.0. This means that you can use Modelica libraries that use either version of the MSL, or create new ones that do so. Automatic conversion of existing libraries from MSL 3.2.3 to MSL 4.0.0 is currently not yet available, it is planned for version 1.18.0.

Please note that the synchronous features in MSL 4.0.0 are still not fully supported, so we suggest not to rely on them in this version of the tool. Better support is planned for version 1.18.0.

### 42.49.3 Graphic Editor OMEdit

The user experience with OMEdit is significantly improved in version 1.17.0, in particular for the Windows version, where the compilation time was drastically reduced by using clang instead of gcc and by dynamic linking instead of static linking of the simulation executable.

Thanks to the upgrade of the employed QT graphics libraries, several issues that plagued the graphical user interface are now resolved.

Replaceable classes continue to have graphical support in OMEdit, even though parameters in redeclared classes cannot yet be modified from the GUI, thus requiring to switch to text mode to do so. The new front end can also be used for some of the API functions called by OMEdit to render the model diagrams, making the response of the GUI much faster. Please note that **both these features are currently optional and needs to be activated** by setting *Tools | Options | General | Enable replaceable support* and *Enable new frontend use in the OMC API (faster GUI response)*. These settings are retained from the previous installation upon version upgrading.

Unsaved code was sometimes lost when switching among different windows in OMEdit, this is no longer happening in this release. Several issues that caused occasional crashes of the GUI were also fixed.

OMEdit now can use both currently maintained versions of the Modelica Standard Library, MSL 3.2.3 and MSL 4.0.0. Please note that the Modelica.Clocked package in MSL 4.0.0 is still not handled in a completely reliable way, while most other models work equally well in the two versions.

When starting the program for the first time after installation, one can choose among three options: load MSL 3.2.3 automatically, which however prevents using libraries that need MSL 4.0.0; load MSL 4.0.0 automatically, which prevents using libraries that need MSL 3.2.3; not loading any version of the library upon starting OMEdit, leaving it to the tool to load the right one when a model or library is opened, thanks to the uses() annotation. The latter option allow to handle different projects that use either version of the MSL without problems, of course one at a time. This choice can be later modified by going to the Tools | Options | Libraries menu and by adding or removing the Modelica library from the automatically loaded system libraries, and/or by modifying the specific version that gets loaded.

Proper support of the package manager from the GUI, including conversion scripts to upgrade existing libraries from MSL 3.2.3 to MSL 4.0.0, is planned for version 1.18.0.

16 bug fixes were made to OMEdit in version 1.17.0, to increase usability of the GUI.

### 42.49.4 Direct support of macOS discontinued from 1.17.0

Until version 1.16.x, OpenModelica was built on Windows, Linux, and macOS. The core functionality of the tool is implemented in Linux, and is ported to Windows using the MinGW environment, and on macOS using the macports environment.

Unfortunately, many libraries OpenModelica depends on are not regularly updated on macports, which caused the Mac build to break every other day. Given our limited resources, we can't take on the burden of the required macports maintenance, so we regret to inform you that we decided to stop providing builds of OpenModelica for macOS. It is still possible to run OpenModelica on the Mac by running a virtual machine with a Linux installation of OpenModelica, see the instructions on the Mac download page. We are still trying to make it possible to build OpenModelica from sources on macOS, please check ticket #6306 for the latest updates and if you want to contribute to the effort. However, we do not guarantee this will be always possible in the future.

### 42.49.5 FMI Support

FMI 2.0 export and FMI simulation with OMSimulator was further improved.

### 42.49.6 Other things

OMSimulator is now integrated into pypi and installed via pip.

A prototype Flat Modelica code export feature is now available, a result of the Emphysis project and eFMI on-going standardization effort. It can be activated with the compilation flag.

The Modelica package manager is still only available from the command line in this release. We plan to integrate it the OMEdit GUI for the 1.18.0 release, together with conversion scripts.

Download it from: https://www.openmodelica.org

## 42.50 Release Notes for OpenModelica 1.16.5

This hopefully the final bugfix release of 1.16.0, which addresses an issue that affected diagrams in OMEdit under certain conditions.

### 42.50.1 What's Changed

- Keep the NFApi settings (#7215) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/7217

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.16.4...v1.16.5

## 42.51 Release Notes for OpenModelica 1.16.4

This is a further bugfix release of 1.16.0, which addresses an issue that affected diagrams in OMEdit under certain conditions.

### 42.51.1 What's Changed

- Move the nfAPI and nfAPINoise settings to general page (#7171) by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/7175
- Prepare for 1.16.4 by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/7186

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.16.3...v1.16.4

## 42.52 Release Notes for OpenModelica 1.16.2

This is a bug fix release.

### 42.52.1 What's Changed

- Omedit fixes by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/6982
- Fixes 1.16 by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/7004
- fix ticket #6300, use NF for getElementAnnotations if -d=nfAPI is on by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/7055
- partial fix for #6287 and fix for #6288 by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/7056

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.16.1...v1.16.2

## 42.53 Release Notes for OpenModelica 1.16.1

This is a further bugfix release of 1.16.0

### 42.53.1 What's Changed

- fix #6167 allow partial handling in NF when -d=nfAPI is on by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/6898
- Do not put libOMEdit.a in build/ by @sjoelund in https://github.com/OpenModelica/OpenModelica/pull/6908
- Copy OMEdit fixes from master to v1.16 by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/6911
- Use assert instead of Q_ASSERT by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/6929

- Copy #6174 fixes to 1.16 by @adrpo in https://github.com/OpenModelica/OpenModelica/pull/6939
- Backport the new ZMQ flags to 1.16 by @sjoelund in https://github.com/OpenModelica/OpenModelica/pull/6950

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.16.0...v1.16.1

## 42.54 Release Notes for OpenModelica 1.16.0

### 42.54.1 OpenModelica Compiler (OMC)

The new frontend has been further improved, with enhanced support of records and arrays. 33 tickets were fixed since the previous 1.14.0 release. The new front-end can now handle 100% of the Modelica Standard Library 3.2.3 models.

Improvements to the back-end:

- new minimal tearing option `--minimalTearing` to disable tearing except for discrete variables
- improved symbolic Jacobian evaluation option `--simJacConstantSplit` reuses constant part of the Jacobian
- improvements to dynamic state selection and common subexpression elimination
- new ASCC algorithm replaces and improves resolveLoops algorithm, allowing to detect high-index problems with indirect structural state constraints, e.g. in three-phase AC circuits
- homotopy operator now used on first try by default
- linearized model export also available in Matlab, Python, and Julia with option `--linearizationDumpLanguage`

Improvements to code generation and runtime:

- Better support for models with records
- CVODE solver from SUNDIALS added;
- 2 methods available: BDF (stiff) and Adams-Moulton (non-stiff)

It is now possible to build a version of OMC with parallel Jacobian evaluation using OpenMP

- On Windows build OMC with `make -f Makefile.omdev.mingw omc -j4 USE_PARJAC=yes`
- On Unix configure with `--enable-parjac` and build OMC.
- Only DASSL and IDA can use parallelized symbolic Jacobians.
- Simulate with `-jacobianThreads=<numberOfThreads>` or set environment variable `OMP_NUM_THREADS=<numberOfThreads>` to use a specific number of threads. Otherwise all available threads will be used.

### 42.54.2 Graphic Editor OMEdit

Replaceable classes now have graphical support in OMEdit. This feature was planned to be included in release 1.15.0, but it eventually turned out to be more convenient to merge it in the 1.16.0 release. Support for replaceable elements in OMEdit is currently limited to redeclare statements without parameter modifiers. This is enough to handle Modelica.Media medium models in Modelica.Fluid components. Please note that **this feature is currently optional and needs to be activated** by setting ToolsGeneral|Enable replaceable support in OMEdit.

Over 50 bug fixes were made to OMEdit to increase usability of the GUI.

OMSimulator GUI improved: text editing of SSP models, undo/redo, delete components, etc.

### 42.54.3 FMI Support

Many FMI export bug fixes and improvements to increase usability of OMC-generated FMUs.

FMI/CS 2.0 now includes CVODE solvers (previously only fixed-step forward Euler) and customization via simulation flags.

### 42.54.4 Other things

Successful integration of Modelon's license manager for encrypted libraries. A special version of OMC available to Consortium members can now handle encrypted libraries, preventing source code browsing, and license management, via Modelon's license manager, embedded in the encrypted library.

Improved Modelica package management. The `conversion(noneFromVersion)` annotation is now fully supported, which means for example that OpenModelica will automatically use the Modelica Standard Library 3.2.3 even for libraries that have a uses annotation pointing to earlier MSL versions, e.g. 3.2.2 or 3.2.1, because the `conversion(noneFromVersion)` annotations in the MSL specify that 3.2.3 can be used instead of 3.2.2 or 3.2.1 without any conversion script, i.e., it is fully backwards compatible. A full-fledged Modelica package manager is also included in OpenModelica 1.16.0, currently only with a command line interface; integration in the GUI is planned for the next 1.17.0 release, together with conversion scripts.

### 42.54.5 New Contributors

- @mflehmig made their first contribution in https://github.com/OpenModelica/OpenModelica/pull/302
- @stheid made their first contribution in https://github.com/OpenModelica/OpenModelica/pull/752

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.15.0-dev...v1.16.0

## 42.55 Release Notes for OpenModelica 1.14.2

A bug fix release for v1.14.1, fixing among other things compilation on Ubuntu 20.04.

### 42.55.1 What's Changed

- Fixes ticket:5733 Don't use the qualified path by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/647
- [NF] Fix some Expression.map*Opt functions. by @perost in https://github.com/OpenModelica/OpenModelica/pull/656
- ticket:5778 Fixed users guide links by @adeas31 in https://github.com/OpenModelica/OpenModelica/pull/666

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.14.1...v1.14.2

## 42.56 Release Notes for OpenModelica 1.14.0

### 42.56.1 OpenModelica Compiler (OMC)

The most dramatic enhancement of the OpenModelica Compiler is the New Frontend, which on the average gives a factor of 10-20 speed improvement in the flattening phase of compilation. The new frontend is default in this release, but a feature is implemented that allows the user to switch to the old frontend if problems appear for a specific model The speed of the OMEdit GUI has only slightly increased in this version, since it is still dependent mostly on the old frontend. Further GUI speed increases are available in the coming OpenModelica.1.15.0. About 200 issues have been fixed, including enhancements, compared to the previous 1.13.2 release. The bug fixes are on trac.

OpenModelica Compiler New Frontend news: • Implementation of expandable connectors completed, a rather large piece of work. • A number of smaller enhancements and fixes • The New Frontend (NF)gives slightly better simulation coverage on MSL 3.2.3 than the Old Frontend • The New Frontend is on the average about 20 times faster on flattening. • Remaining work is mainly on further bug fixing and testing the new frontend for all other libraries, as well as more work on modifiers of arrays in conjunction with non-expanded arrays. (The array modifiers have now been implemented in 1.16.0 but not yet it 1.14.0 in order to not delay the 1.14.0 release)

### 42.56.2 Graphic Editor OMEdit

- Drag and drop for the text layer. • Auto completion of class names, components and annotations. • GUI for data reconciliation – a method for increasing sensor data precision • Improved duplication functionality for copying classes. • Better handling of Compiler flags. • Partly completed: annotations for dynamic icon update. • Support for connectorSizing annotation • Several bug fixes. You can find the list here. • Docs: https://openmodelica.org/doc/OpenModelicaUsersGuide/latest/omedit.html. • Autocomplete annotations. • Support for Icon/Diagram map annotation • Copy paste functionality • Reset OMEdit settings/options. • Array plots update on re-simulation • Support for connectorSizing annotation. • Drag and drop class names to text layer in OMEdit • OMPlot: Improved plotting e.g., top and bottom margins for better view, snap to curve etc. • GUI support for replaceable libraries is being tested in a separate branch and will be made available in the coming 1.15.0 release.

### 42.56.3 OMC backend and run-time system

- A new more efficient and correct implementation of arrays and records.
- The FMI OMSimulator API calls are now also available in the OMC API functions, e.g. for use from OMNotebook, Jupyter notebooks.

#### Backend new features

- Added possibility to generate analytic Jacobians for linear strong components • Use flag LSanalyticJacobian to enable analytical Jacobian for linear loops. Default false.
- Added output language options for linearization: matlab, python, julia. • Available with --linearizationDumpLanguage=modelica/matlab/python/julia. Default is modelica.

#### Backend enhancements

- Unified Jacobian evaluation from DASSL and IDA integrators • Added result check for linear solvers Lis, Klu, Total Pivot and Umfpack if a residual function is available. • Improved debug dumping

• -d=bltdump (Index reduction information) • -d=initialization
• -d=dumpLoops

- Improved warning for iteration variables:

• Only warn about non-linear iteration variables with default start attribute. • Other variables have no influence on simulation at all.

- Build instructions for OpenModelica on Windows Subsystem for Linux • Improved Jacobian evaluation with translation flag -d=symJacConstantSplit (requires --generateSymbolicJacobian). Generate Jacobians with separated constant part to split equations that are independent of the seed vector. These equations only need to be evaluated only once per Jacobian evaluation.

#### Backend bugfixes

- Homotopy: Use simplified version only during initialization to avoid errors during matching and differentiation. • Logging for Homotopy path fixed so log can be loaded in OMEdit. • Support general function call differentiation for equations in residual form. • Equations in residual form don't fail during index reduction any more.

### 42.56.4 FMI Support

Bug fixes to FMI export, see below

**Full Changelog**: https://github.com/OpenModelica/OpenModelica/compare/v1.14.0-dev...v1.14.0

### 42.56.5 Release Notes for OpenModelica 1.13.0

- OMSimulator 2.0 – the second release of our efficient FMI Simulation tool including a GUI for FMI Composition, co-simulation and model-exchange simulation, and SSP standard support. - Model and library encryption/decryption support. (Only for usage by OSMC member organizations) - Improved OpenModelica DAEMode for efficient solution of large Modelica models. - Julia scripting API to OpenModelica. - Basic Matlab scripting API to OpenModelica. - OMSysIdent - parameter estimation module for linear and non-linear parametric dynamic models. - Interactive simulation and control of simulations with OPC-UA. - PDEModelica1 - experimental support for one-dimensional PDEs in Modelica. - Analytic directional derivatives for FMI export and efficient calculation of multiple Jacobian columns – giving much faster simulation for some models - Enhanced OMEdit – including fast multi-file search. - Improved error messages and stability. - A version of the new fast compiler frontend available for testing, can be enabled by a flag Currently (December 10), simulates about 84% of MSL 3.2.2

Note: the replaceable GUI support has been moved to OpenModelica 1.14.0 and will be available in nightly builds.

### 42.56.6 Release Notes for OpenModelica 1.12.0

- A new (stand-alone) FMI- and TLM-based simulation tool OMSimulator, first version for connected FMUs, TLM objects, Simulink models (via wrappers), Adams models (via wrappers), BEAST models (via wrappers), Modelica models
- Graphic configuration editing of composite models consisting of FMUs
- Basic graphical editing support for state machines and transitions
- Faster lookup processing, making some libraries faster to browse and compile
- Additional advanced visualization features for multibody animation
- Increased library coverage including significantly increased verification coverage
- Increased tool interoperability by addition of the ZeroMQ communications protocol
- Further enhanced OMPython including linearization, now also working with Python 3
- Support for RedHat/Fedora binary builds of OpenModelica

#### OpenModelica Compiler (OMC)

- Faster lookup processing
- Initializing external objects together with parameters
- Handle exceptions in numeric solvers
- Support for higher-index discrete clock partitions
- Improved unit checking
- Improved initialization of start values
- Decreased compilation time of models with large size arrays
- New approach for homotopy-based initialization (still experimental)
- A bunch of fixes: Bugs, regressions, performance issues
- Improved Dynamic Tearing by adding constraints for the casual set
- Improved module wrapFunctionCalls with one-time evaluation of Constant CSE-variables
- Added initOptModule for inlineHomotopy
- Added configuration flag tearingStrictness to influence solvability
- New methods for inline integration for continuous equations in clocked partitions, now covering: ExplicitEuler, ImplicitEuler, SemiImplicitEuler and ImplicitTrapezoid
- Complete implementation of synchronous features in C++ runtime

- Refactored linear solver of C++ runtime
- Improved Modelica_synchronous_cpp coverage
- New common linear solver module, optionally sparse, for the C++ runtime
- Coverage of most of the OpenHydraulics library
- Improved coverage of ThermoSysPro, IdealizedContact and Chemical libraries
- Support of time events for cpp-simulation and enabled time events in cpp-FMUs
- Global homotopy method for initialization
- Scripting API to compute accumulated errors (1-norm, 2-norm, max. error) of 2 time series

### Graphic Editor OMEdit

- Additional advanced visualization features for multibody animation (transparency, textures, change colours by dialog)
- An HTML WYSIWYG Editor, e.g. useful for documentation
- Support for choices(checkBox=true) annotation.
- Support for loadSelector & saveSelector attribute of Dialog annotation.
- Panning of icon/diagram view and plot window.
- AutoComplete feature in text editing for keywords, types, common Modelica constructs
- Follow connector transformation from Diagram View to Icon View.
- Further stability improvements
- Improved performance for rendering some icons using the interactive API
- Improved handling of parameters that cannot be evaluated in Icon annotations
- Basic graphic editing support for state machines and transitions (not yet support for showing state internals on diagram layer)
- Interactive state manipulation for FMU-based animations

### FMI Support

- A new (stand-alone) FMI- and TLM-based simulation tool OMSimulator, first version (a main deliverable of the OPENCPS project, significant contributions and code donations from SKF)
- Graphic configuration editing of composite models consisting of FMUs
- Co-simulation/simulation of connected FMUs, TLM objects, Simulink models (via wrappers), Adams models (via wrappers), BEAST models (via wrappers), Modelica models.

### Other things

- Increased OpenModelica tool interoperability by adding the ZeroMQ communications protocol in addition to the previously available Corba. This also enables Python 3 usage in OMPython on all platforms.
- Textual support through the OpenModelica API and graphical support in OMEdit for generation of single or multiple requirement verification scenarios
- VVDRlib – a small library for connecting requirements and models together, with notions for mediators, scenarios, design alternatives
- Further enhanced OMPython including linearization, now also working with Python 3.¨
- Jupyter notebooks also supported with OMPython and Python 3
- New enhanced library testing script (libraries.openmodelica.org/branches).
- Addition of mutable reference data types in MetaModelica

- Support for RedHat/Fedora binary builds of OpenModelica
- Support for exporting the system of equations in GraphML (yEd) format for debugging

### 42.56.7 Release Notes for OpenModelica 1.11.0

- Dramatically improved compilation speed and performance, in particular for large models.
- 3D animation visualization of regular MSL MultiBody simulations and for real-time FMUs.
- Better support for synchronous and state machine language elements, now supports 90% of the clocked synchronous library.
- Several OMEdit improvements including folding of large annotations.
- 64-bit OM on Windows further stabilized
- An updated OMDev (OpenModelica Development Environment), involving msys2. This was needed for the shift to 64-bit on Windows.
- Integration of Sundials/IDA DAE solver with potentially large increase of simulation performance for large models with sparse structure.
- Improved library coverage.
- Parameter sensitivity analysis added to OMC.

#### OpenModelica Compiler (OMC)

- Real-time synchronization support by using simFlag -rt=1.0 (or some other time scaling factor).
- A prototype implementation of OPC UA using an open source OPC UA implementation. The old OPC implementation was not maintained and relied on a Windows-only proprietary OPC DA+UA package. (At the moment, OPC is experimental and lacks documentation; it only handles reading/writing Real/Boolean input/state variables. It is planned for OMEdit to use OPC UA to re-implement interactive simulations and plotting.)
- Dramatically improved compilation speed and dramatically reduced memory requirements for very large models. In Nov 2015, the largest power generation and transmission system model that OMC could handle had 60000 equations and it took 700 seconds to generate the simulation executable code; it now takes only 45 seconds to do so with OMC 1.11.0, which can also handle a model 10 times bigger (600 000 equations) in less than 15 minutes and with less than 32 GB of RAM. Simulation times are comparable to domain-specific simulation tools. See for example ScalableTestSuite for some of the improvements.
- Improved library coverage
- Better support for synchronous and state machine language elements, now simulates 90% of the clocked synchronous library.
- Enhanced Cpp runtime to support the PowerSystems library.
- Integration of Sundials/IDA solver as an alternative to DASSL.
- A DAEMode solver mode was added, which allows to use the sparse IDA solver to handle the DAEs directly. This can lead to substantially faster simulation on large systems with sparse structure, compared to the traditional approach.
- The direct sparse solvers KLU and SuperLU have been added, with benefits for models with large algebraic loops.
- Multi-parameter sensitivity analysis added to OMC.
- Progress on more efficient inline function mechanism.
- Stabilized 64-bit Windows support.
- Performance improvement of parameter evaluation.
- Enhanced tearing support, with prefer iteration variables and user-defined tearing.

- Support for external object aliases in connectors and equations (a non-standard Modelica extension).
- Code generation directly to file (saves maximum memory used). #3356
- Code generation in parallel is enabled since #3356 (controlled by omc flag `-n`). This improves performance since generating code directly to file avoid memory allocation.
- Allowing mixed dense and sparse linear solvers in the generated simulation (chosen depending on simflags `-ls` (dense solver), `-lss` (sparse solver), `-lssMaxDensity` and `-lssMinSize`).

#### Graphic Editor OMEdit

- Significantly faster browsing of most libraries.
- Several GUI improvements including folding of multi-line annotations.
- Further improved code formatting preservation during edits.
- Support for all simulation logging flags.
- Select and export variables after simulation.
- Support for Byte Order Mark. Added support enables other tools to correctly read the files written by OMEdit.
- Save files with line endings according to OS (Windows (CRLF), Unix (LF)).
- Added OMEdit support for FMU cross compilation. This makes it possible to launch OMEdit on a remote or virtual Linux machine using a Windows X server and export an FMU with Windows binaries.
- Support of DisplayUnit and unit conversion.
- Fixed automatic save.
- Initial support for DynamicSelect in model diagrams (texts and visible attribute after simulation, no expressions yet).
- An HTML documentation editor (not WYSIWYG; that editor will be available in the subsequent release).
- Improved logging in OMEdit of structured messages and standard output streams for simulations.

#### FMI Support

- Cross compilation of C++ FMU export. Compared to the C runtime, the C++ cross compilation covers the whole runtime for model exchange.
- Improved Newton solver for C++ FMUs (scaling and step size control).

#### Other things

- 3D animation visualization of regular MSL MultiBody simulations and for real-time FMUs.
- An updated OMDev (OpenModelica Development Environment), involving msys2. This was needed for the shift to 64-bit on Windows.
- OMWebbook, a web version of OMNotebook online. Also, a script is available to convert an OMNotebook to an OMWebbook.
- A Jupyter notebook Modelica mode, available in OpenModelica.

1.11.0,status=closed,severity!=trivial,resolution=fixed|-,col=changelog,group=component,format=table)

### 42.56.8 Release Notes for OpenModelica 1.10.0

The most important enhancements in the OpenModelica 1.10.0 release:

#### OpenModelica Compiler (OMC)

New features:

- Real-time synchronization support by using simFlag -rt=1.0 (or some other time scaling factor). - A prototype implementation of OPC UA using an open source OPC UA implementation. The old OPC implementation was not maintained and relied on a Windows-only proprietary OPC DA+UA package. (At the moment, OPC is experimental and lacks documentation; it only handles reading/writing Real/Boolean input/state variables. It is planned for OMEdit to use OPC UA to re-implement interactive simulations and plotting.)

Performance enhancements:

- Code generation directly to file (saves maximum memory used). #3356 - Code generation in parallel enabled since #3356 allows this without allocating too much memory (controlled by omc flag `-n`). - Various scalability enhancements, allowing the compiler to handle hundreds of thousands of equations. See for example ScalableTestSuite for some of the improvements. - Better defaults for handling tearing (OMC flags `--maxSizeLinearTearing` and `--maxSizeNonlinearTearing`).
- Allowing mixed dense and sparse linear solvers in the generated simulation (chosen depending on simflags `-ls` (dense solver), `-lss` (sparse solver), `-lssMaxDensity` and `-lssMinSize`).

#### Graphic Editor OMEdit

#### OpenModelica Notebook (OMNotebook)

#### Optimization

#### FMI Support

#### OpenModelica Development Environment (OMDev)

### 42.56.9 Release Notes for OpenModelica 1.9.4

OpenModelica v1.9.4 was released 2016-03-09. These notes cover the v1.9.4 release and its subsequent bug-fix releases (now up to 1.9.7).

#### OpenModelica Compiler (OMC)

- Improved simulation speed for many models. simulation speed went up for 80% of the models. The compiler frontend became faster for almost all models, average about 40% faster.
- Initial support for synchronous models with clocked equations as defined in the Modelica 3.3 standard
- Support for homotopy operator

#### Graphic Editor OMEdit

- Undo/Redo support.
- Preserving text formatting, including indentation and whitespace. This is especially important for diff/merge with several collaborating developers possibly using several different Modelica tools.
- Better support for inherited classes.
- Allow simulating models using visual studio compiler.
- Support for saving Modelica package in a folder structure.
- Allow reordering of classes inside a package.
- Highlight matching parentheses in text view.
- When copying the text retain the text highlighting and formatting.
- Support for global head definition in the documentation by using `__OpenModelica_infoHeader` annotation.
- Support for expandable connectors.
- Support for uses annotation.

### FMI Support

- Full FMI 2.0 co-simulation support now available
- Upgrade Cpp runtime from C++03 to C++11 standard, minimizing external link dependencies. Exported FMUs don't depend on additional libraries such as boost anymore
- FMI 2.0 is broken for some models in 1.9.4. Upgrading to 1.9.6 is advised.

## 42.56.10 Release Notes for OpenModelica 1.9.3

The most important enhancements in the OpenModelica 1.9.3 release:

- Enhanced collaborative development and testing of OpenModelica by moving to the GIT-hub framework for versioning and parallel development.
- More accessible and up-to-date automatically generated documentation provided in both html and pdf.
- Further improved simulation speed and coverage of several libraries.
- OMEdit graphic connection editor improvements.
- OMNotebook improvements.

### OpenModelica Compiler (OMC)

This release mainly includes improvements of the OpenModelica Compiler (OMC), including, but not restricted to the following:

- Further improved simulation speed and coverage for several libraries.
- Faster generated code for functions involving arrays, factor 2 speedup for many power generation models.
- Better initialization.
- An implicit inline Euler solver available.
- Code generation to enable vectorization of for-loops.
- Improved non-linear, linear and mixed system solving.
- Cross-compilation for the ARMhf architecture.
- A prototype state machine implementation.
- Improved performance and stability of the C++ runtime option.
- More accessible and up-to-date automatically generated documentation provided in both html and .pdf.

### Graphic Editor OMEdit

There are several improvements to the OpenModelica graphic connection editor OMEdit:

- Support for uses annotations.
- Support for declaring components as vectors.
- Faster messages browser with clickable error messages.
- Support for managing the stacking order of graphical shapes.
- Several improvements to the plot tool and text editor in OMEdit.

### OpenModelica Notebook (OMNotebook)

Several improvements:

- Support for moving cells from one place to another in a notebook.
- A button for evaluation of whole notebooks.

- A new cell type called Latex cells, supporting Latex formatted input that provides mathematical typesetting of formulae when evaluated.

#### Optimization

Several improvements of the Dynamic Optimization module with collocation, using Ipopt:

- Better performance due to smart treatment of algebraic loops for optimization.
- Improved formulation of optimization problems with an annotation approach which also allows graphical problem formulation.
- Proper handling of constraints at final time.

#### FMI Support

Further improved FMI 2.0 co-simulation support.

#### OpenModelica Development Environment (OMDev)

A big change: version handling and parallel development has been improved by moving from SVN to GITHub. This makes it easier for each developer to test his/her fixes and enhancements before committing the code. Automatic mirroring of all code is still performed to the OpenModelica SVN site.

### 42.56.11 Release Notes for OpenModelica 1.9.2

The OpenModelica 1.9.2 Beta release is available now, January 31, 2015. Please try it and give feedback! The final release is planned within 1-2 weeks after some more testing. The most important enhancements in the OpenModelica 1.9.2 release:

- The OpenModelica compiler has moved to a new development and release platform: the bootstrapped OpenModelica compiler. This gives advantages in terms of better programmability, maintenance, debugging, modularity and current/future performance increases.
- The OpenModelica graphic connection editor OMEdit has become 3-5 times faster due to faster communication with the OpenModelica compiler linked as a DLL. This was made possible by moving to the bootstrapped compiler.
- Further improved simulation coverage for a number of libraries.
- OMEdit graphic connection editor improvements

#### OpenModelica Compiler (OMC)

This release mainly includes improvements of the OpenModelica Compiler (OMC), including, but not restricted to the following:

- The OpenModelica compiler has moved to a new development and release platform: the bootstrapped OpenModelica compiler. This gives advantages in terms of better programmability, maintenance, debugging, modularity and current/future performance increases.
- Further improved simulation coverage for a number of libraries compared to 1.9.1. For example:
  - MSL 3.2.1 100% compilation, 97% simulation (3% increase)
  - MSL Trunk 99% compilation (1% increase), 93% simulation (3% increase)
  - ModelicaTest 3.2.1 99% compilation (2% increase), 95% simulation (6% increase)
  - ThermoSysPro 100% compilation, 80% simulation (17% increase)
  - ThermoPower 97% compilation (5% increase), 85% simulation (5% increase)
  - Buildings 80% compilation (1% increase), 73% simulation (1% increase)
- Further enhanced OMC compiler front-end coverage, scalability, speed and memory.
- Better initialization.

- Improved tearing.
- Improved non-linear, linear and mixed system solving.
- Common subexpression elimination support - drastically increases performance of some models.

#### Graphic Editor OMEdit

- The OpenModelica graphic connection editor OMEdit has become 3-5 times faster due to faster communication with the OpenModelica compiler linked as a DLL. This was made possible by moving to the bootstrapped compiler.
- Enhanced simulation setup window in OMEdit, which among other things include better support for integration methods and dassl options.
- Support for running multiple simultaneous simulation.
- Improved handling of modifiers.
- Re-simulate with changed options, including history support and re-simulating with previous options possibly edited.
- More user friendly user interface by improved connection line drawing, added snap to grid for icons and conversion of icons from PNG to SVG, and some additional fixes.

#### Optimization

Some smaller improvements of the Dynamic Optimization module with collocation, using Ipopt.

#### FMI Support

Further improved for FMI 2.0 model exchange import and export, now compliant according to the FMI compliance tests. FMI 1.0 support has been further improved.

### 42.56.12 Release Notes for OpenModelica 1.9.1

The most important enhancements in the OpenModelica 1.9.1 release:

- Improved library support.
- Further enhanced OMC compiler front-end coverage and scalability
- Significant improved simulation support for libraries using Fluid and Media.
- Dynamic model debugger for equation-based models integrated with OMEdit.
- Dynamic algorithm model debugger with OMEdit; including support for MetaModelica when using the bootstrapped compiler.

New features: Dynamic debugger for equation-based models; Dynamic Optimization with collocation built into OpenModelica, performance analyzer integrated with the equation model debugger.

#### OpenModelica Compiler (OMC)

This release mainly includes improvements of the OpenModelica Compiler (OMC), including, but not restricted to the following:

- Further improved OMC model compiler support for a number of libraries including MSL 3.2.1, ModelicaTest 3.2.1, PetriNet, Buildings, PowerSystems, OpenHydraulics, ThermoPower, and ThermoSysPro.
- Further enhanced OMC compiler front-end coverage, scalability, speed and memory.
- Better coverage of Modelica libraries using Fluid and Media.
- Automatic differentiation of algorithms and functions.
- Improved testing facilities and library coverage reporting.
- Improved model compilation speed by compiling model parts in parallel (bootstrapped compiler).

- Support for running model simulations in a web browser.
- New faster initialization that handles over-determined systems, under-determined systems, or both.
- Compiler back-end partly redesigned for improved scalability and better modularity.
- Better tearing support.
- The first run-time Modelica equation-based model debugger, not available in any other Modelica tool, integrated with OMEdit.
- Enhanced performance profiler integrated with the debugger.
- Improved parallelization prototype with several parallelization strategies, task merging and duplication, shorter critical paths, several scheduling strategies.
- Some support for general solving of mixed systems of equations.
- Better error messages.
- Improved bootstrapped OpenModelica compiler.
- Better handling of array subscripts and dimensions.
- Improved support for reduction functions and operators.
- Better support for partial functions.
- Better support for function tail recursion, which reduces memory usage.
- Partial function evaluation in the back-end to improve solving singular systems.
- Better handling of events/zero crossings.
- Support for colored Jacobians.
- New differentiation package that can handle a much larger number of expressions.
- Support for sparse solvers.
- Better handling of asserts.
- Improved array and matrix support.
- Improved overloaded operators support.
- Improved handling of overconstrained connection graphs.
- Better support for the cardinality operator.
- Parallel compilation of generated code for speeding up compilation.
- Split of model files into several for better compilation scalability.
- Default linear tearing.
- Support for impure functions.
- Better compilation flag documentation.
- Better automatic generation of documentation.
- Better support for calling functions via instance.
- New text template based unparsing for DAE, Absyn, SCode, TaskGraphs, etc.
- Better support for external objects (#2724, reject non-constructor functions returning external objects)
- Improved C++ runtime.
- Improved testing facilities.
- New unit checking implementation.
- Support for model rewriting expressions via rewriting rules in an external file.
- Reject more bad code (r19986, consider records with different components type-incompatible)

#### OpenModelica Connection Editor (OMEdit)

- Convenient editing of model parameter values and re-simulation without recompilation after parameter changes.
- Improved plotting.
- Better handling of flags/units/resources/crashes.
- Run-time Modelica equation-based model debugger that provides both dynamic run-time debugging and debugging of symbolic transformations.
- Run-time Modelica algorithmic code debugger; also MetaModelica debugger with the bootstrapped OpenModelica compiler.

#### OMPython

The interface was changed to version 2.0, which uses one object for each OpenModelica instance you want active. It also features a new and improved parser that returns easier to use datatypes like maps and lists.

#### Optimization

A builtin integrated Dynamic Optimization module with collocation, using Ipopt, is now available.

#### FMI Support

Support for FMI 2.0 model exchange import and export has been added. FMI 1.0 support has been further improved.

### 42.56.13 Release Notes for OpenModelica 1.9.0

This is the summary description of changes to OpenModelica from 1.8.1 to 1.9.0, released 2013-10-09. This release mainly includes improvements of the OpenModelica Compiler (OMC), including, but not restricted to the following:

#### OpenModelica Compiler (OMC)

This release mainly includes bug fixes and improvements of the OpenModelica Compiler (OMC), including, but not restricted to the following:

- A more stable and complete OMC model compiler. The 1.9.0 final version simulates many more models than the previous 1.8.1 version and OpenModelica 1.9.0 beta versions.
- Much better simulation support for MSL 3.2.1, now 270 out of 274 example models compile (98%) and 245 (89%) simulate, compared to 30% simulating in the 1.9.0 beta1 release.
- Much better simulation for the ModelicaTest 3.2.1 library, now 401 out of 428 models build (93%) and 364 simulate (85%), compared to 32% in November 2012.
- Better simulation support for several other libraries, e.g. more than twenty examples simulate from ThermoSysPro, and all but one model from PlanarMechanics simulate.
- Improved tearing algorithm for the compiler backend. Tearing is by default used.
- Much faster matching and dynamic state selection algorithms for the compiler backend.
- New index reduction algorithm implementation.
- New default initialization method that symbolically solves the initialization problem much faster and more accurately. This is the first version that in general initialize hybrid models correctly.
- Better class loading from files. The package.order file is now respected and the file structure is more thoroughly examined (#1764).
- It is now possible to translate the error messages in the omc kernel (#1767).
- FMI Support. FMI co-simulation with OpenModelica as master. Improved FMI Import and export for model exchange. Most of FMI 2.0 is now also supported.

- Checking (when possible) that variables have been assigned to before they are used in algorithmic code (#1776).
- Full version of Python scripting.
- 3D graphics visualization using the Modelica3D library.
- The PySimulator package from DLR for additional analysis is integrated with OpenModelica (see Modelica2012 paper), and included in the OpenModelica distribution (Windows only).
- Prototype support for uncertainty computations, special feature enabled by special flag.
- Parallel algorithmic Modelica support (ParModelica) for efficient portable parallel algorithmic programming based on the OpenCL standard, for CPUs and GPUs.
- Support for optimization of semiLinear according to MSL 3.3 chapter 3.7.2.5 semiLinear (r12657,r12658).
- The compiler is now fully bootstrapped and can compile itself using a modest amount of heap and stack space (less than the RML-based compiler, which is still the default).
- Some old debug-flags were removed. Others were renamed. Debug flags can now be enabled by default.
- Removed old unused simulation flags noClean and storeInTemp (r15927).
- Many stack overflow issues were resolved.
- Dynamic Optimization with OpenModelica. Dynamic optimization with XML export to the CasADi package is now integrated with OpenModelica. Moreover, a native integrated Dynamic Optimization prototype using Ipopt is now in the OpenModelica release, but currently needs a special flag to be turned on since it needs more testing and refinement before being generally made available.

### OpenModelica Notebook (OMNotebook)

- A `shortOutput` option has been introduced in the simulate command for less verbose output. The DrModelica interactive document has been updated and the models tested. Almost all models now simulate with OpenModelica.

### OpenModelica Eclipse Plug-in (MDT)

- Enhanced debugger for algorithmic Modelica code, supporting both standard Modelica algorithmic code called from simulation models, and MetaModelica code.

### OpenModelica Development Environment (OMDev)

- Migration of version handling and configuration management from CodeBeamer to Trac.

### Graphic Editor OMEdit

- General GUI: backward and forward navigation support in Documentation view, enhanced parameters window with support for Dialog annotation. Most of the images are converted from raster to vector graphics i.e PNG to SVG.
- Libraries Browser: better loading of libraries, library tree can now show protected classes, show library items class names as middle ellipses if the class name text is larger, more options via the right click menu for quick usage.
- ModelWidget: add the partial class as a replaceable component, look for the default component prefixes and name when adding the component.
- GraphicsView: coordinate system manipulation for icon and diagram layers. Show red box for models that do not exist. Show default graphical annotation for the components that doesn't have any graphical annotations. Better resizing of the components. Properties dialog for primitive shapes i.e Line, Polygon, Rectangle, Ellipse, Text and Bitmap.
- File Opening: open one or more Modelica files, allow users to select the encoding while opening the file, convert files to UTF-8 encoding, allow users to open the OpenModelica result files.

- Variables Browser: find variables in the variables browser, sorting in the variables browser.
- Plot Window: clear all curves of the plot window, preserve the old selected variable and update its value with the new simulation result.
- Simulation: support for all the simulation flags, read the simulation output as soon as is is obtained, output window for simulations, options to set matching algorithm and index reduction method for simulation. Display all the files generated during the simulation is now supported. Options to set OMC command line flags.
- Options: options for loading libraries via loadModel and loadFile each time GUI starts, save the last open file directory location, options for setting line wrap mode and syntax highlighting.
- Modelica Text Editor: preserving user customizations, new search & replace functionality, support for comment/uncomment.
- Notifications: show custom dialogs to users allowing them to choose whether they want to see this dialog again or not.
- Model Creation: Better support for creating new classes. Easy creation of extends classes or nested classes.
- Messages Widget: Multi line error messages are now supported.
- Crash Detection: The GUI now automatically detects the crash and writes a stack trace file. The user is given an option to send a crash report along with the stack trace file and few other useful files via email.
- Autosave: OMEdit saves the currently edited model regularly, in order to avoid losing edits after GUI or compiler crash. The save interval can be set in the Options menu.

#### ModelicaML

- Enhanced ModelicaML version with support for value bindings in requirements-driven modeling available for the latest Eclipse and Papyrus versions. GUI specific adaptations. Automated model composition workflows (used for model-based design verification against requirements) are modularized and have improved in terms of performance.

### 42.56.14 Release Notes for OpenModelica 1.8.1

The OpenModelica 1.8.1 release has a faster and more stable OMC model compiler. It flattens and simulates more models than the previous 1.8.0 version. Significant flattening speedup of the compiler has been achieved for certain large models. It also contains a New ModelicaML version with support for value bindings in requirements-driven modeling and importing Modelica library models into ModelicaML models. A beta version of the new OpenModelica Python scripting is also included. The release was made on 2012-04-03 (r11645).

#### OpenModelica Compiler (OMC)

This release includes bug fixes and improvements of the flattening frontend part of the OpenModelica Compiler (OMC) and several improvements of the backend, including, but not restricted to:

- A faster and more stable OMC model compiler. The 1.8.1 version flattens and simulates more models than the previous 1.8.0 version.
- Support for operator overloading (except Complex numbers).
- New ModelicaML version with support for value bindings in requirements-driven modeling and importing Modelica library models into ModelicaML models.
- Faster plotting in OMNotebook. The feature sendData has been removed from OpenModelica. As a result, the kernel no longer depends on Qt. The plot3() family of functions have now replaced to plot(), which in turn have been removed. The non-standard visualize() command has been removed in favour of more recent alternatives.
- Store OpenModelica documentation as Modelica Documentation annotations.
- Re-implementation of the simulation runtime using C instead of C++ (this was needed to export FMI source-based packages).

- FMI import/export bug fixes.
- Changed the internal representation of various structures to share more memory. This significantly improved the performance for very large models that use records.
- Faster model flattening, Improved simulation, some graphical API bug fixes.
- More robust and general initialization, but currently time-consuming.
- New initialization flags to omc and options to simulate(), to control whether fast or robust initialization is selected, or initialization from an external (.mat) data file.
- New options to API calls list, loadFile, and more.
- Enforce the restriction that input arguments of functions may not be assigned to.
- Improved the scripting environment. cl := $TypeName(Modelica);getClassComment(cl); now works as expected. As does looping over lists of typenames and using reduction expressions.
- Beta version of Python scripting.
- Various bugfixes.
- NOTE: interactive simulation is not operational in this release. It will be put back again in the near future, first available as a nightly build. It is also available in the previous 1.8.0 release.

#### OpenModelica Notebook (OMNotebook)

- Faster and more stable plottning.

#### OpenModelica Shell (OMShell)

- No changes.

#### OpenModelica Eclipse Plug-in (MDT)

- Small fixes and improvements.

#### OpenModelica Development Environment (OMDev)

- No changes.

#### Graphic Editor OMEdit

- Bug fixes.

#### OMOptim Optimization Subsystem

- Bug fixes.

#### FMI Support

- Bug fixes.

### 42.56.15 OpenModelica 1.8.0, November 2011

The OpenModelica 1.8.0 release contains OMC flattening improvements for the Media library - it now flattens the whole library and simulates about 20% of its example models. Moreover, about half of the Fluid library models also flatten. This release also includes two new tool functionalities - the FMI for model exchange import and export, and a new efficient Eclipse-based debugger for Modelica/MetaModelica algorithmic code.

#### OpenModelica Compiler (OMC)

This release includes bug fixes and improvements of the flattening frontend part of the OpenModelica Compiler (OMC) and several improvements of the backend, including, but not restricted to: A faster and more stable OMC model compiler. The 1.8.0 version flattens and simulates more models than the previous 1.7.0 version.

- Flattening of the whole Media library, and about half of the Fluid library. Simulation of approximately 20% of the Media library example models. - Functional Mockup Interface FMI 1.0 for model exchange, export and import, for the Windows platform. - Bug fixes in the OpenModelica graphical model connection editor OMEdit, supporting easy-to-use graphical drag-and-drop modeling and MSL 3.1. - Bug fixes in the OMOptim optimization subsystem. - Beta version of compiler support for a new Eclipse-based very efficient algorithmic code debugger for functions in MetaModelica/Modelica, available in the development environment when using the bootstrapped OpenModelica compiler. - Improvements in initialization of simulations. - Improved index reduction with dynamic state selection, which improves simulation. - Better error messages from several parts of the compiler, including a new API call for giving better error messages. - Automatic partitioning of equation systems and multi-core parallel simulation of independent parts based on the shared-memory OpenMP model. This version is a preliminary experimental version without load balancing.

#### OpenModelica Notebook (OMNotebook)

No changes.

#### OpenModelica Shell (OMShell)

Small performance improvements.

#### OpenModelica Eclipse Plug-in (MDT)

Small fixes and improvements. MDT now also includes a beta version of a new Eclipse-based very efficient algorithmic code debugger for functions in MetaModelica/Modelica.

#### OpenModelica Development Environment (OMDev)

Third party binaries, including Qt libraries and executable Qt clients, are now part of the OMDev package. Also, now uses GCC 4.4.0 instead of the earlier GCC 3.4.5.

#### Graphic Editor OMEdit

Bug fixes. Access to FMI Import/Export through a pull-down menu. Improved configuration of library loading. A function to go to a specific line number. A button to cancel an on-going simulation. Support for some updated OMC API calls.

#### New OMOptim Optimization Subsystem

Bug fixes, especially in the Linux version.

#### FMI Support

The Functional Mockup Interface FMI 1.0 for model exchange import and export is supported by this release. The functionality is accessible via API calls as well as via pull-down menu commands in OMEdit.

### 42.56.16 OpenModelica 1.7.0, April 2011

The OpenModelica 1.7.0 release contains OMC flattening improvements for the Media library, better and faster event handling and simulation, and fast MetaModelica support in the compiler, enabling it to compiler itself. This release also includes two interesting new tools – the OMOptim optimization subsystem, and a new performance profiler for equation-based Modelica models.

#### OpenModelica Compiler (OMC)

This release includes bug fixes and performance improvements of the flattening frontend part of the OpenModelica Compiler (OMC) and several improvements of the backend, including, but not restricted to:

- Flattening of the whole Modelica Standard Library 3.1 (MSL 3.1), except Media and Fluid. - Progress in supporting the Media library, some models now flatten. - Much faster simulation of many models through more efficient handling of alias variables, binary output format, and faster event handling. - Faster and more stable simulation through new improved event handling, which is now default. - Simulation result storage in binary .mat files, and plotting from such files. - Support for Unicode characters in quoted Modelica identifiers, including Japanese and Chinese. - Preliminary MetaModelica 2.0 support. (use setCommandLineOptions({"+g=MetaModelica"}) ). Execution is as fast as MetaModelica 1.0, except for garbage collection. - Preliminary bootstrapped OpenModelica compiler: OMC now compiles itself, and the bootstrapped compiler passes the test suite. A garbage collector is still missing. - Many bug fixes.

#### OpenModelica Notebook (OMNotebook)

Improved much faster and more stable 2D plotting through the new OMPlot module. Plotting from binary .mat files. Better integration between OMEdit and OMNotebook, copy/paste between them.

#### OpenModelica Shell (OMShell)

Same as previously, except the improved 2D plotting through OMPlot.

#### Graphic Editor OMEdit

Several enhancements of OMEdit are included in this release. Support for Icon editing is now available. There is also an improved much faster 2D plotting through the new OMPlot module. Better integration between OMEdit and OMNotebook, with copy/paste between them. Interactive on-line simulation is available in an easy-to-use way.

#### New OMOptim Optimization Subsystem

A new optimization subsystem called OMOptim has been added to OpenModelica. Currently, parameter optimization using genetic algorithms is supported in this version 0.9. Pareto front optimization is also supported.

#### New Performance Profiler

A new, low overhead, performance profiler for Modelica models has been developed.

### 42.56.17 OpenModelica 1.6.0, November 2010

The OpenModelica 1.6.0 release primarily contains flattening, simulation, and performance improvements regarding Modelica Standard Library 3.1 support, but also has an interesting new tool – the OMEdit graphic connection editor, and a new educational material called DrControl, and an improved ModelicaML UML/Modelica profile with better support for modeling and requirement handling.

#### OpenModelica Compiler (OMC)

This release includes bug fix and performance improvemetns of the flattening frontend part of the OpenModelica Compiler (OMC) and some improvements of the backend, including, but not restricted to:

- Flattening of the whole Modelica Standard Library 3.1 (MSL 3.1), except Media and Fluid. - Improved flattening speed of a factor of 5-20 compared to OpenModelica 1.5 for a number of models, especially in the MultiBody library. - Reduced memory consumption by the OpenModelica compiler frontend, for certain large models a reduction of a factor 50.
- Reorganized, more modular OpenModelica compiler backend, can now handle approximately 30 000 equations, compared to previously approximately 10 000 equations. - Better error messages from the compiler, especially regarding functions. - Improved simulation coverage of MSL 3.1. Many models that did not simulate before are now simulating. However, there are still many models in certain sublibraries that do not simulate. - Progress in supporting the Media library, but simulation is not yet possible. - Improved support

for enumerations, both in the frontend and the backend. - Implementation of stream connectors. - Support for linearization through symbolic Jacobians. - Many bug fixes.

#### OpenModelica Notebook (OMNotebook)

A new DrControl electronic notebook for teaching control and modeling with Modelica.

#### OpenModelica Development Environment (OMDev)

Several enhancements. Support for match-expressions in addition to matchcontinue. Support for real if-then-else. Support for if-then without else-branches. Modelica Development Tooling 0.7.7 with small improvements such as more settings, improved error detection in console, etc.

#### New Graphic Editor OMEdit

A new improved open source graphic model connection editor called OMEdit, supporting 3.1 graphical annotations, which makes it possible to move models back and forth to other tools without problems. The editor has been implemented by students at Linköping University and is based on the C++ Qt library.

### 42.56.18 OpenModelica 1.5.0, July 2010

This OpenModelica 1.5 release has major improvements in the OpenModelica compiler frontend and some in the backend. A major improvement of this release is full flattening support for the MultiBody library as well as limited simulation support for MultiBody. Interesting new facilities are the interactive simulation and the integrated UML-Modelica modeling with ModelicaML. Approximately 4 person-years of additional effort have been invested in the compiler compared to the 1.4.5 version, e.g., in order to have a more complete coverage of Modelica 3.0, mainly focusing on improved flattening in the compiler frontend.

#### OpenModelica Compiler (OMC)

This release includes major improvements of the flattening frontend part of the OpenModelica Compiler (OMC) and some improvements of the backend, including, but not restricted to:

- Improved flattening speed of at least a factor of 10 or more compared to the 1.4.5 release, primarily for larger models with inner-outer, but also speedup for other models, e.g. the robot model flattens in approximately 2 seconds. - Flattening of all MultiBody models, including all elementary models, breaking connection graphs, world object, etc. Moreover, simulation is now possible for at least five MultiBody models: Pendulum, DoublePendulum, InitSpringConstant, World, PointGravityWithPointMasses. - Progress in supporting the Media library, but simulation is not yet possible. - Support for enumerations, both in the frontend and the backend. - Support for expandable connectors. - Support for the inline and late inline annotations in functions. - Complete support for record constructors, also for records containing other records. - Full support for iterators, including nested ones. - Support for inferred iterator and for-loop ranges. - Support for the function derivative annotation. - Prototype of interactive simulation. - Prototype of integrated UML-Modelica modeling and simulation with ModelicaML. - A new bidirectional external Java interface for calling external Java functions, or for calling Modelica functions from Java. - Complete implementation of replaceable model extends. - Fixed problems involving arrays of unknown dimensions. - Limited support for tearing. - Improved error handling at division by zero. - Support for Modelica 3.1 annotations. - Support for all MetaModelica language constructs inside OpenModelica. - OpenModelica works also under 64-bit Linux and Mac 64-bit OSX. - Parallel builds and running test suites in parallel on multi-core platforms. - New OpenModelica text template language for easier implementation of code generators, XML generators, etc. - New OpenModelica code generators to C and C# using the text template language. - Faster simulation result data file output optionally as comma-separated values. - Many bug fixes.

It is now possible to graphically edit models using parts from the Modelica Standard Library 3.1, since the simForge graphical editor (from Politecnico di Milano) that is used together with OpenModelica has been updated to version 0.9.0 with a important new functionality, including support for Modelica 3.1 and 3.0 annotations. The 1.6 and 2.2.1 Modelica graphical annotation versions are still supported.

#### OpenModelica Notebook (OMNotebook)

Improvements in platform availability.

- Support for 64-bit Linux. - Support for Windows 7. - Better support for MacOS, including 64-bit OSX.

### 42.56.19 OpenModelica 1.4.5, January 2009

This release has several improvements, especially platform availability, less compiler memory usage, and supporting more aspects of Modelica 3.0.

#### OpenModelica Compiler (OMC)

This release includes small improvements and some bugfixes of the OpenModelica Compiler (OMC):

- Less memory consumption and better memory management over time. This also includes a better API supporting automatic memory management when calling C functions from within the compiler. - Modelica 3.0 parsing support. - Export of DAE to XML and MATLAB. - Support for several platforms Linux, MacOS, Windows (2000, Xp, Vista). - Support for record and strings as function arguments. - Many bug fixes. - (Not part of OMC): Additional free graphic editor SimForge can be used with OpenModelica.

#### OpenModelica Notebook (OMNotebook)

A number of improvements, primarily in the plotting functionality and platform availability.

- A number of improvements in the plotting functionality: scalable plots, zooming, logarithmic plots, grids, etc. - Programmable plotting accessible through a Modelica API. - Simple 3D visualization. - Support for several platforms Linux, MacOS, Windows (2000, Xp, Vista).

### 42.56.20 OpenModelica 1.4.4, Feb 2008

This release is primarily a bug fix release, except for a preliminary version of new plotting functionality available both from the OMNotebook and separately through a Modelica API. This is also the first release under the open source license OSMC-PL (Open Source Modelica Consortium Public License), with support from the recently created Open Source Modelica Consortium. An integrated version handler, bug-, and issue tracker has also been added.

#### OpenModelica Compiler (OMC)

This release includes small improvements and some bugfixes of the OpenModelica Compiler (OMC):

- Better support for if-equations, also inside when. - Better support for calling functions in parameter expressions and interactively through dynamic loading of functions. - Less memory consumtion during compilation and interactive evaluation. - A number of bug-fixes.

#### OpenModelica Notebook (OMNotebook)

Test release of improvements, primarily in the plotting functionality and platform availability.

- Preliminary version of improvements in the plotting functionality: scalable plots, zooming, logarithmic plots, grids, etc., currently available in a preliminary version through the plot2 function. - Programmable plotting accessible through a Modelica API.

#### OpenModelica Eclipse Plug-in (MDT)

This release includes minor bugfixes of MDT and the associated MetaModelica debugger.

#### OpenModelica Development Environment (OMDev)

Extended test suite with a better structure. Version handling, bug tracking, issue tracking, etc. now available under the integrated Codebeamer.

## 42.56.21 OpenModelica 1.4.3, June 2007

This release has a number of significant improvements of the OMC compiler, OMNotebook, the MDT plugin and the OMDev. Increased platform availability now also for Linux and Macintosh, in addition to Windows. OMShell is the same as previously, but now ported to Linux and Mac.

### OpenModelica Compiler (OMC)

This release includes a number of improvements of the OpenModelica Compiler (OMC):

- Significantly increased compilation speed, especially with large models and many packages. - Now available also for Linux and Macintosh platforms. - Support for when-equations in algorithm sections, including elsewhen. - Support for inner/outer prefixes of components (but without type error checking). - Improved solution of nonlinear systems. - Added ability to compile generated simulation code using Visual Studio compiler. - Added "smart setting of fixed attribute to false. If initial equations, OMC instead has fixed=true as default for states due to allowing overdetermined initial equation systems. - Better state select heuristics. - New function getIncidenceMatrix(ClassName) for dumping the incidence matrix. - Builtin functions String(), product(), ndims(), implemented. - Support for terminate() and assert() in equations. - In emitted flat form: protected variables are now prefixed with protected when printing flat class. - Some support for tables, using omcTableTimeIni instead of dymTableTimeIni2. - Better support for empty arrays, and support for matrix operations like a*[1,2;3,4]. - Improved val() function can now evaluate array elements and record fields, e.g. val(x[n]), val(x.y) . - Support for reinit in algorithm sections. - String support in external functions. - Double precision floating point precision now also for interpreted expressions - Better simulation error messages. - Support for der(expressions). - Support for iterator expressions such as {3*i for i in 1..10}. - More test cases in the test suite. - A number of bug fixes, including sample and event handling bugs.

### OpenModelica Notebook (OMNotebook)

A number of improvements, primarily in the platform availability.

- Available on the Linux and Macintosh platforms, in addition to Windows. - Fixed cell copying bugs, plotting of derivatives now works, etc.

### OpenModelica Shell (OMShell)

Now available also on the Macintosh platform.

### OpenModelica Eclipse Plug-in (MDT)

This release includes major improvements of MDT and the associated MetaModelica debugger:

- Greatly improved browsing and code completion works both for standard Modelica and for MetaModelica. - Hovering over identifiers displays type information. - A new and greatly improved implementation of the debugger for MetaModelica algorithmic code, operational in Eclipse. Greatly improved performance - only approx 10% speed reduction even for 100 000 line programs. Greatly improved single stepping, step over, data structure browsing, etc. - Many bug fixes.

### OpenModelica Development Environment (OMDev)

Increased compilation speed for MetaModelica. Better if-expression support in MetaModelica.

## 42.56.22 OpenModelica 1.4.2, October 2006

This release has improvements and bug fixes of the OMC compiler, OMNotebook, the MDT plugin and the OMDev. OMShell is the same as previously.

### OpenModelica Compiler (OMC)

This release includes further improvements of the OpenModelica Compiler (OMC):

- Improved initialization and index reduction. - Support for integer arrays is now largely implemented. - The val(variable,time) scripting function for accessing the value of a simulation result variable at a certain point in the simulated time. - Interactive evalution of for-loops, while-loops, if-statements, if-expressions,

in the interactive scripting mode. - Improved documentation and examples of calling the Model Query and Manipulation API. - Many bug fixes.

#### OpenModelica Notebook (OMNotebook)

Search and replace functions have been added. The DrModelica tutorial (all files) has been updated, obsolete sections removed, and models which are not supported by the current implementation marked clearly. Automatic recognition of the .onb suffix (e.g. when double-clicking) in Windows makes it even more convenient to use.

#### OpenModelica Eclipse Plug-in (MDT)

Two major improvements are added in this release:

- Browsing and code completion works both for standard Modelica and for MetaModelica. - The debugger for algorithmic code is now available and operational in Eclipse for debugging of MetaModelica programs.

### 42.56.23 OpenModelica 1.4.1, June 2006

This release has only improvements and bug fixes of the OMC compiler, the MDT plugin and the OMDev components. The OMShell and OMNotebook are the same.

#### OpenModelica Compiler (OMC)

This release includes further improvements of the OpenModelica Compiler (OMC):

- Support for external objects. - OMC now reports the version number (via command line switches or CORBA API getVersion()). - Implemented caching for faster instantiation of large models. - Many bug fixes.

#### OpenModelica Eclipse Plug-in (MDT)

Improvements of the error reporting when building the OMC compiler. The errors are now added to the problems view. The latest MDT release is version 0.6.6 (2006-06-06).

#### OpenModelica Development Environment (OMDev)

Small fixes in the MetaModelica compiler. MetaModelica Users Guide is now part of the OMDev release. The latest OMDev was release in 2006-06-06.

### 42.56.24 OpenModelica 1.4.0, May 2006

This release has a number of improvements described below. The most significant change is probably that OMC has now been translated to an extended subset of Modelica (MetaModelica), and that all development of the compiler is now done in this version..

#### OpenModelica Compiler (OMC)

This release includes further improvements of the OpenModelica Compiler (OMC):

- Partial support for mixed system of equations. - New initialization routine, based on optimization (minimizing residuals of initial equations). - Symbolic simplification of builtin operators for vectors and matrices. - Improved code generation in simulation code to support e.g. Modelica functions. - Support for classes extending basic types, e.g. connectors (support for MSL 2.2 block connectors). - Support for parametric plotting via the plotParametric command. - Many bug fixes.

#### OpenModelica Shell (OMShell)

Essentially the same OMShell as in 1.3.1. One difference is that now all error messages are sent to the command window instead of to a separate log window.

#### OpenModelica Notebook (OMNotebook)

Many significant improvements and bug fixes. This version supports graphic plots within the cells in the notebook. Improved cell handling and Modelica code syntax highlighting. Command completion of the most common OMC commands is now supported. The notebook has been used in several courses.

#### OpenModelica Eclipse Plug-in (MDT)

This is the first really useful version of MDT. Full browsing of Modelica code, e.g. the MSL 2.2, is now supported. (MetaModelica browsing is not yet fully supported). Full support for automatic indentation of Modelica code, including the MetaModelica extensions. Many bug fixes. The Eclipse plug-in is now in use for OpenModelica development at PELAB and MathCore Engineering AB since approximately one month.

#### OpenModelica Development Environment (OMDev)

The following mechanisms have been put in place to support OpenModelica development.

- A separate web page for OMDev (OpenModelica Development Environment).
- A pre-packaged OMDev zip-file with precompiled binaries for development under Windows using the mingw Gnu compiler from the Eclipse MDT plug-in. (Development is also possible using Visual Studio). - All source code of the OpenModelica compiler has recently been translated to an extended subset of Modelica, currently called MetaModelica. The current size of OMC is approximately 100 000 lines All development is now done in this version. - A new tutorial and users guide for development in MetaModelica. - Successful builds and tests of OMC under Linux and Solaris.

### 42.56.25 OpenModelica 1.3.1, November 2005

This release has several important highlights.

This is also the *first* release for which the New BSD (Berkeley) open-source license applies to the source code, including the whole compiler and run-time system. This makes is possible to use OpenModelica for both academic and commercial purposes without restrictions.

#### OpenModelica Compiler (OMC)

This release includes a significantly improved OpenModelica Compiler (OMC):

- Support for hybrid and discrete-event simulation (if-equations, if-expressions, when-equations; not yet if-statements and when-statements). - Parsing of full Modelica 2.2 - Improved support for external functions. - Vectorization of function arguments; each-modifiers, better implementation of replaceable, better handling of structural parameters, better support for vector and array operations, and many other improvements. - Flattening of the Modelica Block library version 1.5 (except a few models), and simulation of most of these. - Automatic index reduction (present also in previous release). - Updated User's Guide including examples of hybrid simulation and external functions.

#### OpenModelica Shell (OMShell)

An improved window-based interactive command shell, now including command completion and better editing and font size support.

#### OpenModelica Notebook (OMNotebook)

A free implementation of an OpenModelica notebook (OMNotebook), for electronic books with course material, including the DrModelica interactive course material. It is possible to simulate and plot from this notebook.

#### OpenModelica Eclipse Plug-in (MDT)

An early alpha version of the first Eclipse plug-in (called MDT for Modelica Development Tooling) for Modelica Development. This version gives compilation support and partial support for browsing Modelica package hierarchies and classes.

### OpenModelica Development Environment (OMDev)

The following mechanisms have been put in place to support OpenModelica development.

- Bugzilla support for OpenModelica bug tracking, accessible to anybody.
- A system for automatic regression testing of the compiler and simulator, (+ other system parts) usually run at check in time. - Version handling is done using SVN, which is better than the previously used CVS system. For example, name change of modules is now possible within the version handling system.

CHAPTER

# FORTYTHREE

# CONTRIBUTORS TO OPENMODELICA

This Appendix lists the individuals who have made significant contributions to OpenModelica, in the form of software development, design, documentation, project leadership, tutorial material, promotion, etc. The individuals are listed for each year, from 1998 to the current year: the project leader and main author/editor of this document followed by main contributors followed by contributors in alphabetical order.

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# INDEX

## O


OMEdit, 208
OMSimulator, 151
    Command Line Interface Examples, 172
    Examples, 154
    Flags, 151
OMSimulatorGui, 218
    Creating and Opening Models, 221
    Diagram Canvas, 223
    Element Properties, 225
    Launching, 221
    Main Window, 221
    Options, 233
    Parameter Files, 225
    pip, 218
    Requirements, 218
    Resources, 229
    Simulate, 233
    Simulation Settings, 229
    System Tree, 222
    Variants, 229
OMSimulatorLib, 159
OMSimulatorPython3, 171
    Command Line Interface, 172
    Parameter Calibration, 173
OpenModelicaScripting, 199
    Examples, 199
    Scripting Commands, 200