Technical Overview of OpenModelica and its Development Environment

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2016-02-01

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www.OpenModelica.org
OpenModelica
- What is OpenModelica?
- The past

OpenModelica Technical Overview
- OMC, OMSHell, OMNotebook,
- OMEdit, ModelicaML

OpenModelica Development Environment
- MetaModelica (RML/OMC)
- The Eclipse Environment (MDT)

OpenModelica Latest Developments (2015-2016)
OpenModelica is ... its developers, testers, bug reporters, contributors

Thank you!

asodja, sjoelund.se, sebco011, lochel, wbraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levsa, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florox, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka, krsta, edgarlopez, hanke, henjo, wuzhu.chen, fbergero, harka011, tmtuomas, bjozac, AlexeyLebedev, x06klaj, ankar, kajny, vasaie_p, niemisto, donida, hkiel, davbr, otto@mathcore.com, Kaie Kubjas, x06krino, afshe, x06mikbl, leonardo.laguna, petfr, dhedberg, g-karbe, x06henma, abhinnk, azazi, x02danhe, rruusu, x98petro, mater, g-bjosa, x02kajny, g-pavgr, x05andre, vaden, jansilar, ericmeyers, x05simel, anda, leist, choeger, Ariel.Liebman, frisk, vaurich, mwalther, mtiller, ptauber, casella, vitalij, hkiel, janK, adrpo, rfranke, mflehmig
What is OpenModelica? (I)

- Advanced Interactive Modelica compiler (OMC)
  - Supports MSL v. 3.2.1/3.2.2/MSL trunk
- Basic and advanced environments for creating models
  - OMShell - an interactive command handler
  - OMNotebook - a literate programming notebook
  - OMEdit - OpenModelica Connection Editor
  - OMPlot - OpenModelica Plotting
  - OMOptim - OpenModelica Optimization Editor
  - OMPython - OpenModelica Python Environment
  - MDT - an advanced textual environment in Eclipse
What Is OpenModelica? (II)

- Advanced Eclipse-based Development Environment
- Modelica Development Tooling (MDT) - started in 2005
  - Code Assistance, Debugging, Outline & a lot more
  - Used heavily for OpenModelica development
  - Used in many OpenModelica Development Courses
- ModelicaML UML/SysML integration
What is OpenModelica? (III)

- Open-source community services
  - Website and Support Forum
  - Source versioning (github.com)
  - Trac with bug database
  - Development courses
  - Mailing lists
What is OpenModelica? (IV)

- Open-source community services
  - Extensive testing (unit & library coverage: MSL 3.2.1, ModelicaTest 3.2.1, PetriNet, Buildings, PowerSystems, OpenHydraulics, ThermoPower, and ThermoSysPro) with interactive result comparison
  - ~2800 tests ran on each commit via Hudson (4 test servers currently)
    - Linux (GCC & CLANG), Windows (MinGW GCC), Mac OS (GCC)
    - Automatic nightly builds for Window & Linux & Mac OS
What is OpenModelica? (V)

- An incubator platform for research
  - 9 PhDs since 2004 (Debugging, Parallelization, PDEs Extensions)
  - 36 Master’s theses since 2004
  - Both the students and the project benefit

- Master theses at PELAB 2006-2016
  - Refactoring/Parsing and Language extensions
  - UML/SysML view of Modelica code
  - 2D and 3D visualization tools
  - Static and runtime debugging tools
  - Advanced code generation and parallelization of simulation code
  - Bootstrapping and Java Interface
  - Function pointers
  - NVIDIA for Cuda and OpenCL parallel simulation
  - OMEdit - Modelica Connection Editor
  - OMWeb - server based Modelica simulation for teaching
  - OMCcc parser
  - PDE-solver using ParModelica

- External Master theses
  - Model based diagnostics at ISY (Dep. Of Electrical Engineering)
  - Monte-Carlo simulation of Satellite Separation Systems at SAAB
  - Interactive Simulations (EADS)
  - Additional Solvers + Event handling (FH-Bielefeld)
  - EADS - ModelicaML

- A Base for commercial and open source products
  - MathCore AB, Bosch Rexroth, InterCAX (MagicDraw SysML), VTT, Equa, Evonik, ABB
1997 - started as a master thesis
2003 - first usable internal version
2004 - first external version: OpenModelica 1.1
2005 - more development: OpenModelica 1.3.1

2006 - major milestone
- Translated the whole compiler to MetaModelica
- Integrated Development Environment for the compiler
- OpenModelica website started
- Moved the code repository to Subversion management
- Extended the OpenModelica environment with new tools
- 4 versions released during the year
- External people start using OpenModelica
  - ~ 200 downloads/month
  - first development course at INRIA
2007 - continued development and community involvement

- Improvement in website, support and documentation
- Answered ~1000 questions on the forum
- Portability is highly improved, ported to 4 platforms
  - Linux, Mac, Solaris, Windows (version 1.4.3)
- Improvement of the compiler development tools in Eclipse
- OpenModelica Community starts to react
  - contribute code & report bugs & request enhancements & participate in answering questions in the OpenModelica forum
  - participate at courses and workshops
- New server acquired for better community services
- Increased usage: ~600 downloads/month
- Open Modelica Consortium created in December 4
  - 4 months of work
  - 9 organizations as members already (3 Universities, 6 Companies)
  - discussions are ongoing with other 6 companies
2008 - Further work on the compiler

- Release 1.4.4 and 1.4.5
  - Linux, Mac, Solaris, Windows
- New Solver Interface
- Refactoring
- Dynamic loading of functions
- Merging of MathCore front-end code
- 744 commits in Subversion
- Other things I don’t remember
2009

- Work mainly happened in OSMC (partially on a non-public branch)
- Front-end
  - Refactoring (OSMC)
  - Enumerations (OSMC)
  - Java Interface and Bootstrapping (Martin Sjölund)
  - MultiBody flattening (OSMC)
  - Constraint connection graph breaking (VTT + OSMC)
  - Support for Modelica 3.x and 3.x annotations (OSMC)
- Back-end
  - Tearing in the back-end (Jens Frenkel)
  - Template Code Generation and CSharp backend (Pavol Privitzer, Charles University Prague)
  - Interactive Simulations (EADS)
  - C++ Code generation (Bosch Rexroth)
  - Java Interface and Bootstrapping (Martin Sjölund)
  - Additional Solvers + Events (Willi Braun, FH-Bielefeld)
- General
  - New ModelicaML + SysML prototype (EADS)
  - 1144 commits in subversion (Since 2009 to February 8, 2010)
  - Bug fixes (OSMC)
  - Release 1.5.0 and 1.5.0-RC_X (Linux, Mac, Solaris, Windows)
- More things I don’t remember
2010 - 2011

- Support for Modelica Standard Library 3.1 (Media & Fluid in works)

**Front-end**
- MultiBody flattening (OSMC)
- Support for Modelica 3.x and 3.x annotations (OSMC)
- Performance Enhancements
- Stream connectors
- Media & Fluid work is on the way

**Back-end**
- Back-end redesign (Jens, Willi, Martin, Per, Adrian, Kristian, Filippo)
- Tearing in the back-end (Jens Frenkel)
- Template Code Generation and CSharp backend (Pavol Privitzer, Charles University Prague)
- Interactive Simulations (EADS)
- C++ Code generation (Bosch Rexroth)
- Additional Solvers + Events + Linearization (Willi Braun, FH-Bielefeld)

**General**
- OMEdit - new connection editor
- Bootstrapping OMC (90% finished)
- 2550 commits in subversion from 2010 to Feb. 7, 2011 (double than 2009-2010)
- Bug fixes ~300+ (OSMC)
- Release 1.6.0 (Linux, Mac, Windows)
- Downloads Windows (~16434), Linux (~8301), Mac (~2816)

- More things I don’t remember
OpenModelica Roadmap - Past

2012 - 2013

- Support for Modelica Standard Library 3.2.1 including Media & Fluid

- Front-end
  - Performance Enhancements
  - Media & Fluid work
  - Operator overloading
  - New instantiation module started

- Back-end
  - Modular back-end with more optimization modules (Jens, Willi, Martin)
  - New simulation runtime redesign (Willi, Lennart, Jens, Martin, Adrian)
  - C++ Code generation (Bosch Rexroth)
  - FMI export & import
  - Initialization, Jacobians (Lennart Lochel, Willi Braun, FH-Bielefeld)
  - Support for parallelization (Martin)
  - Parallel extensions in functions

- General
  - Uncertainties support (OpenTURNS connection & Data reconciliation)
  - MDT GDB debugging based on GDB and the bootstrapped compiler
  - OMEdit - improvements
  - Bootstrapping OMC (100% finished) using Boehm GC
  - 3909 commits in subversion from 2012 to Feb. 4, 2013
  - 2000 forum posts (questions and answers)
  - Bug fixes ~247+ (OSMC)
  - Release 1.9.0 (Linux, Mac, Windows)
  - Downloads Windows (~45307), Linux (~15543), Mac (~5367)

- More things I don’t remember
2014 - 2015 - Most focus on libraries support & performance
- MSL 3.2.1 (100% build/98% simulate), ModelicaTest 3.2.1, PetriNet, Buildings, PowerSystems, OpenHydraulics, ThermoPower, and ThermoSysPro
- Switch to bootstrapped compiler

Front-end, Back-end, Simulation Runtime, Graphical Clients
- Development switched to bootstrapped compiler since November 2014
- Partially new graph-based front-end with better support for libraries
- Improved back-end: initialization, system solving, parallelization, cse optimization, dynamic optimization
- Faster and much more user friendly OpenModelica Connection editor

General
- 4960 commits in subversion from Feb. 2014 to Feb., 2015
- Bug fixes
- Release 1.9.2 (Linux, Mac, Windows)
OpenModelica Testing (I)

- 2016-02-01 g675b7d6 - total 278 - build 278 (100%) - sim 271 (98%)

MSL_3.2.1 Coverage
OpenModelica Testing (II)

- 2016-02-01 g675b7d6 - total 440 - build 434 (99%) - sim 422 (96%)

ModelicaTest_3.2.1 Coverage

Legend:
- Target: 440
- Compile: 434
- Simulate: 422
- Verified: 0

Date 2012-10-20 - 2016-01-26
OpenModelica Statistics (I)

- Moved the source code to github May 2015
- Mature code base: https://github.com/OpenModelica
- ~8000K lines of code and tests

- From Feb 2015 - Feb 2016
  - 55 contributors - up by 17 contributors (44%)
  - 5745 commits - up by 1631 commits (40%)
OpenModelica Statistics (II)

Feb 7, 2015 – Feb 1, 2016
Contributions to master, excluding merge commits

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<thead>
<tr>
<th>Contributors</th>
<th>Commits</th>
<th>Additions</th>
<th>Improvements</th>
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<tr>
<td>sjoelund</td>
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<td>lochel</td>
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<td>rfranke</td>
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<td>MarcusWalther</td>
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<td>adrpo</td>
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Outline

- OpenModelica
  - What is OpenModelica?
  - The past

- OpenModelica Technical Overview
  - OMC, OMSheell, OMNotebook,
  - OMEdit, ModelicaML, SimForge

- OpenModelica Development Environment
  - MetaModelica (RML/OMC)
  - The Eclipse Environment

- OpenModelica Latest Developments (2015-2016)
OMShell & OMNotebook

OpenModelica 1.4.3
Copyright 2002-2006, PELAB, Linkoping University

To get help on using OMShell and OpenModelica, type "help()" and press enter.

```om
>> loadModel(Modelica)
true

>> loadFile("C:/OpenModelica1.4.3/testmodels/BouncingBall.mo")
true

>> simulate(BouncingBall, stopTime=3)
record
    resultfile = "BouncingBall_res.plt"
end record

>> plot(h)
true
```

DrModelica

Van der Pol Model

This example describes a Van der Pol oscillator. Notice that here the keyword model is used instead of class with the same meaning. This example contains declarations of two state variables \(x\) and \(y\), both of type Real and a parameter constant \(\lambda\), which is a so-called simulation parameter. The keyword parameter specifies that the variable is constant during a simulation run, but can have its value initialized before a run, or between runs. Finally, there is an equation section starting with the keyword equation, containing two mutually dependent equations that definitely define the dynamics of the model.

```
model VanDerPol
  "Van der Pol oscillator model"
  Real xstart = 1;
  Real ystart = 1;
  parameter Real lambda = 0.3;
  equation
    der(x) = y;
    der(y) = -x + lambda*(1 - x^2)*y;
  end VanDerPol;
```

1 Simulation of Van der Pol

To illustrate the behavior of the model, we give a command to simulate the Van der Pol oscillator during 25 seconds starting at time 0.

```om
simulate(VanDerPol, startime=0, stopTime=25);
```

Perform a parametric plot:

```om
plotParametric( x, y );
```
OMEdit - OpenModelica Connection Editor
- Implemented mainly in MetaModelica and C/C++
- The compiler has 258 packages
// Parse the file and get an AST back
ast = Parse.parse(modelicaFile);

// Translate to simplified C code
scode = SCode.absyn2SCode(ast);

// flatten the simplified code
(cache, dae1) = Inst.instantiate(Env.emptyCache, scode);

// Call the function that optimizes the DAE
optimizeDae(scode, ast, dae, dae, lastClassName);
- OpenModelica
  - What is OpenModelica?
  - The past and present

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  - MetaModelica
  - The Eclipse Environment

- OpenModelica Latest Developments (2015-2016)
- **OMC**
  - Implemented mainly in MetaModelica and C/C++

- **Modelica**
  - classes, models, records, functions, packages
  - behavior is defined by equations or/and functions
  - equations
    - differential algebraic equations and conditional equations

- **MetaModelica extensions**
  - local equations
  - pattern equations
  - match expressions
  - high-level data structures: lists, tuples, option and union types
OpenModelica Context

Server: Main Program
Including Compiler, Interpreter, etc.

Client: Eclipse
Plugin
Corba
Client: OMShell
Interactive Session Handler
Server: Main Program
Including Compiler, Interpreter, etc.

Untyped API
Typed Checked Command API

Client: Eclipse
Plugin

Corba

Client: Graphic
Model Editor

SCode

Interactive

Inst

Ceval

plot

system
The MDT Eclipse Environment (I)
The MDT Eclipse Environment (II)

- .mo file
- OMC Compiler
- Small Modelica Parser
- AST Information
- Modelica model
  - Modelica Browser
  - Modelica Editor
  - Modelica Code Assistant

Eclipse

- OMC Compiler Bootstrapping
- Code compiled with GDB symbols
- MetaModelica GDB Debugging

OMC instantation
Creating Modelica projects (I)

Creation of Modelica projects using wizards
Creating Modelica projects (II)
Creating Modelica packages using wizards
Creating Modelica classes

Creation of Modelica classes, models, etc, using wizards
Code browsing for easy navigation within Modelica files. Automatic update on file save.
Error detection (I)

Parse error detection on file save.
Error detection (II)

Semantic error detection on compilation
Code assistance (I)

Code Assistance on imports
Code assistance (II)

Code Assistance on assignments
Code assistance (III)

Code Assistance on function calls
Code Outline and Hovering Info

Identifier Info on Hovering

Code Outline for easy navigation within Modelica files
Eclipse Debugging Environment

- Type information for all variables
- Browsing of complex data structures
- GDB based
Tutorial 1 - tomorrow at ModProd 2016!
1. System Modeling with ModelicaML

2. Modelica Code Generation

3. System Simulation with Modelica Tools
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  - The Eclipse Environment

- OpenModelica Latest Developments (2015-2016)
Latest Developments (2015-2016)

- **2015 - 2016 - Most focus on libraries support & performance**
  - MSL 3.2.1 (100% build/99% simulate), ModelicaTest 3.2.1, PetriNet, Buildings, PowerSystems, OpenHydraulics, ThermoPower, and ThermoSysPro, Modelica_Synchronous
  - Switched to bootstrapped compiler
  - Moved the source code to [https://github.com/OpenModelica](https://github.com/OpenModelica)

- **Front-end, Back-end, Simulation Runtime, Graphical Clients**
  - Development switched to bootstrapped compiler
  - Support for synchronous language features and state machines
  - Better support for libraries in the front-end and back-end
  - Improved back-end: initialization, system solving, parallelization, cse optimization, dynamic optimization
  - Performance and scalability improvements
  - Faster and much more user friendly OpenModelica Connection Editor
  - Improved FMI support for Model Exchange and Co-Simulation

- **General**
  - Feb 2015 - Feb 2016
    - 55 contributors - up by 17 contributors (44%)
    - 5745 commits - up by 1631 commits (40%)
  - Bug fixes
  - Release 1.9.3 (Linux, Mac, Windows)
Latest Developments (2015-2016)

- Front-end issues still in works
  - support for querying the instance of a flattened model needed for OMEdit handling of model structure
  - support for choicesAllMatching annotation (subtyping relationship of models/comps) needed for OMEdit handling of replaceable components/models
  - scalability & performance basically do things once and not several times separate lookup, modifier application, typing, array expansion, equation & connection handling, etc.

- General
  - 64 bit Windows versions
Thank You!
Questions?

asodja, sjoelund.se, sebco011, lochel, wbraun, nklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, leva, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florosx, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka, krsta, edgarlopez, hanke, henjo, wuzhu.chen, fbergero, harka011, tmttuomas, bjozac, AlexeyLebedev, x06klasj, ankar, kajny, vasaie_p, niemisto, donida, hkiel, davbr, otto@mathcore.com, Kaie Kubjas, x06krino, afshe, x06mikbl, leonardo.laguna, petfr, dhedberg, g-karbe, x06henma, abhinnk, azazi, x02danhe, rruusu, x98petro, mater, g-bjosa, x02kajny, g-pavgr, x05andre, vaden, jansilar, ericmeyers, x05simel, andsa, leist, choeger, Ariel.Liebman, frisk, vaurich, mwalther, mtiller, ptauber, casella, vitalij, hkiel, jank, adrpo, rfranke, mflehmig

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