Technical Overview of OpenModelica and its Development Environment

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

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

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

What is OpenModelica? (0)

OpenModelica is ... its developers, testers, bug reporters, contributors

Thank you!

asodja, sjoelund.se, sebco011, lochel, wbtraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levs, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florosx, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka, krsta, edgarlopez, hanke, henjo, wuzhu.chen, fbergero, harka011, tmtuomas, bjozac, AlexeyLebedev, x06klasj, ankar, kajny, vasaipe, niemisto, donida, hkiel, darbr, otto@mathcore.com, Kaie Kubjas, x06krino, af3he, x06mikbl, leonardolaguna, 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, adrepo

Developers (96)

Martin
Per
Adeel
Jens
Willi
Lennart
Alexey
Mahder
Olena
Mohsen
Kristian
Hubert
Niklas
Kaie
Kiel
Peter *
Leonardo
Filippo
Xenofon
Frederico
Edgar
Kaj
Levon
Stefan
Rickard
Bjorn
David
Otto
Eric
...
Adrian
What is OpenModelica? (I)

- Advanced Interactive Modelica compiler (OMC)
  - Supports MLS v. 3.1/MSL v. 3.2.1/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
  - Version-controlled source base
  - 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
  - 7 PhDs since 2004 (Debugging, Parallelization, PDEs Extensions)
  - 32 Master’s theses since 2004
  - Both the students and the project benefit

- Master theses at PELAB 2006-2014
  - 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

- 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
OpenModelica Roadmap - Past

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
OpenModelica Roadmap - Past

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
OpenModelica Roadmap - Past

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**
  - OMEEdit - 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
OpenModelica Testing (I)

- 2015-02-02 r24359 - total 278 - build 278 (100%) - sim 268 (97%)
- 2015-02-02 r24359 - total 440 - build 432 (99%) - sim 416 (95%)

ModelicaTest_3.2.1 Coverage

Legend
- Target: 440
- Compile: 432
- Simulate: 416

Date 2012-10-20 - 2015-02-01
- ~ 7000K lines of code and tests
Outline

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  - What is OpenModelica?
  - The past

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  - The Eclipse Environment

OMShell & OMNotebook

Demo?

```
OpenModelica 1.4.3
Copyright 2002-2006, PELAB, Linkoping University

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

>> loadModel(Modelica)
true

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

>> simulate(BouncingBall, stopTime=3)
record
  resultFile = "BouncingBall_res.png"
end record

>> plot(h)
true

>>
```
The OMC Compiler

- 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);
Outline

- OpenModelica
  - What is OpenModelica?
  - The past and present

- OpenModelica Technical Overview
  - OMC, OMSHell, OMNotebook
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- OpenModelica Development Environment
  - MetaModelica
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- **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 uniontypes
The MDT Eclipse Environment (I)

### Eclipse Platform

- **Workbench IDE UI**
- **Team**
- **Compare/Search**
- **Workspace/Resources**
- **Workbench Text Editor**
- **Update**
- **Forms**
- **Outline/Property Views**
- **Workbench UI (Editors, Views, Perspectives)**
- **Help**
- **JFace Text**
- **JFace**
- **SWT**
- **Platform Runtime (based on OSGi)**

### Features

- **Modelica Browser**
- **Modelica Editor**
- **Modelica Code Assistant**
- **MetaModelica Debugging**
- **Modelica Perspective**
The MDT Eclipse Environment (III)

- .mo file
- OMC
- Bootstrapped Compiler
- Executable + GDB
- MetaModelica
- GDB Debugging
- Modelica Editor
- Eclipse
Creating Modelica projects (I)

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

Creation of Modelica packages using wizards
Creating Modelica classes

Creation of Modelica classes, models, etc, using wizards
Error detection (I)

Parse error detection on file save

```modelica
model VanDerPol "Van der Pol oscillator model"
  Real x(start = 1);
  Real y(start = 1);
  parameter Real lambda = 0.3;
  parameter Real e = Modelica.Constants.e;
  equation
    der(x) = y;
    der(y) = -x + lambda*(1 - x*x)*y;
  end VanDerPol;
```
Error detection (II)

Semantic error detection on compilation
Code Assistance on imports
Code assistance (II)

Code Assistance on assignments
Code Assistance on function calls
Code indentation

// Van der Pol model

model VanDerPol "Van der Pol oscillator model"

import Modelica.Math;

Real x(start = 1);
Real y(start = 1);
parameter Real lambda = 0.3;
parameter Real e = Modelica.Constants.e;

equation

der(x) = y;
der(y) = - x + lambda*(1 - x*x)*y;
end VanDerPol;
Code Outline and Hovering Info

- Code Outline for easy navigation within Modelica files
- Identifier Info on Hovering
Eclipse Debugging Environment

- Type information for all variables
- Browsing of complex data structures
- GDB based
Tutorial 5 - tomorrow at ModProd 2015!
Eclipse environment for ModelicaML

1. System Modeling with ModelicaML

2. Modelica Code Generation

3. System Simulation with Modelica Tools
OpenModelica
- What is OpenModelica?
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- OMC, OMShell, OMNotebook

OpenModelica Development Environment
- MetaModelica
- The Eclipse Environment

2014 - 2015 - Most focus on libraries support & performance
- MSL 3.2.1 (100% build/97% 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)

- **Front-end issues fixed since Feb 2014**
  - support for calling function via instance (MultiBody, VehicleDynamics, PowerTrain)
    
    ```
    world.gravityAcceleration(...)
    ```
  - handle same type with different redeclares (Media & Fluid)
    
    ```
    T x1(redeclare function f = f1)
    T x2(redeclare function f = f2)
    ```
  - better support for package constants (ExternalMedia, Media & Fluid)
  - fix remaining redeclare issues (Media.Examples.R134*)

- **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, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levs, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florosx, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka, krsta, edgarlopez, hanke, henjo, wuzhu.chen, fbergero, harka011, tmtuomas, 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-bjoza, x02kajny, g-pavgr, x05andre, vaden, jansilar, ericmeyers, x05simel, andsa, leist, choeger, Ariel.Liebman, frisk, vaurich, mwalther, mtiller, ptauber, casella, vitalij, hkiel, jank, adrpo

OpenModelica Project
http://www.OpenModelica.org
Funny Facts

- 2012 (left) vs. 2015 (right)