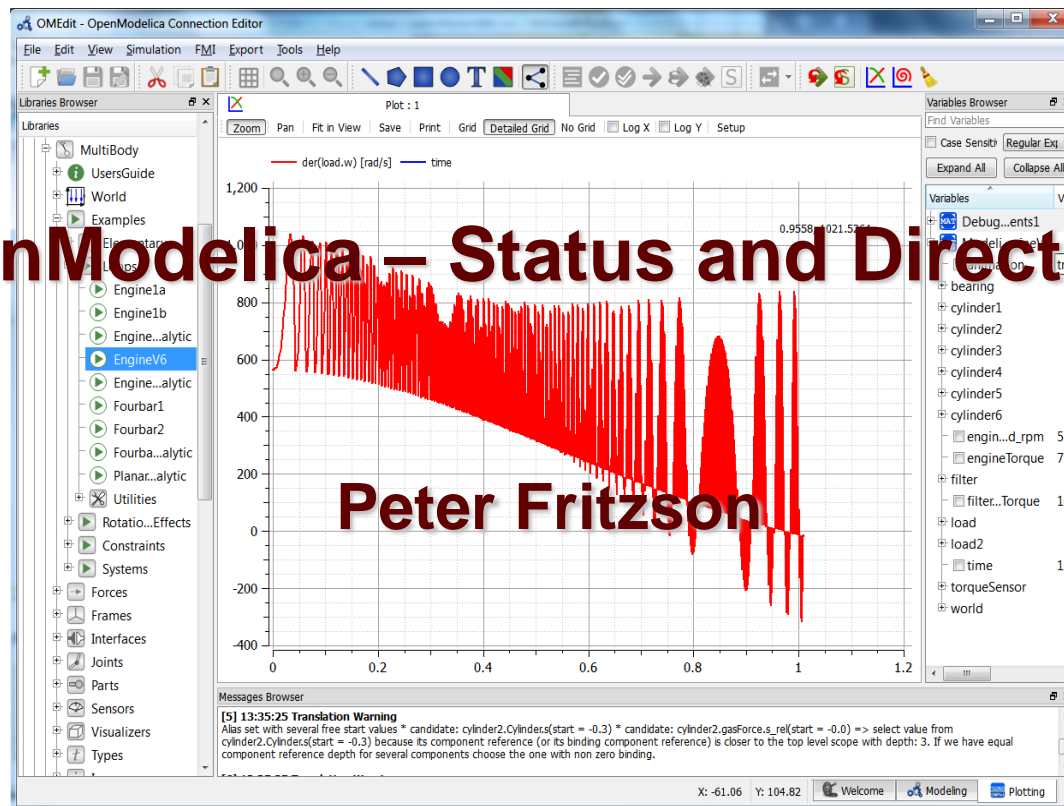


12th Annual OpenModelica Workshop

Feb 3, 2020

OpenModelica – Status and Directions



Peter Fritzson

Goals for the OpenModelica Effort

- Comprehensive **modeling, simulation and systems engineering** environment for research, teaching, and industrial usage
- **Open-source** for both **industrial** and **academic** usage
- Invitation for **open-source cooperation** around OpenModelica, tools, and applications
- **Increased** emphasis on **industrial** usage

Changed OSMC Administrative procedures 2019

- OSMC has got **its own bank account**
 - (previously used SICS East, but SICS East has become part of RISE, a large bureaucratic organization)
- OSMC **sends invoices itself** to members instead of SICS East or RISE
- More **direct control** of OSMC money
- OSMC can directly employ people if needed (only small scale)

Updated OSMC Release Strategy

- **Date based** releases instead of feature-based
- Goal: At least **two main releases per year** (before OSMC Annual, and before or after summer).
- 3 kinds: Official release, Stable development, nightly build

Official Release

1.14.1
(32bit/64bit)

- contains only validated new features
- intended for productive usage

Stable Development

1.15.0-dev
(32bit/64bit)

- dev.xx versions are released during development when the performance is sufficiently stable; they contain bug fixes and some new features that still need to be validated
- dev.betaxx versions are released in preparation to official releases for testing; no new features are added to beta versions, only bug fixes

Nightly Build

1.16.0-dev
(32bit/64bit)

- built daily with the latest additions to the code base that passed the standard regression tests
- intended to make the latest developments and enhancements available for testers and developers, not for productive usage
- features that are not subject to regression testing may get broken between one nightly build and the next

Proposed OpenModelica Library Support Strategy

- Proposed 4 classes of libraries
- Good libraries, **fully supported**, coverage reported.
- Good libraries, **partially supported** (reported separately)
- **Experimental** or with low maintenance (also reported separately)
- **Obsolete** libraries

Main Releases 2019 and February 2020

- OpenModelica **1.14.0 final release** (Dec 6, 2019), **1.14.1** (Dec 31)
 - **First release with production version of New Frontend (now default)**
 - The New Frontend is now much more complete
 - New Frontend also supports array modifiers (for non-expanded arrays)
 - **Complete Matlab scripting** API to OpenModelica
 - **Enhanced OMEdit** – including, but not limited to:
 - auto-completion of names, copy-paste and duplication of models
 - connectorSizing annotation, drag and drop from text layer, and much more
 - A new **more efficient** and correct implementation of **arrays and records**
 - Enhanced **DAEMode** more suitable for industrial applications
 - More **efficient Jacobian** evaluation suitable for large-scale simulation
 - New **Minimal Tearing** method suitable for large-scale simulation
 - New experimental FMI-based **OpenModelicaSimulationInterface** (OMSI)
 - FMI OMSimulator API calls also available in OMC API
 - Encryption being deployed for commercial library
- OpenModelica **1.15.0, beta1 release** (February, 2020)
 - OMEdit GUI functionality for replaceable

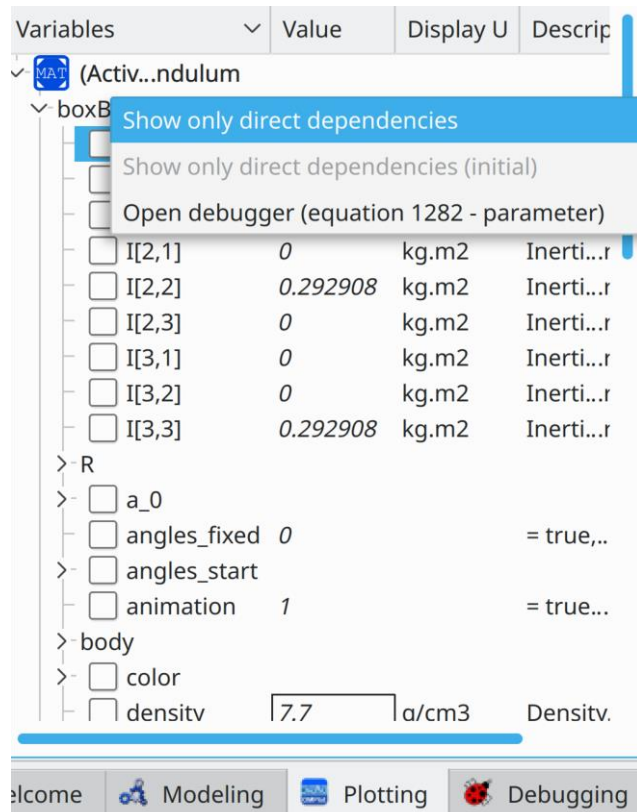
New Frontend and OMEdit Replaceable Support

- The OpenModelica **new compiler frontend (NF)** – a **large** effort to rewrite about half of the compiler to gain high compilation **performance** and 100% Modelica semantics
- Effort was much bigger than initially estimated
- The New frontend is about **10 to 100 times faster** than the old one
- Status **January 2019**, OMC with newfrontend simulates more than 95% of MSL

- Status **December 2019**, **More complete NF** in 1.14.1 release
Even more complete NF with **array modifiers** in 1.16.0 trunk
 - 100% of MSL 3.2.3 pass code generation with NF
 - 96.7% of MSL 3.2.3 verified simulation
- Status **February 2020**: **NF** with **replaceable** GUI in 1.15.0 Beta

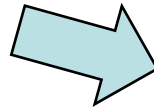
Enhanced OM Debugger that can trace (and plot) which variables and equations influence a variable

New menu choice to show direct dependencies

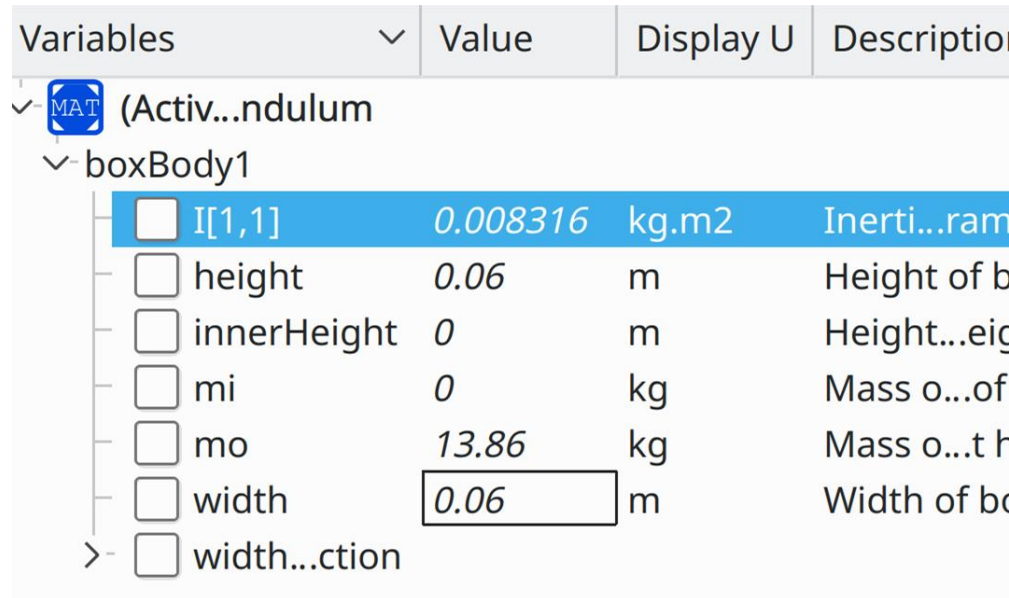


The screenshot shows the OM Debugger interface with a tree view of variables. A context menu is open over the 'boxBody1' variable, highlighting the option 'Show only direct dependencies'. The table below shows the variables and their values.

Variables	Value	Display U	Descript
<input checked="" type="checkbox"/> (Activ...ndulum)			
<input checked="" type="checkbox"/> boxB			
<input type="checkbox"/> I[2,1]	0	kg.m2	Inerti...r
<input type="checkbox"/> I[2,2]	0.292908	kg.m2	Inerti...r
<input type="checkbox"/> I[2,3]	0	kg.m2	Inerti...r
<input type="checkbox"/> I[3,1]	0	kg.m2	Inerti...r
<input type="checkbox"/> I[3,2]	0	kg.m2	Inerti...r
<input type="checkbox"/> I[3,3]	0.292908	kg.m2	Inerti...r
> R			
> <input type="checkbox"/> a_0			
<input type="checkbox"/> angles_fixed	0	= true...	
> <input type="checkbox"/> angles_start			
<input type="checkbox"/> animation	1	= true...	
> body			
> <input type="checkbox"/> color			
<input type="checkbox"/> densitiv	7.7	a/cm3	Densitiv.



List of Variables directly influencing:

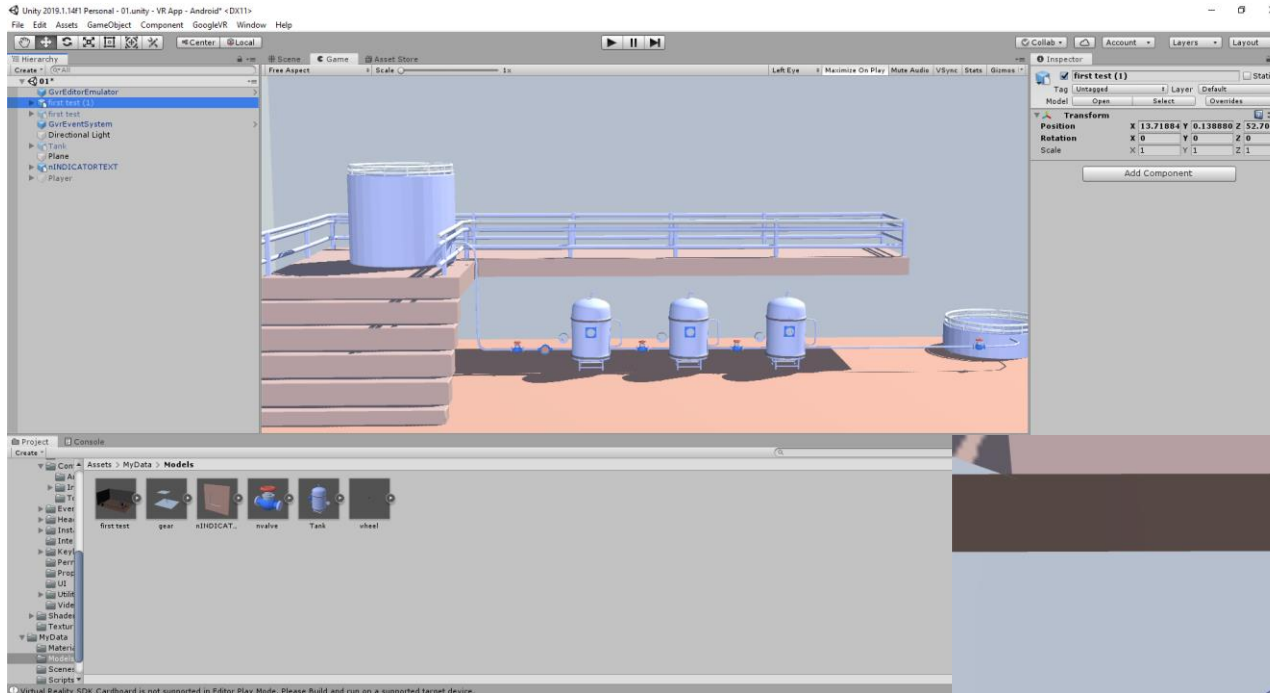


The screenshot shows the OM Debugger interface with a list of variables directly influencing the selected variable. The table below shows the variables and their values.

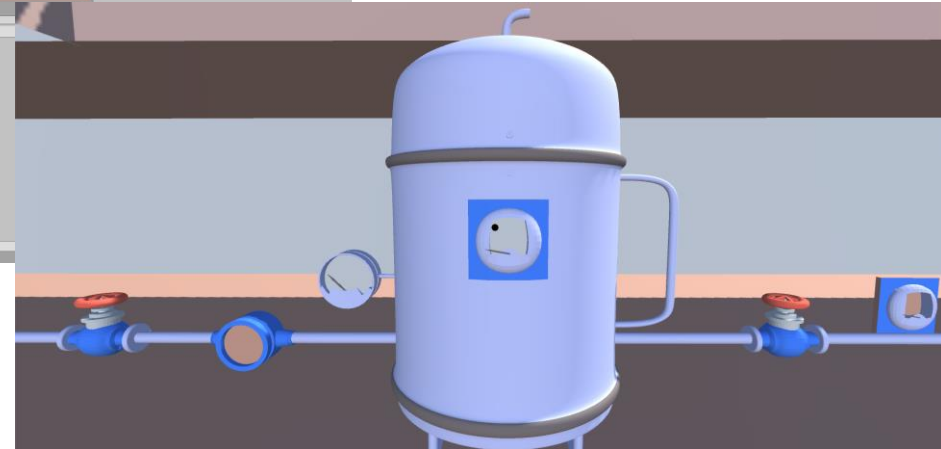
Variables	Value	Display U	Description
<input checked="" type="checkbox"/> (Activ...ndulum)			
<input checked="" type="checkbox"/> boxBody1			
<input type="checkbox"/> I[1,1]	0.008316	kg.m2	Inerti...ram
<input type="checkbox"/> height	0.06	m	Height of b
<input type="checkbox"/> innerHeight	0	m	Height...eig
<input type="checkbox"/> mi	0	kg	Mass o...of
<input type="checkbox"/> mo	13.86	kg	Mass o...t h
<input type="checkbox"/> width	0.06	m	Width of b
> <input type="checkbox"/> width...ction			

Integration with Unity 3D Visualization in VAL – Virtual Automation Lab (talk later today)

Development environment



VR Model – Unity 3D



Developed by Modelicon and BMSCE
in Bangalore, India

FMI export and Enhanced OMSimulator

(talk by Lennart later today)

- **Greatly enhanced** OMSimulator tool, further enhanced 2020
- **Simulation** environment based on **FMUs** that provide both **signal connections** and **TLM connections**
- Model exchange & Co-simulation FMUs
- **Scripting** interface (Python, Lua)
- Graphical user interface (OMEdit, Papyrus)
- Graphical **composition** of FMUs
- **Distributed** simulations utilizing TLM master
- **SSP** support for composite models, being updated to SSP 1.0 standard
- Ongoing work on **enhanced FMI Export**
- (FMI tutorial tomorrow Tuesday)

Experimental OpenModelica Compiler in Julia

Work in progress (talk later today)

- Developed a preliminary MetaModelica to Julia translator
- Translated most of the previous OM frontend
- Able to execute some translated MetaModelica functions
- Further performance tuning needed
- Also remains to attach to a numeric solver for simulation



Enhanced OpenModelica Backend, Simulation and Run-time (talks later today)

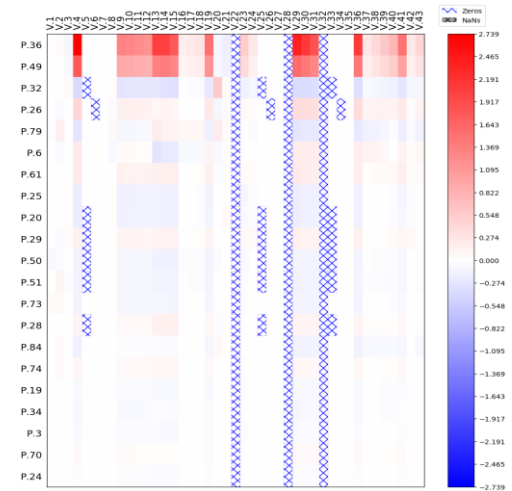
- Enhanced index reduction
- Structural singularity conversion
- Enhanced DAE mode
- New tearing method: minimal Tearing
- More efficient Jacobian evaluation
- FMI-based OpenModelicaSimulationInterface OMSI
- Improved homotopy solver
- Ongoing work on symbolic Hessians
- Ongoing work on parallelization of Jacobians

OMSens – Simultaneous Param-based Sensitivity Analysis and Robust Optimization (released in 1.16.0)

- To define a sensitivity experiment:
 - The state variable to analyze
 - The set of parameters to perturb
 - The allowed perturbation intervals for each parameter
- Main goal: pinpoint a small number of parameters that produce the largest deviations when perturbed within narrow ranges around their default values
- To select parameters and their intervals is not a trivial task
 - Responsibility relies completely on the expertise of the user
 - Enabling all parameters can lead to very costly experiments
- Use a top-N subset of parameters from a ranked list
 - obtained using individual parameter-based analysis
- Using CURVIF robust derivative-free model building method for few function evaluations
- Heat-map visualization of parameter influence

**In tutorial
February 4, 2020**

Paper at
EOOLT 2017
(prototype)

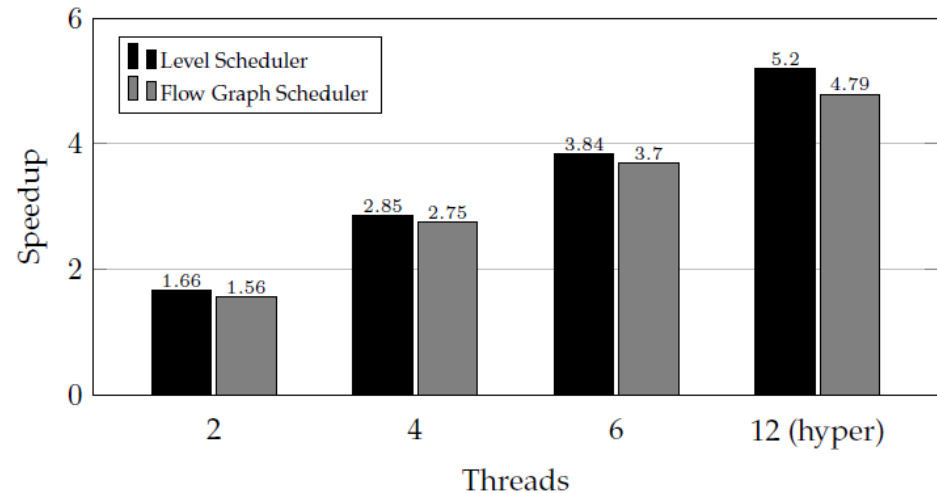


ParModAuto Parallelization (Release spring 2020)

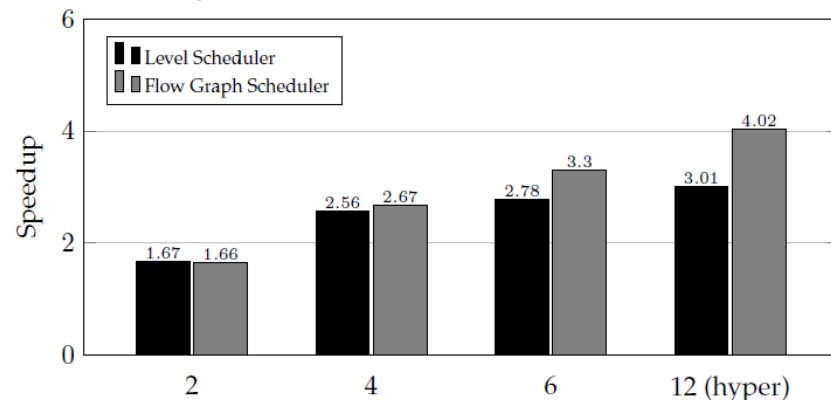
Automatic AutoTuned Parallelization of Equation-based Models

- Automatic **Parallelization**
- Automatic **clustering** of small tasks
- **Automatic load balancing** based on measurements, automatically adapts to changing load
- **Shared-memory** task parallelization
- Planned for release spring 2020

SteamPipe640 model, Speedup 5.2 on 6 cores:



BranchingDynamicPipes model, Speedup 4 on 6 cores:



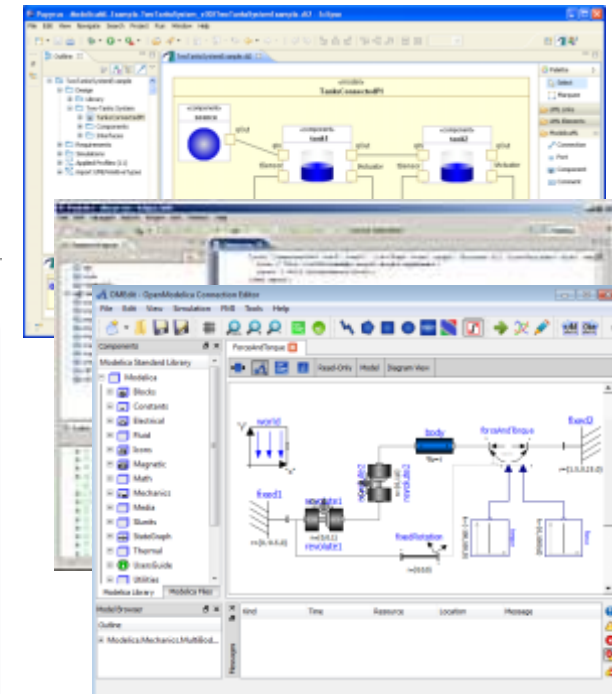
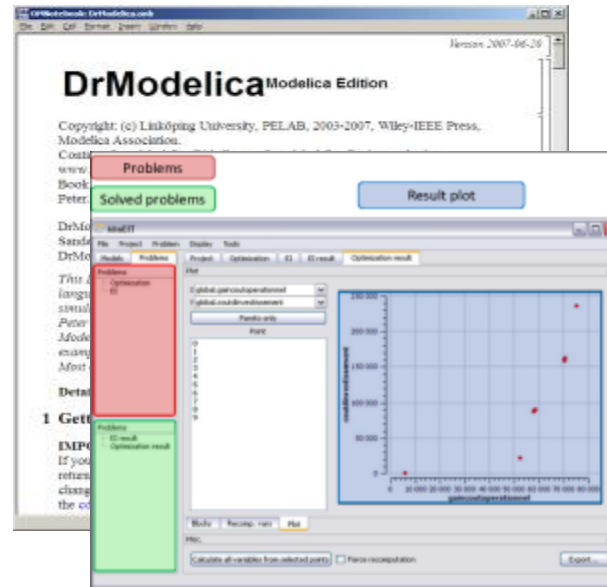
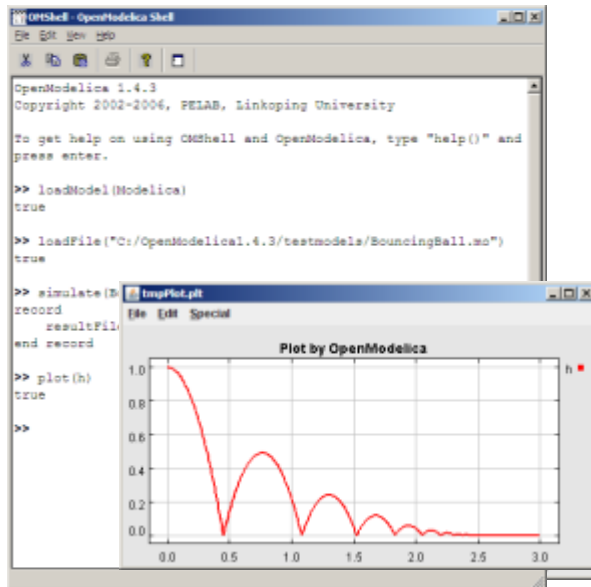
OSMC Plan of Operations for 2020

- **Main goal: OpenModelica 2.0.0** release late 2020 with significantly improved **coverage** for **libraries**, and significantly improved compiler and simulation **performance**, tool **robustness** and **quality**, including support for large-scale models (2 million equations), and MSL 4.0.
- Mid 2020 (June/July) Release of **OM 1.16.0** including:
 - further improved **NF**
 - Further improved **backend**.
 - **OMSens** – multiparameter sensitivity analysis and optimization.
 - **ParModAuto** – **Parallelization** capability from Mahder's PhD
 - Further Enhanced Equation model **debugging** support
- Conversion script capability for migrating MSL3.2.3 to MSL 4.0
- Fall 2020 **Unified run-time**, (OMSI) FMI-based.
- Fall 2020 A Simulation run-time supporting non-expanded arrays.
- Whole 2020. Development of more **Industrial Use Cases**. Simplify use of Jupyter notebooks.
- Further enhanced **embedded** system code generation and development support
- **Further deployment** of **Encryption** support for use of commercial libraries with OM
- Enhanced **FMI**, complete FMI export, Full FMI 2.0, complete SSP support, OMSimulator 2.1
- Enhanced MetaModelica 3.0 documentation & environment with improved ease-of-use; Further investigation of OMC **Julia** interfacing and **LLVM** code gen usage.
- Get a few **DFD/MSA contracts** signed and activated

The OpenModelica Open Source Environment

www.openmodelica.org

- **Advanced Interactive Modelica compiler (OMC)**
 - Supports most of the Modelica Language
 - **Modelica, Python, Julia, and Matlab scripting**
- **OMSimulator – FMI Simulation/Co-simulation**
- **Basic environment for creating models**
 - **OMShell** – an interactive command handler
 - **OMNotebook** – a literate programming notebook
 - **MDT** – an advanced textual environment in Eclipse
- **OMEdit** graphic Editor
- **OMDebugger** for equations
- **OMOptim** optimization tool
- **OM Dynamic optimizer** collocation
- **ModelicaML** UML Profile
- **MetaModelica** extension
- **ParModelica** extension



Current Main Industrial OpenModelica Usage (not including research usage)

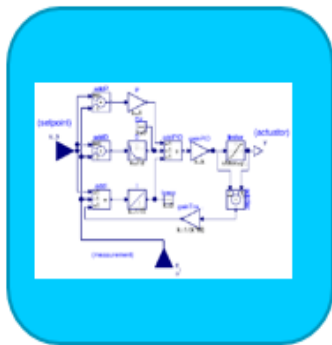
- ABB OPTIMAX – Process control, generating code controlling almost 10% of German power production
- DHI, OEM usage of OM compiler frontend in DHI product
- Bosch-Rexroth, in-house product usage for Modelica model import and simulation
- EDF – ThermoSysPro Library and Applications
- Politecnico di Milano – molten-salt-powered once-through steam generator model
- Politecnico di Milano – Calcium looping CO₂ capture
- ABB – fluid sub-model of a district heating plant is running in production
- Modelicon – Model-based Control of UAVs and Robots

Bosch Rexroth Control Edge Designer and Testing Framework

The screenshot displays the Control Edge Designer 1.13 software interface, which is used for designing and testing hydraulic valves. The interface is divided into several panels:

- Projektexplorer:** A tree view on the left showing the project structure, including the hydraulic system, housing, and various ports (A, B, T, P) with their respective positions and dimensions.
- Nutform (B.1):** A central panel for configuring the valve's nut profile. It includes fields for length, diameter, chamfer, offset, and angle for different sections.
- Graph:** A plot showing pressure (p(Ventil)) versus piston stroke (Kolbenhub [mm]). The graph displays multiple curves representing different valve configurations and their pressure responses over time.
- Flächentabelle:** A table on the right providing detailed dimensions for the valve's components, such as the nut and housing, across different stroke positions.
- Nutformansicht - Schnittansicht:** A cross-sectional view of the valve's internal components, showing the nut and its interaction with the housing.
- Kolbenabwicklungsansicht:** A view showing the piston's profile and its interaction with the valve's internal surfaces.
- Nutkoordinatentabelle:** A table at the bottom right providing specific coordinates and dimensions for the nut's profile, including parameters like angle, type, diameter, and offset.

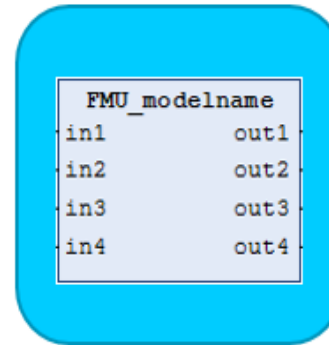
Bosch Rexroth Controller Code Generation Based on FMI



Simulation Tool



Code Export



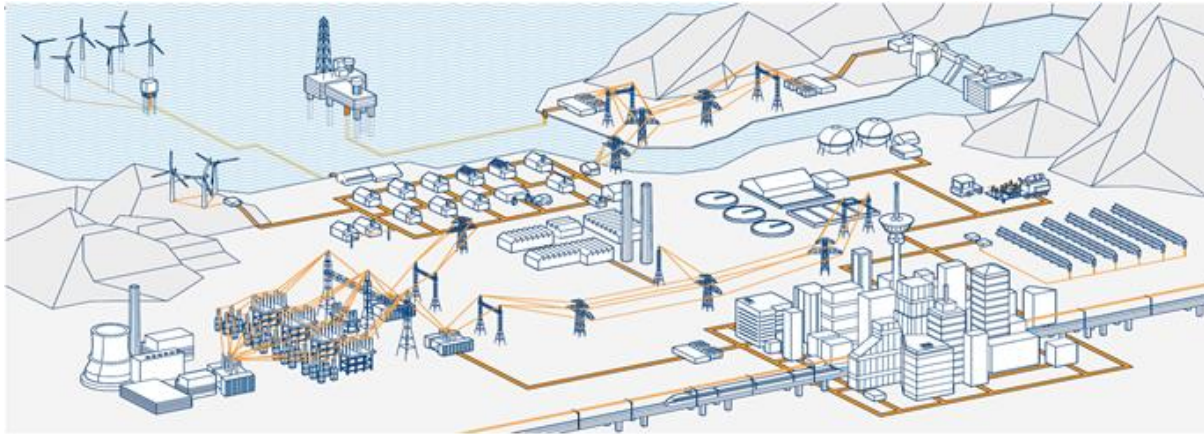
IEC Function Block



PLC

Large OpenModelica Industrial Use Case: ABB Industry Use of OpenModelica FMI 2.0 and Debugger

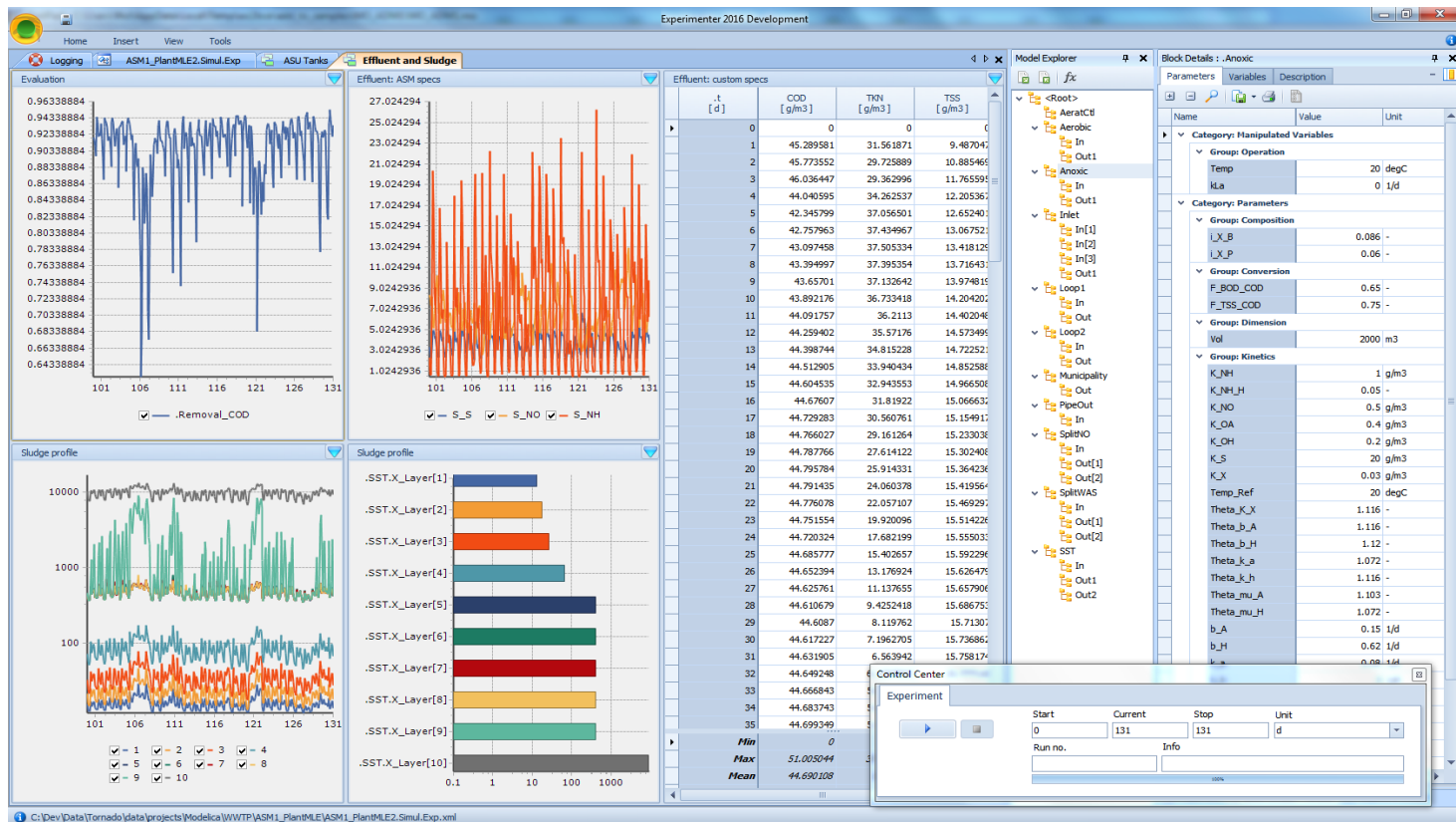
- ABB OPTIMAX® provides advanced model based control products for power generation and water utilities



- ABB: “ABB uses several compatible Modelica tools, including OpenModelica, depending on specific application needs.”
- ABB: “OpenModelica provides outstanding debugging features that help to save a lot of time during model development.”

MIKE by DHI, www.mikebydhi.com, WEST Water Quality Product

- The MIKE by DHI, www.mikebydhi.com, WEST Water Quality modeling and simulation environment includes a large part of the OpenModelica compiler using the OEM license.



The Open Source Modelica Consortium

Purpose of the Consortium

- The Open Source Modelica Consortium, created the 4th of December 2007 in Linköping, Sweden, in the following called OSMC, is a non-profit, non-governmental organization with the aim of developing and promoting the development and usage of the **OpenModelica open source implementation of the Modelica computer language** (also named Modelica modeling language) and **OpenModelica associated open-source tools and libraries**, collectively named the OpenModelica Environment, in the following referred to as OpenModelica.
- OpenModelica is **available for commercial and non-commercial usage under the conditions of the OSMC Public License**. It is the aim of OSMC, within the limitations of its available resources, to provide **support and maintenance of OpenModelica**, to support its publication on the web, and to **coordinate** contributions to OpenModelica.

Open Source Modelica Consortium

Originally Created Dec 4, 2007

7 Founding Organizational Members

- Bosch-Rexroth AG, Germany
- Equa Simulation AB, Sweden
- TLK Thermo, Germany
- VTT, Finland
- Linköping University, Sweden
- Hamburg University of Technology/TuTech, Institute of Thermo-Fluid Dynamics, Germany
- Technical University of Braunschweig, the Institut of Thermodynamik, Germany

OSMC – Open Source Modelica Consortium

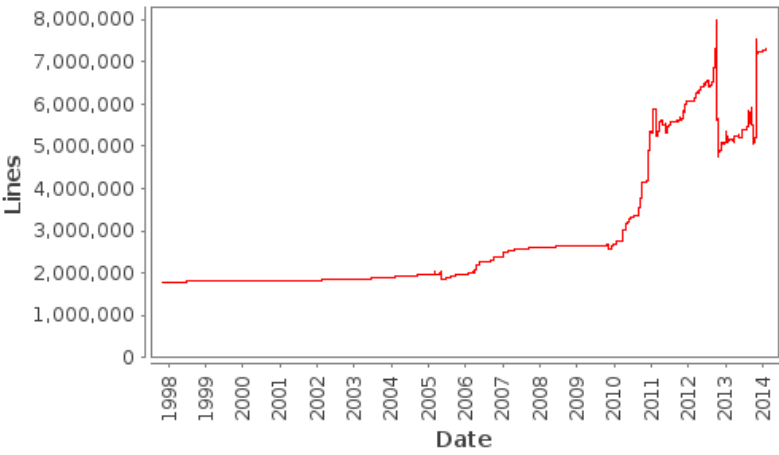
Founded Dec 4, 2007

Open-source community services

- Website and Support Forum
- Version-controlled source base
- Bug database
- Development courses
- www.openmodelica.org

Code Statistics

/trunk: Lines of Code



OpenModelica Login Create an account

HOME DOWNLOAD TOOLS & APPS USERS DEVELOPERS FORUM EVENTS RESEARCH search ...

Top information

- Industrial Products**
Commercial Applications using OpenModelica
- OMEdit**
Enhanced OpenModelica Connection Editor.
- Library Coverage**
Latest library coverage.

Introduction

OPENMODELICA is an open-source Modelica-based modeling and simulation environment intended for industrial and academic usage. Its long-term development is supported by a non-profit organization – the Open Source Modelica Consortium (OSMC).

The goal with the OpenModelica effort is to create a comprehensive Open Source Modelica modeling, compilation and simulation environment based on free software distributed in binary and source code form for research, teaching, and industrial usage. We invite researchers and students, or any interested developer to participate in the project and cooperate around OpenModelica, tools, and applications.

Latest news

- January 17, 2017: OpenModelica 1.11 Beta3 released
- December 20, 2016: OpenModelica 1.11 Beta2 released
- November 22, 2016: OpenModelica 1.9.7 released
- March 16, 2016: OpenModelica 1.9.6 released
- March 9, 2016: OpenModelica 1.9.4 released
- February 18, 2016: OpenModelica 1.9.4 beta2 released
- Program OpenModelica Annual Workshop 2016
- January 31, 2016: OpenModelica 1.9.4 beta1 released
- September 8, 2015: OpenModelica 1.9.3 released
- July 10, 2015: SIMS 2015 registration open

Modelica/OpenModelica Videos

Overview of Modelica...

Register yourself to get information about new releases. Participate in the OpenModelicaInterest mailing list. Help us: get the latest source code or nightly-build and report bugs.

To learn about Modelica, read a book or a tutorial about Modelica. Interactive step-by-step beginners Modelica on-line spoken tutorials Interactive OMWebbook with examples of Modelica textual modeling

OSMC 51 Organizational Members, Dec 2019

(initially 7 members, 2007)

Companies and Institutes

- ABB AB, Sweden
- Bosch Rexroth AG, Germany
- CDAC Centre, Kerala, India
- Creative Connections, Prague
- DHI, Aarhus, Denmark
- Dynamica s.r.l., Cremona, Italy
- EDF, Paris, France
- Equa Simulation AB, Sweden
- Fraunhofer IWES, Bremerhaven
- INRIA, Rennes, France
- ISID Dentsu, Tokyo, Japan
- Maplesoft, Canada
- RTE France, Paris, France
- Saab AB, Linköping, Sweden
- SKF, Göteborg, Sweden
- SmartFluidPower, Modena, Italy
- Siemens Turbo, Sweden
- Sozhou Tongyuan, China
- SRON Space Research Institute, Netherlands
- Talent Swarm, Spain
- TLK Thermo, Germany
- VTI, Linköping, Sweden
- VTT, Finland

Universities

- Augsburg University, Germany
- FH Bielefeld, Bielefeld, Germany
- University of Bolivar, Colombia
- TU Braunschweig, Germany
- Chalmers Univ, Control, Sweden
- Chalmers Univ, Machine, Sweden
- TU Darmstadt, Germany
- TU Delft, Netherlands
- TU Dresden, Germany
- Université Laval, Canada
- Georgia Inst of Technology, USA
- Ghent University, Belgium
- Halmstad University, Sweden
- Heidelberg University, Germany
- TU Hamburg/Harburg Germany
- IIT Bombay, Mumbai, India
- K.L. University, KLEF, Waddeswaram, India
- Linköping University, Sweden
- Univ of Maryland, Syst Eng USA
- Univ of Maryland, CEEE, USA
- Politecnico di Milano, Italy
- Ecoles des Mines, CEP, France
- Mälardalen University, Sweden
- Univ Pisa, Italy
- RPI, Troy, USA
- Univ SouthEast Norway
- Tsinghua Univ, Beijing, China
- Vanderbilt Univ, Nashville, USA

Open Source Modelica Consortium

Individual Members

(74 individual members, 4 February 2020)

- Peter Fritzson, Adrian Pop, Martin Sjölund, Per Östlund, Peter Aronsson, Adeel Asghar, Mikael Axin, Bernhard Bachmann, Vasile Baluta, Adam Bergmark, Robert Braun, Willi Braun, David Broman, Stefan Brus, Francesco Casella, Filippo Donida, Atiyah Elsheikh, Jens Frenkel, Mahder Gebremedhin, Pavel Grozman, Daniel Hedberg, Michael Hanke, Zoheb Hossain, Alf Isaksson, Kim Jansson, Daniel Kanth, Tommi Karhela, Juha Kortelainen, Abhinn Kothari, Petter Krus, Rahul Jain, Alexey Lebedev, Oliver Lenord, Ariel Liebman, Rickard Lindberg, Håkan Lundvall, Abhi Raj Metkar, Eric Meyers, Tuomas Miettinen, Afshin Moghadam, Kenneth Nealy, Maroun Nemer, Hannu Niemistö, Peter Nordin, Kristoffer Norling, Lennart Ochel, Arunkumar Palanisamy, Karl Pettersson, Pavol Privitzer, Reino Ruusu, Per Sahlin, Wladimir Schamai, Gerhard Schmitz, Sunil Shah, Alachew Shitahun, Magnus Sjöstrand, Anton Sodja, Ingo Staack, Kristian Stavåker, Sonia Tariq, Mohsen Torabzadeh-Tari, Parham Vasaiely, Niklas Worschech, Robert Wotzlaw, Björn Zackrisson, Azam Zia

Open Source Modelica Consortium – OSMC

Board of Directors 2019

- **Rüdiger Franke**, OSMC Chairman; Manager, ABB AG, Germany
- **Oliver Lenord**, OSMC Vice Chairman; Project manager, Germany
- **Peter Fritzson**, OSMC Director; Prof, Linköping Univ, Sweden
- **Francesco Casella**, OSMC Vice Director; Prof, Politec. di Milano, Italy
- **Juha Kortelainen**, Manager, VTT, Finland
- **Gerhard Schmitz**, Prof, Univ. Hamburg, Germany
- **Kilian Link**, Manager, Siemens, Germany
- **Niklas Worschech**, Techn Specialist, Bosch-Rexroth, Germany.
- **Daniel Bouskela**, Manager, EDF, France
- **Bernhard Bachmann**, Prof, FH Bielefeld, Germany
- **Adrian Pop**, adjoined to the Board, Tech coordinator, OSMC

OSMC Board – 3 Meetings Jan 1 2019 – Dec 31 2019

Meeting dates

- 190517
- 190926
- 191203

Board Work

- Planning and prioritizing the OSMC work
- OSMC Business models
- Admitting new members
- Planning the workshop
- Budget
- etc.

Some Supporting Research Projects 2019 (2020)

- PARADOM, German national project including ABB, Bosch-Rexroth, Siemens AG, TU Dresden, FHBielefeld
- ITEA3 project OPENCPS, started Dec 2015, finished 2019 (Open Cyber-Physical System Model-Driven Certified Development) Sweden, France, Finland, Hungary
- Swedish project RTISIM, started Dec 2015, finished 2019
- ITEA3 project EMPHYSIS, Sweden joined Dec 2017
- Swedish project EMISYS, 2019 – 2021
- Swedish project LargeDyn, 2019 – 2022
- New ITEA3 project EMBRACE, started Nov 2019, kickoff 2020
- New EU project HUBCAP, starting January 2020

Special Thanks

- The developers who worked very hard during 2019 and modelers who tested and gave important feedback
- The OpenModelica consortium organizational members for support including ABB, Bosch-Rexroth, Wolfram-MathCore, RTE, EDF, Equa, Dynamica, etc...
- Master students and PhD students who made important contributions.

Conclusions and Summary 2019/Febr 2020

- Dec 6, 2019. OpenModelica **1.14.0 release**, Dec 31 **1.14.1**
First release with the New Frontend.
- February, 2020. OpenModelica **1.15.0 beta1** release with replaceable GUI
- 2020. Good prospects for the future – towards a standard **high performance, quality, compliant** open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.
Expected OpenModelica 1.16.0 and 2.0 releases

Questions?

www.openmodelica.org