OpenModelica – Status and Directions

Francesco Casella – OSMC Director
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

• **Increasing** emphasis on **industrial** usage
OpenModelica Releases in 2021

- Version 1.17.0 released 23 March 2021
- Version 1.18.0 released 4 September 2021
- Version 1.18.1 released 23 December 2021

- Improvements of tool quality
- Improvements of library support and coverage
- Improvements of numerical robustness
Collaboration with LBL on Buildings

- Strategic partnership started in 2021 with LBL (US gov’t laboratory in Berkeley)
- Goal: provide open-source support for Modelica libraries (Buildings, IBPSA) involved in the Spawn of Energy Plus project

➢ Objective for 2021: near 100% simulation success on Buildings 7.0.x
Collaboration with LBL on Buildings

Buildings_maint.7.0.x

Library version: 7.0.3-maint.7.0.x (36967ce1b5136c4d09aa8d8dd2cd656659697e92)

<table>
<thead>
<tr>
<th>Branch</th>
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<th>Parsing</th>
<th>Frontend</th>
<th>Backend</th>
<th>SimCode</th>
<th>Templates</th>
<th>Compilation</th>
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➤ Mission accomplished!
Collaboration with LBL on Buildings

- Benefits in general on the performance of OpenModelica on open-source libraries

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<th>Branch</th>
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<th>Execution time # Simulate # Total</th>
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Status of New Frontend

• The development of the new OpenModelica frontend, started in 2016, is now nearly complete.
• OMC can now flatten **100%** of the models in the following libraries:
  
  Buildings (7.0.3), Chemical, ConPNLib, HanserModelica, HelmholtzMedia, IBPSA, MEV, ModelicaByExample, Modelica (3.2.3 & 4.0.0), ModelicaTest, Modelica_DeviceDrivers, OpenHydraulics, OpenIPSL, PNLib, PhotoVoltaics, PhotoVoltaics_TGM, PlanarMechanics, PowerGrids, PowerSysPro, PowerSystems, ScalableTestGrids, ScalableTestSuite, SystemDynamics, ThermoPower, TILMedia, ThermoFluidStream, VehicleInterfaces

• On-going work to fix remaining corner cases on many other libraries
• Conversion script support is now implemented
Improvements to Backend and Code Generation

- **ASSC algorithm** handles non-trivial cases of **index reduction** (e.g. 3-phase AC circuits)
- Improved algorithm to handle **mixed-determined initialization** problems due to index reduction
- Improved and more numerically robust **tearing**
- More efficient handling of **functions returning arrays**
- **spatialDistribution()** operator implemented
- Improved **delay()** implementation
- Improved **homotopy()** implementation
- Improved handling of **synchronous systems** (clocked variables)
- Many bug fixes regarding **code generation with records**
- On-going work on **new backend**, with more rational structure and including array-preserving analysis and code generation

Talk by Karim Abdelhak and Bernhard Bachmann later today
Improvements to Code Compilation and Runtime

- Much improved **C++ runtime** (talk by Rudiger Franke later today)
- **Automatic selection** of linear/nonlinear **sparse solvers** for efficient simulation large algebraic loops
- Fixed memory leak in sparse solver implementation
- Much **faster C compilation** on Windows using **clang** instead of gcc
- Much faster **dynamic library linking** on Windows
Improvements to OMEdit GUI

- Updated QT libraries for better and faster rendering
- More responsive support when editing and debugging large models
- Support of Modelica Standard Library 3.2.3 and 4.0.0
- Improved plotting of results (unit prefixed, sign toggling, etc.)
- GUI integration of data reconciliation feature from EDF
- Many bugfixes and performance improvements

(upcoming in v. 1.19.0)
- Improved support of choices annotations
- Integrated package manager for the automatic installation of open-source Modelica libraries
- Integrated support for conversion scripts (→ updating older libraries to MSL 4.0.0)
Experimental OpenModelica Compiler in Julia

- John Tinnerholm’s PhD work continues

- Goals
  - Automatically translate MetaModelica frontend into Julia
  - Leverage on large and growing Julia ecosystem for symbolic and numerical handling of equations
  - Fast prototyping of new concepts, e.g. simulation of variable-structure systems

➤ Talk by John Tinnerholm and Adrian Pop later today
Highlights for 2022 OpenModelica Development

- Continue the cooperation with LBL on Buildings
  - Achieve 100% successful simulation of Buildings 7.0.3, 8.0.1 and 9.0.0
  - Assess quality of simulation results and improve simulation performance

- Improve performance of daeMode simulation (sponsored by RTE)
  - Analytic jacobians in daeMode
  - Correct and efficient event-handling in large systems
  - Further optimizations for efficient large system simulations

- Redesigned OMEdit – OMC interface for model editing (sponsored by LBL and Bosch-Rexroth)
  - Based on partial instantiation of models using the new frontend
  - Correct rendering of conditional connectors
  - Menu-based editing of parameters in replaceable models and classes
  - Editing of parameters and replaceable classes in hierarchically stuctured models
Highlights for 2022 OpenModelica Development

- Deploy integrated library management in OMEdit (v. 1.19.0)
  - Package manager linked to database of OSMC-supported libraries
  - Version management and automatic conversion scripts
- Improved support for commercial libraries
  (Bosch-Rexroth, XRG, TLK-Thermo)
  - Full coverage of libraries for advanced industrial and research applications
  - Deployment of user-friendly encrypted library support
- Enable experimental use of new backend, including support for efficient array-preserving code generation
- Improved support of FMI export and FMI simulation in OMSimulator
- Enable user-friendly parallel simulation of large models
  (ParModAuto)
- Continue the development of web-based GUIs for lightweight deployment of OpenModelica technology
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.
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, Institute of Thermodynamics, Germany
# OSMC 57 Organizational Members, Gen 2022
(initially 7 members, 2007)

## Companies and Institutes
- ABB AB, Germany
- 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, Germany
- Fraunhofer FCC, Gothenburg, Sweden
- INRIA, Rennes, France
- ISID Dentsu, Tokyo, Japan
- Juelich, FZI, Germany
- LBL Laboratories, Berkeley CA, USA
- Maplesoft, Canada
- Metroscope, Paris, France
- REUSE, Madrid, Spain
- RISE; Sweden
- RTE France, Paris, France
- Saab AB, Linköping, Sweden
- SmartFluidPower, Modena, Italy
- Sozhou Tongyuan, China
- SRON Space Research Institute, Netherlands
- Talent Swarm, Spain
- TLK Thermo, Braunschweig, Germany
- Volvo Cars AB, Sweden
- VTI, Linköping, Sweden
- XRG Simulation GmbH, Hamburg, Germany

## Universities
- Augsburg University, Germany
- Australian National University, Australia
- 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, Atlanta, Georgia, USA
- Ghent University, Belgium
- Halmstad University, Sweden
- TU Hamburg/Harburg Germany
- Heidelberg University, 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
- Politecnica Catalunya Spain
- Mälardalen University, Sweden
- Univ Pisa, Italy
- RPI, Troy, USA
- Univ SouthEast Norway
- Tsinghua Univ, Beijing, China
- Vanderbilt Univ, Nashville, USA
Organizational Members Update 2021

• New members:
  • Metroscope, Paris, France
  • REUSE, Madrid, Spain
  • XRG Simulation, Hamburg, Germany
  • Volvo Cars, Sweden
  • Australian National University, Australia
  • Lawrence Berkeley National Laboratories, Berkeley CA, USA

• Leaving members:
  • VTT Simulation, Finland
Open Source Modelica Consortium
Individual Members (73 individual members)

Open Source Modelica Consortium – OSMC
Board of Directors 2020

- Rüdiger Franke, OSMC Chairman; Manager, ABB AG, Germany
- Oliver Lenord, OSMC Vice Chairman; Project manager, Germany
- Francesco Casella, OSMC Director; Prof, Politec. di Milano, Italy
- Peter Fritzson, OSMC Vice Director; Prof, Linköping Univ, Sweden
- Juha Kortelainen, Manager, VTT, Finland
- Gerhard Schmitz, Prof, Univ. Hamburg, Germany
- Adrien Guironnet, Manager, RTE, France
- 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 – 2 Meetings During 2021

<table>
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<th>Meeting dates</th>
<th>Board Work</th>
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<td>12/05/2021</td>
<td>Planning and prioritizing the OSMC work</td>
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<tr>
<td>17/12/2021</td>
<td>OSMC Business models</td>
</tr>
</tbody>
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- Admitting new members
- Planning the workshop
- Budget
- etc.
Some Supporting Research Projects 2020 (2021)

- PHyMoS - Proper Hybrid Models for Smarter Vehicles. German national project including Bosch, LTX, XRG, TLK, ESI ITI GmbH, Modelon, TU Braunschweig, Universität Augsburg, FH Bielefeld. Starts 2021
- Swedish project LargeDyn, 2019 – 2022
- Swedish project ELLIIT Cloud Tooling for Large-Scale Cyber-Physical System Model-Based Development (one 5-yrs PhD)
- ITEA3 project EMBRACE, 2019-2022
- EU project HUBCAP, 2020-2022
Special Thanks

• The developers who worked very hard during 2021 and modelers who tested and gave important feedback

• The OpenModelica consortium organizational members for support including, in particular ABB, Bosch-Rexroth, EDF, LBL, RTE, XRG Simulation, TLK-Thermo, etc...

• Master students and PhD students who made important contributions.
Conclusions and Summary 2021-2022

• Mar 23, 2021. OpenModelica 1.17.0
• Sep 4, 2021. OpenModelica 1.18.0
• Dec 23, 2021. OpenModelica 1.18.1
• Feb 2022 (planned) OpenModelica 1.19.0
• Towards a standard high performance, quality, compliant open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.

• Expected OpenModelica 1.20.0 and 2.0.0 (?) in 2022

Questions?

www.openmodelica.org