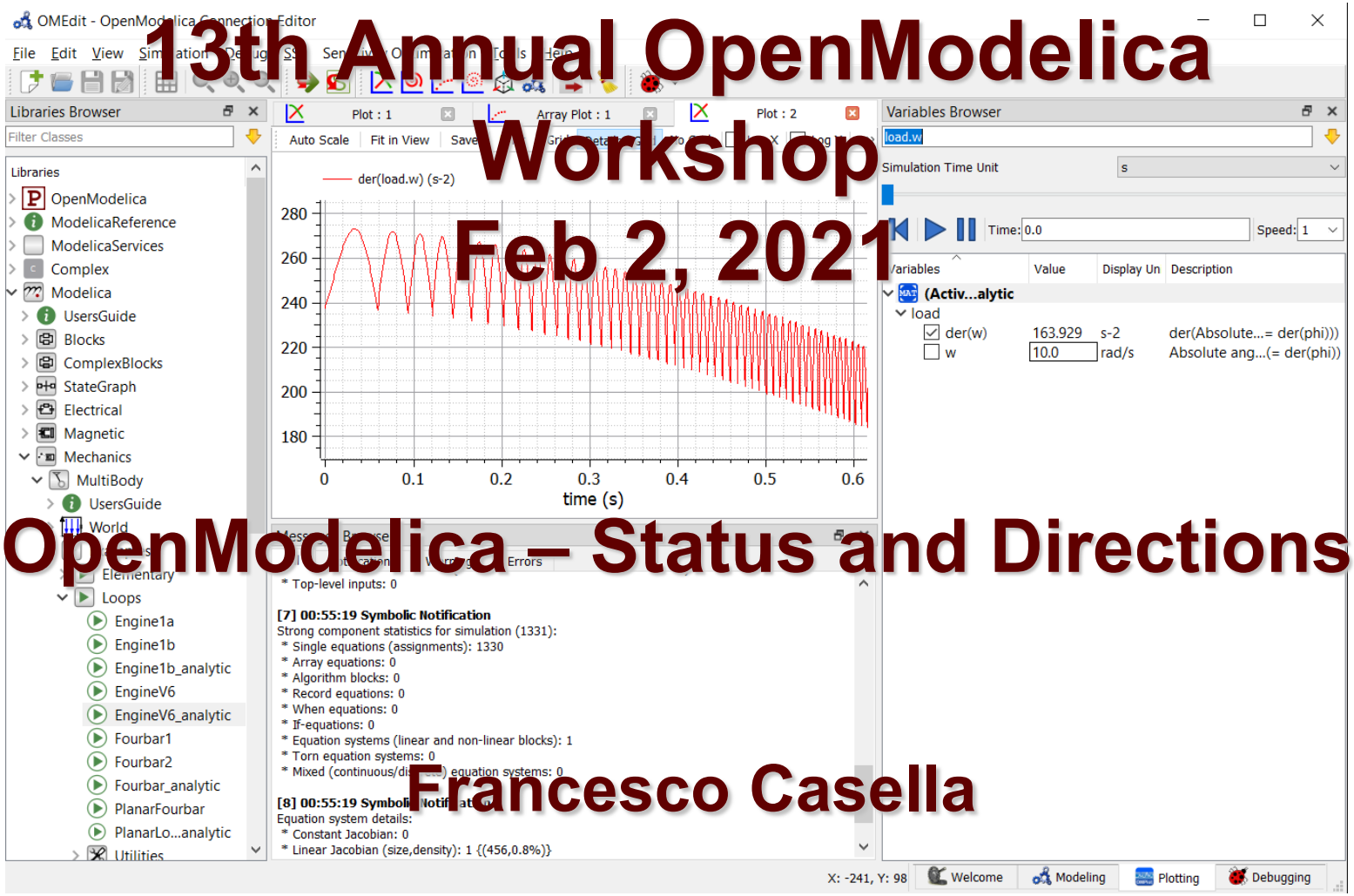
13th Annual OpenModelica Workshop
Feb 2, 2021



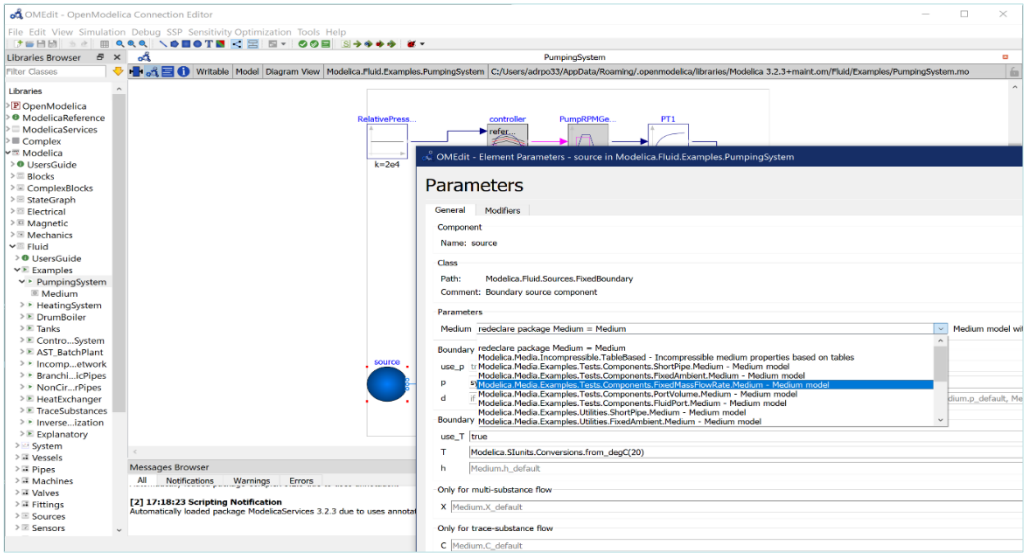
OpenModelica – Status and Directions

Francesco Casella

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

Releases OpenModelica 1.16.0 (Oct 24, 2020) and OpenModelica 1.16.2 (Dec 21, 2020)



Most important feature: Replaceable GUI with the new frontend

Left. Use of replaceable GUI in OM 1.16.02

- The new frontend has been further improved, with enhanced support of records and arrays. The new front-end can now handle 100% of the Modelica Standard Library 3.2.3 models.
- Also improvements to backend and simulation run-time regarding homotopy, CVODE solver included, new minimal tearing, better support for models with records,
- Enhanced OpenModelica debugger that can show direct variable dependencies,
- A full-fledged Modelica package manager is included, currently available via the command line interface
- Improved FMI support in OpenModelica OMSimulator: GUI: text editing of SSP models, undo/redo functionality, delete components, etc. FMI/CoSimulation 2.0 now includes CVODE solvers and customization via simulation flags. SSP 1.0 is supported

OpenModelica 1.17.0 February 2021
(as Alpha release January 2021)

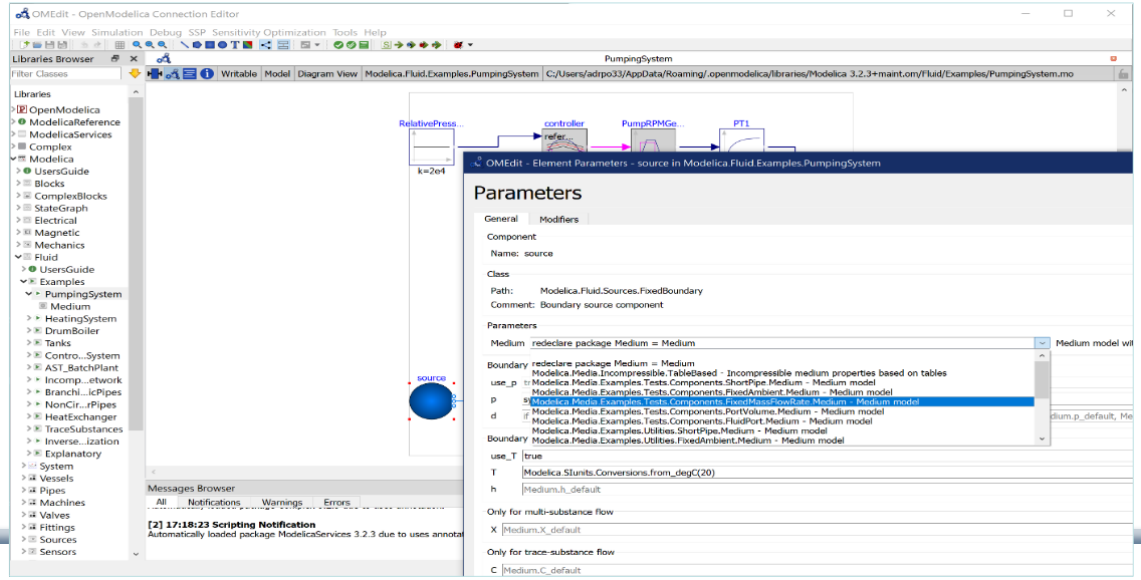
- The **new front-end** now performs systematically better It is used by default in OMEdit since 1.14.0. Now **default** also in the scripting environments in 1.17.0.
- The MSYS environment used by OMC under Windows was upgraded.
- Several OMEdit issues resolved thanks to new QT version being used
- Clang support added in Windows, much faster C and C++ compilation
- Switched from static to **dynamic linking** for faster turnaround.
- Vastly improved support for libraries PowerSysPro, Chemical, and HelmholtzMedia
- Fixed problems of lost modified code when working on multiple windows in OMEdit.
- Several issues with code generation were fixed.
- **FMI** export and OMSimulator FMI simulation has improved greatly.
- PIP – Package Installer for Python is integrated in OpenModelica and OMSimulator.
- Enhanced **solver** support in OM, new version of Sundials now integrated.
- Research project LargeDyn. Prototype Julia-based implementation, translated from MetaModelica. Experiments with variable structured systems.
- Support for OMSens sensitivity analysis and optimization has improved. There will be a better supported version in 1.17.0

New Conversion scripts, Flat Modelica, Package manager in 1.17.0

- Prototype of conversion script support developed
- Flat Modelica export prototype (paper submitted), ongoing standardization by Modelica Association
- Modelica package manager developed. Already operational via scripting. GUI still to be done.

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
- The New frontend is about **10 to 100 times faster** than the old one
- Status **January 2020**, new frontend is default in OMC.
  NF flattening supports 100% of MSL 3.2.3 and MSL 4.0.
- OMEdit Replaceable GUI for NF available in 1.16.0 (no params).



FMI export and Enhanced OMSimulator (Jan 2020)
(talk by Andreas and Lennart later today)

- **Greatly enhanced** OMSimulator tool, further enhanced 2020
- Model exchange & Co-simulation FMUs
- **Scripting** interface (Python with PIP support, also LUA)
- ImprovedGraphical user interface (OMEdit)
- Graphical **composition** of FMUs
- **Distributed** simulations utilizing TLM master
- Support for composite models, compliant to SSP 1.0 standard

- Much improved **FMI Export**
- (FMI tutorial tomorrow)

A Detailed 45 page Overview Journal Paper about OpenModelica was published November 9

- **Authors**: Peter Fritzson, Adrian Pop, Karim Abdelhak, Adeel Ashgar, Bernhard Bachmann, Willi Braun, Daniel Bouskela, Robert Braun, Lena Buffoni, Francesco Casella, Rodrigo Castro, Rüdiger Franke, Dag Fritzson, Mahder Gebremedhin, Andreas Heuermann, Bernt Lie, Alachew Mengist, Lars Mikelsons, Kannan Moudgalya, Lennart Ochel, Arunkumar Palanisamy, Vitalij Ruge, Wladimir Schamai, Martin Sjölund, Bernhard Thiele, John Tinnerholm, Per Östlund
- Title: **The OpenModelica Integrated Environment for Modeling, Simulation, and Model-Based Development**
- Journal: **Modeling, Identification and Control**. 2020;41(4):241-295, November 2020, DOI 10.4173/mic.2020.4.1.

Modeling, Identification and Control, Vol. 41, No. 4, 2020, pp. 241–285, ISSN 1890–1328

MIC

The OpenModelica Integrated Environment for Modeling, Simulation, and Model-Based Development

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Alachew Mengist[1] Lars Mikelsons[1] Kannan Moudgalya[4] Lennart Ochel[1]
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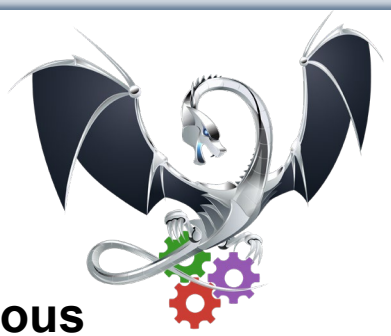
Abstract

OpenModelica is a unique large-scale integrated open-source Modelica- and FMI-based modeling, simulation, optimization, model-based analysis and development environment. Moreover, the OpenModelica environment provides a number of facilities such as debugging; optimization; visualization and 3D animation; web-based model editing and simulation; scripting from Modelica, Python, Julia, and Matlab; efficient simulation and co-simulation of FMI-based models; compilation for embedded systems; Modelica-UML integration; requirement verification; and generation of parallel code for multi-core architectures. The environment is based on the equation-based object-oriented Modelica language and currently uses the MetaModelica extended version of Modelica for its model compiler implementation. This overview paper gives an up-to-date description of the capabilities of the system, short overviews of used open source symbolic and numeric algorithms with pointers to published literature, tool integration aspects, some lessons learned, and the main vision behind its development.

Experimental OpenModelica Compiler in Julia

Varying (talk later today, John Tinnerholm and Adrian Pop)



- Developed a preliminary MetaModelica to Julia translator
- **Translated the high-performance frontend.**
- **Able to execute and translate MetaModelica functions**
- **Able to simulate discrete-hybrid systems + regular continuous systems**
- **Experimental backend developed**
  - Completed causalization sorting, matching.
  - Integrated LightGraphs.jl package, DAG representation of the hybrid DAE
  - Integrated Plots.jl for interactive plotting and animation
  - Integrated the Reduce Computer Algebra system for automatic symbolic manipulation and symbolic derivation.
  - Integration with Sundials. IDAS used for numerical integration
- Further performance **tuning needed**
- Starting experimenting with **variable-structure systems**

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

- Enhanced **nonlinear** loop **initialization**
- Improved **homotopy** initialization
- Differentiation rules updated for more efficient code (exploit known/constant/parameter values)
- Better symbolic **function inversion** (generate correct asserts)
- **Linearized** models for different target languages (Modelica, Matlab, Python, Julia)
- Removed obsolete **unit** checking in the backend and only use frontend unit checking
- Better support for **Data Reconciliation**
- Better support for HelmholtzMedia library

Development of new OpenModelica Backend
(talk later today, Karim and Bernhard)

- Design document developed spring 2020
- Implementation started 2020, several prototype parts in the works
  - Improved, more rational structure
  - Non-expanded array support (prototyping)
  - Matching support for non-expanded arrays (prototyping)
  - In general much more efficient array handling
  - Improved performance, modularity
  - Easier maintenance
- The first MSL models have started working with the new backend

Ongoing – New Web-based Graphical Editor
(prototype developed in HUBCAP research project)

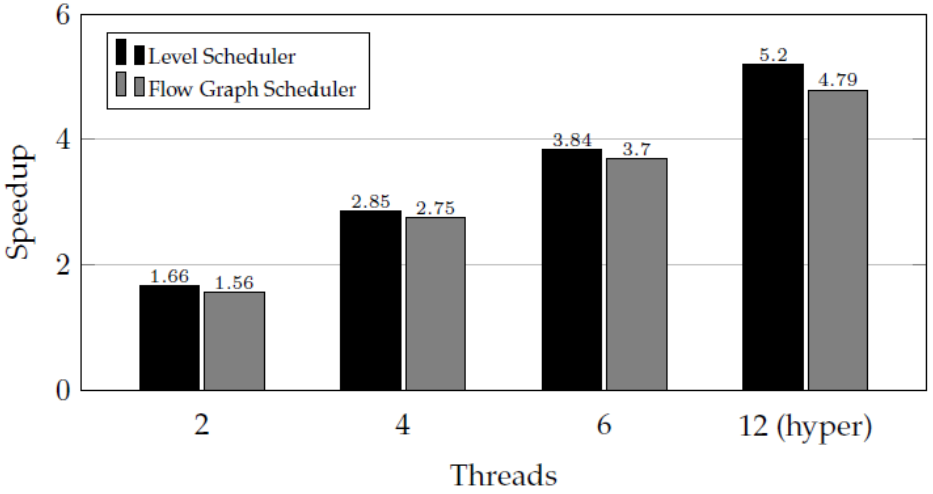
- Currently ongoing work on a more general OpenModelica web based interface also including graphical model editing. It consists of two major parts:
  - 1. The OMWebService that provides the API https://en.wikipedia.org/wiki/Representational_state_transfer for querying the model information and performing the simulation. The implementation is based on the Python Flask web framework https://en.wikipedia.org/wiki/Flask_(web_framework) and uses OMPython for communication with the OpenModelica Model Compiler.
  - 2. OMWebEdit which is a new OpenModelica web based editor using the React JS framework https://en.wikipedia.org/wiki/React_(web_framework).
- It is still in a very early implementation phase. The idea is to host this on AWS (Amazon web service) https://en.wikipedia.org/wiki/Amazon_Web_Services).
- Right now there is ongoing work on a simple client-server mechanism but the future plans are to have more collaborative approach which should allow users to create and share workspaces.

ParModAuto Parallelization (Released fall 2020)

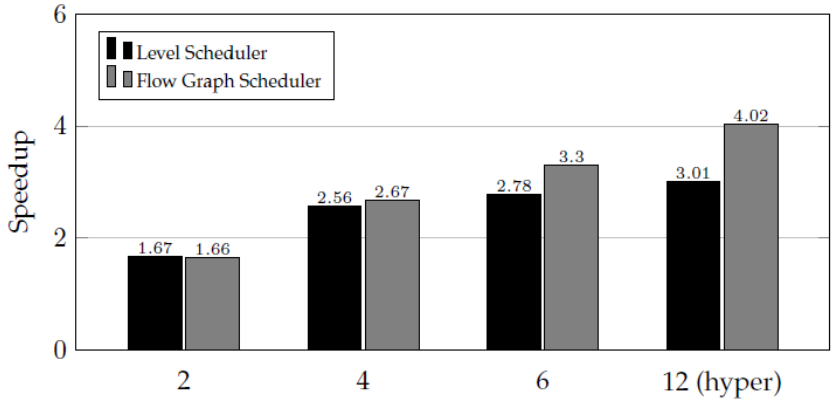
Automatic AutoTuned Parallelization of Equation-based Models

- Automatic **Parallelization**
- Automatic **clustering** of small tasks
- **Automatic load balancing** based on measurements, automatically adapts to changing load
- **Shared-memory** task parallelization
- Released in 1.16.2

SteamPipe640 model, Speedup 5.2 on 6 cores:



BranchingDynamicPipes model, Speedup 4 on 6 cores:



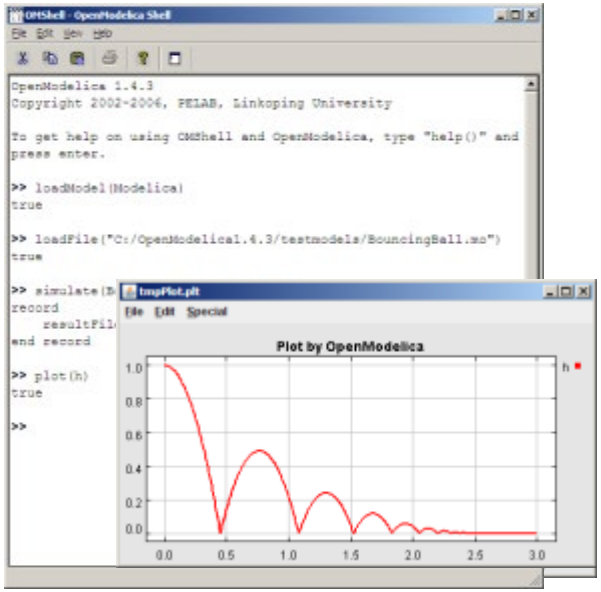
Plan of Operations for 2021

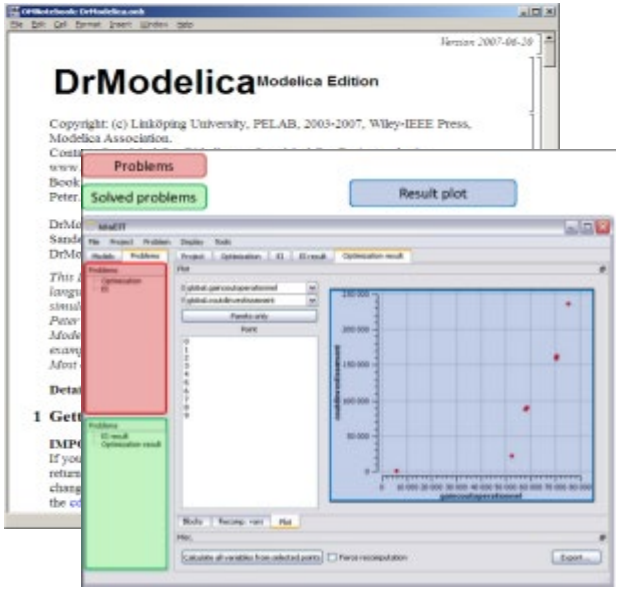
- **Main goal**: **OpenModelica 2.0.0** release December 2021 with significantly improved **coverage** for **libraries**, and significantly improved compiler and simulation **performance**, tool **robustness** and **quality**, including support for large-scale models
- February 2021 Release of OM 1.17.0, mostly improved robustness, coverage, and speed
- Mid 2021 (July) Release of **OM 1.18.0**
- Further improved **new frontend (NF)**
- Further improved **backend**.
- Further Enhanced Equation model **debugging** support
- Finalize integrated library management and MSL 4.0.0 support in OMEdit, including conversion scripts
- Implement model duplication functionality
- Improve coverage of libraries, in particular Buildings (partnership with LBL).
- Support replaceable classes with parameter editing in OMEdit
- Migrate state machines and MetaModelica support to NF
- Proper support of parameter-depending conditional connectors and dialogs in OMEdit
- Continued development of new backend
- Enhanced **FMI**, complete FMI export, Full FMI 2.0, complete SSP support, OMSimulator 2.1

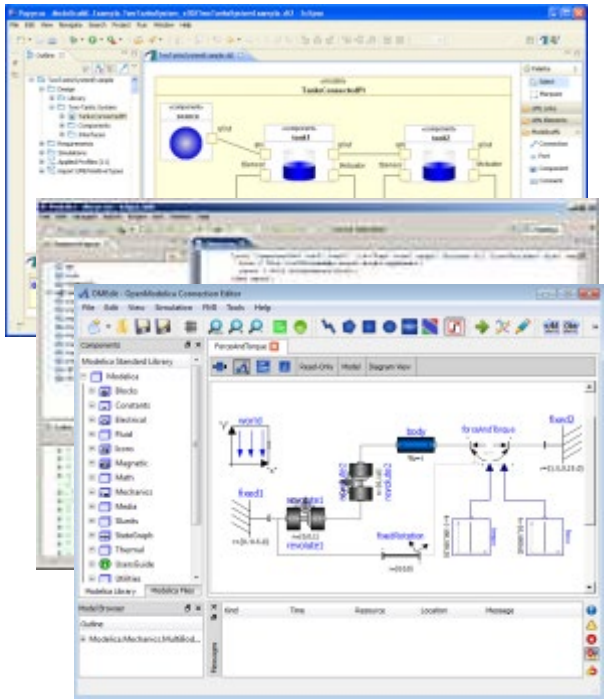
The OpenModelica Open Source Environment
www.openmodelica.org

- 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



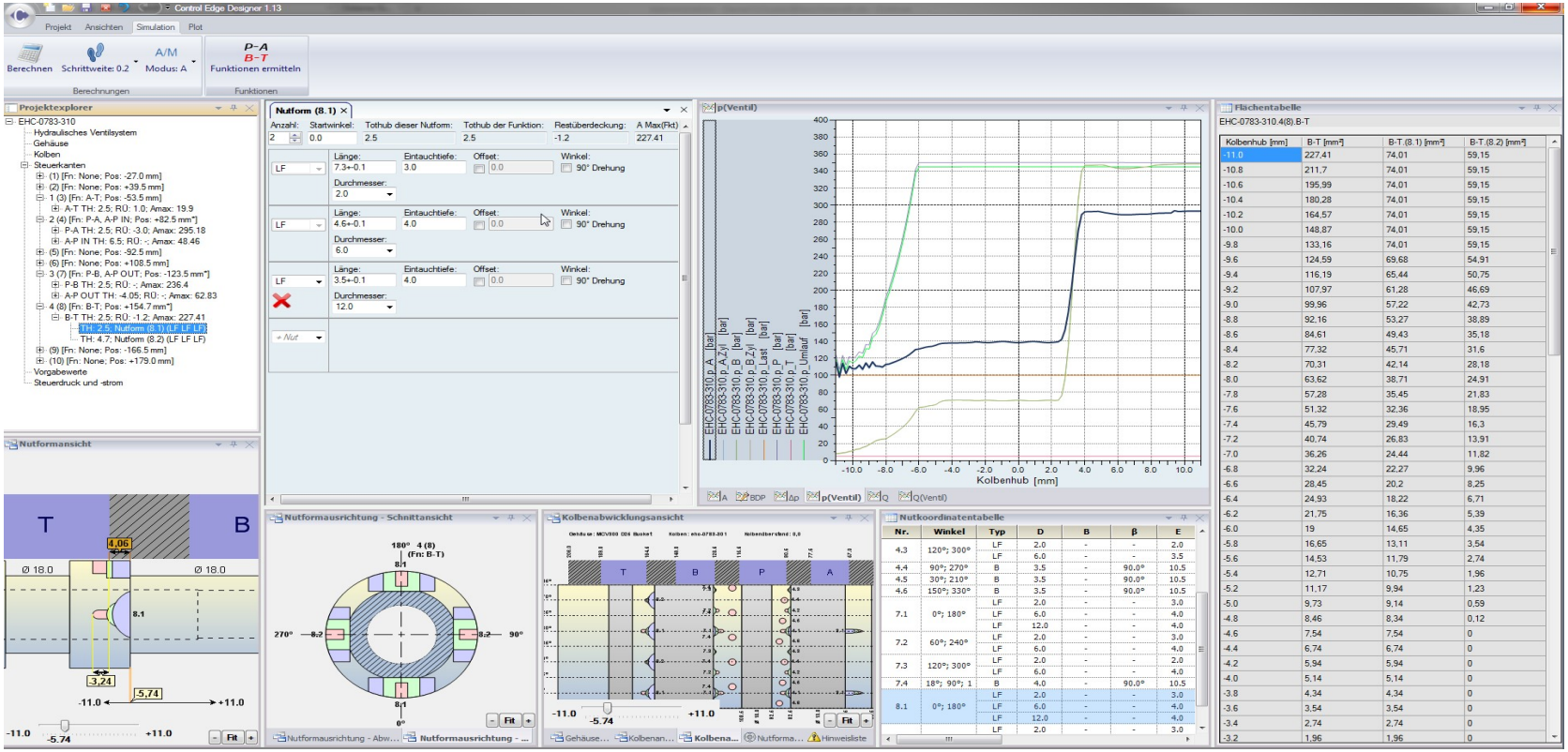




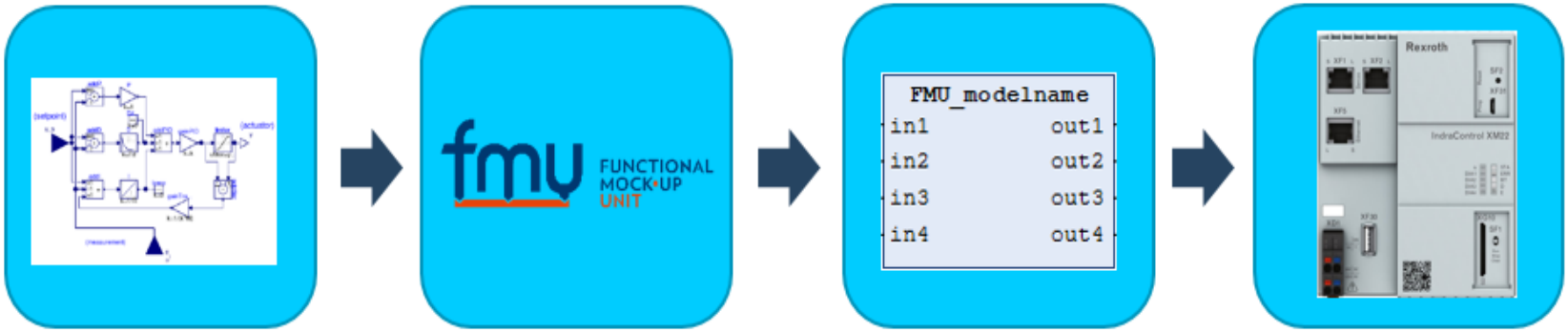
Current Main Industrial OpenModelica Usage (not including research usage)

- 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 – Innovative sCO2 cycle power plants models
- Politecnico di Milano – National gas distribution network simulation and optimization
- 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

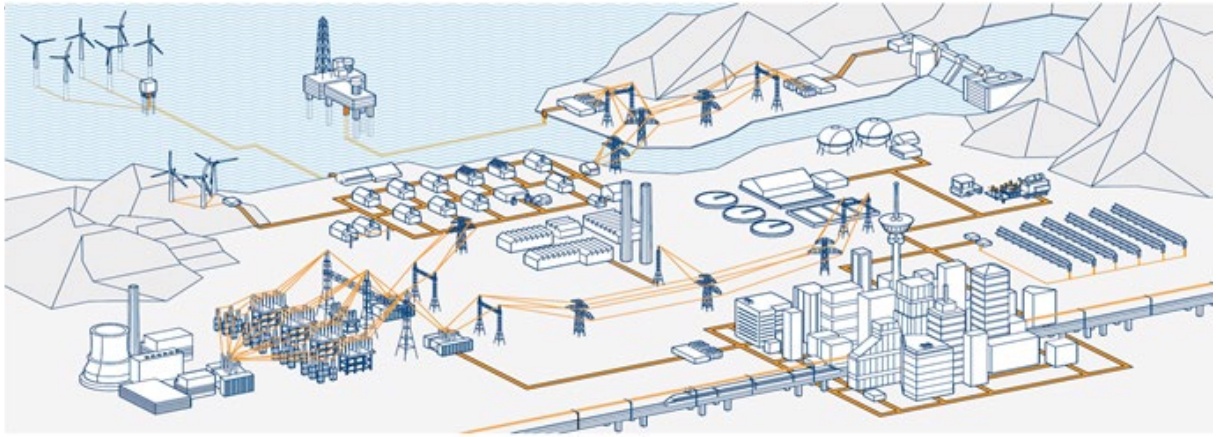


Bosch Rexroth Controller Code Generation Based on FMI



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

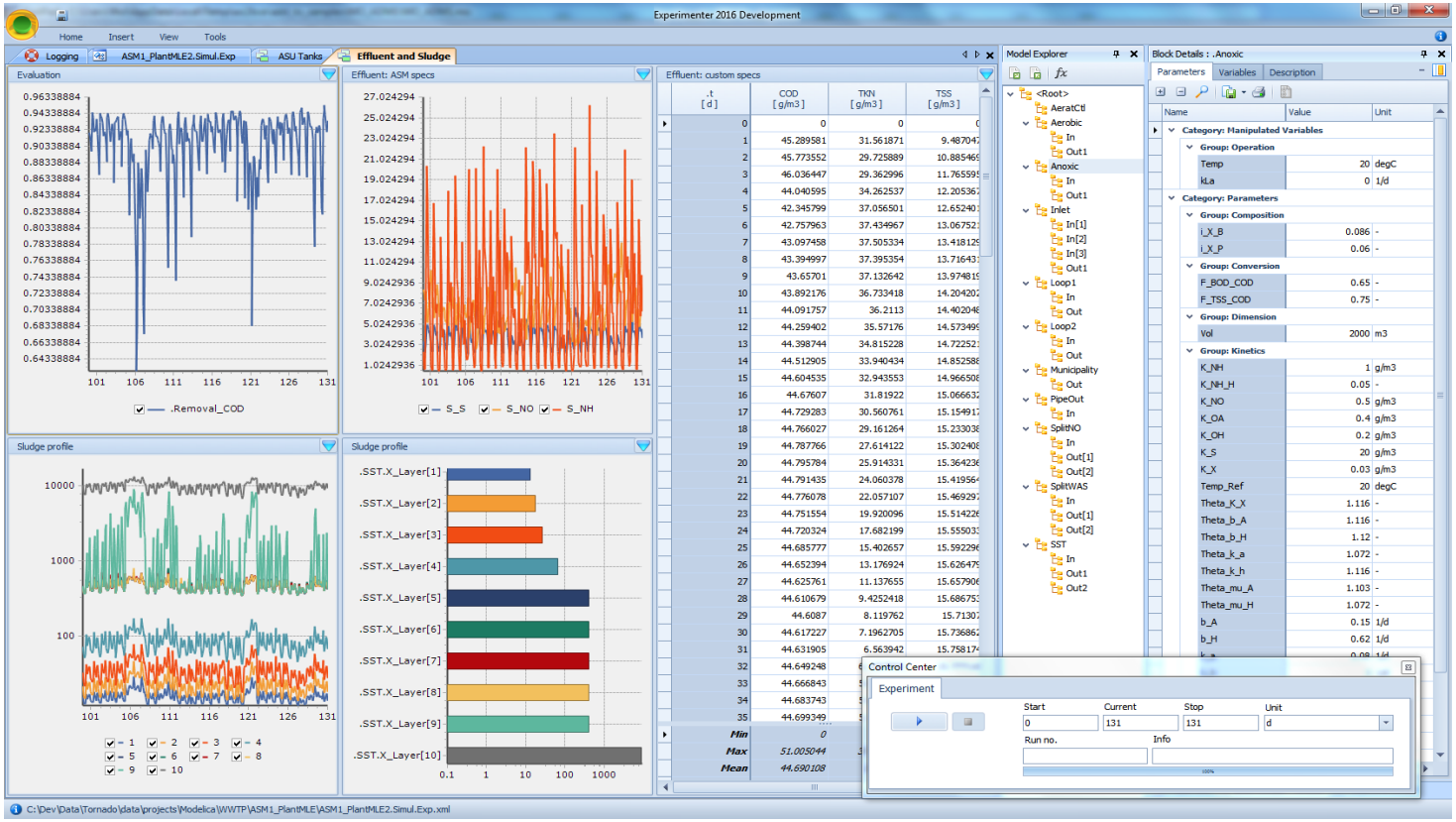
- ABB OPTIMAX® provides advanced model based control products for power generation and water utilities



- 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, Institute of Thermodynamics, Germany

OSMC 52 Organizational Members, Feb 2021
(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
- Fraunhofer FCC, Gothenburg
- INRIA, Rennes, France
- ISID Dentsu, Tokyo, Japan
- Juelich, FZI, Germany
- Maplesoft, Canada
- 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, 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, 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

Open Source Modelica Consortium Individual Members

(73 individual members, 2 February 2021)

- 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 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 – 4 Meetings Jan 1 2020 – Dec 31 2020

Meeting dates

- 200327
- 200617
- 200923
- 201215

Board Work

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

Some Supporting Research Projects 2020 (2021)

- PARADOM, German national project including ABB, Bosch-Rexroth, Siemens AG,TU Dresden, FHBielefeld. Ended 2020.
- 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
- ITEA3 project EMPHYSIS, 2018-2021
- Swedish project EMISYS, 2019 – 2021
- Swedish project LargeDyn, 2019 – 2022
- ITEA3 project EMBRACE, 2019-2022
- EU project HUBCAP, 2020-2022

Special Thanks

- The developers who worked very hard during 2020 and modelers who tested and gave important feedback
- The OpenModelica consortium organizational members for support including ABB, Bosch-Rexroth, RTE, EDF, Equa, Dynamica, etc...
- Master students and PhD students who made important contributions.

Conclusions and Summary 2020/Febr 2021

- Oct 24, 2020. OpenModelica **1.16.0**
- Dec 21, 2020. OpenModelica **1.16.2**
- February, 2020. OpenModelica **1.17.0**
- 2021. 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 1.18.0 and 2.0.0 (?)** in 2021

Questions?

www.openmodelica.org