10th Annual OpenModelica Workshop
Feb 5, 2017

OpenModelica – Status and Directions

Peter Fritzson
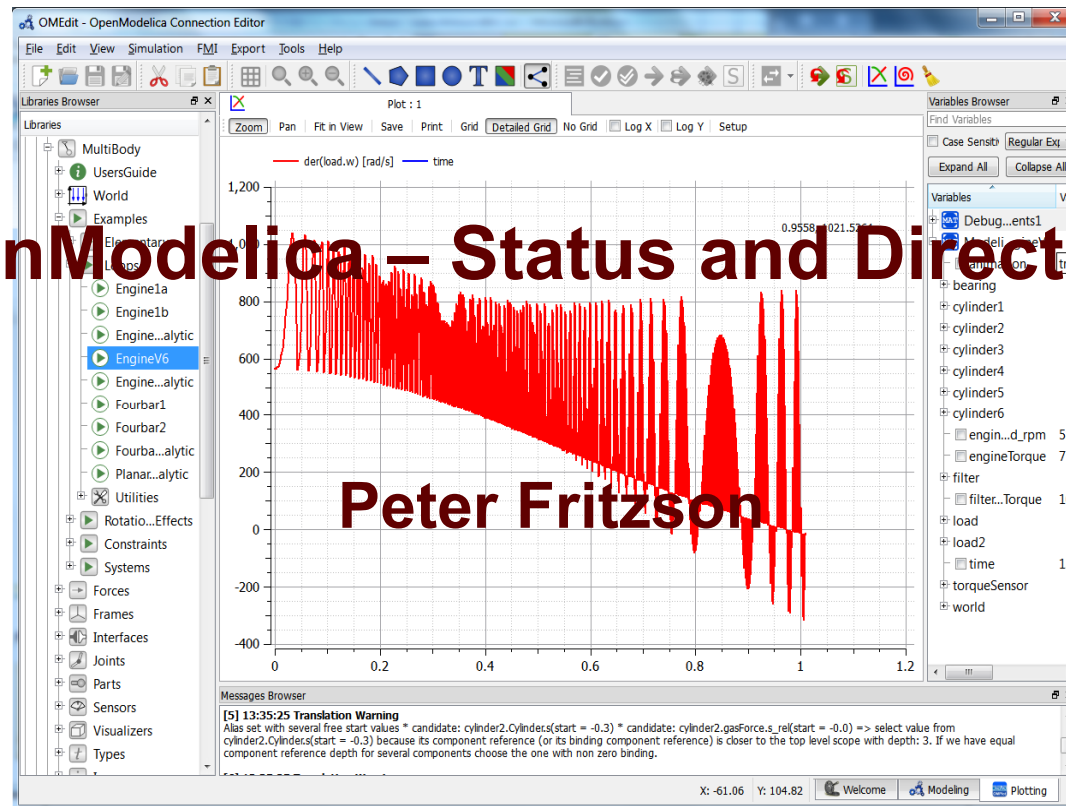
Goals for the OpenModelica Effort

- 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

MODELICA

Main Releases 2017

- OpenModelica **1.11.0 final release** (February 6, 2017)
  - Dramatically improved compilation **speed** and **performance**, esp. large models
  - Stabilized **Windows 64-bit** support; Updated OMDev involving msys2
  - **3D animation** visualization of MSL MultiBody simulations & for real-time FMUs
  - Faster and **more robust** OMEdit **GUI**.
  - A **DAEMode** solver mode for using the sparse IDA solver
  - Clocked/Synchronous: Supports about **100%** of library Modelica_synchronous
  - **OMWebbook**, an on-line web version of OMNotebook

- OpenModelica **1.12.0 final release** (Oct 31, 2017)
  - **OMSimulator** 1.0 – **FMI-TLM** simulator including **FMU composition**
  - Basic **graphical** editing support for **state machines** and transitions
  - Faster **lookup** processing, making some libraries faster to browse and compile
  - Additional advanced **visualization** features for multibody animation
  - Increased library **coverage** including increased verification coverage
  - Increased tool **interoperability** with the ZeroMQ communications protocol
  - Enhanced **OMPython** including **linearization**, now also working with Python 3
  - Support for **Linux** RedHat/Fedora **binary** builds of OpenModelica

MODELICA

New Frontend and OMEdit Replaceable Support
(work in progress)

- The OpenModelica **new compiler frontend** – a **large** effort to rewrite about half of the compiler to gain high compilation **performance** and 100% Modelica semantics

- Delayed – effort was much bigger than initially estimated

- Status December 2017, measured 36 times **faster** than the old frontend on medium/large test models

- Status January 2018, a rapidly increasing (but still small) number of MSL models **simulate** with the new frontend

- Status January 2018 – **replaceable** OMEdit GUI using the new frontend is **starting to work** on a number of MSL models
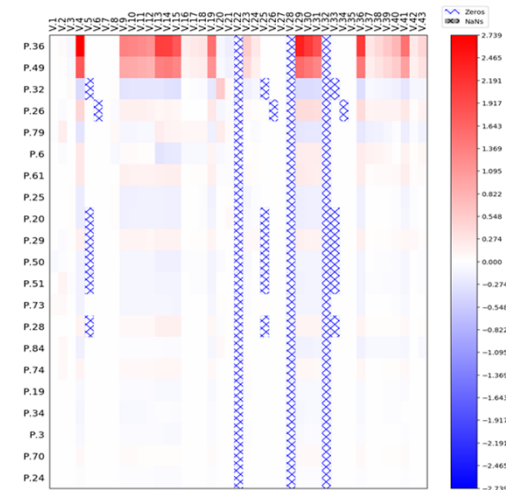
- Now we believe we can see **light in the tunnel** …

MODELICA

OMSimulator (TLM & FMI) (talk by Lennart later today)

- **Main goal**: (**Co-)simulation** environment based on **FMU**s that provide both **signal connections** and **TLM connections**

- Model exchange & Co-simulation FMUs

- **Scripting** interface (Python, Modelica, Lua)

- Graphical user interface (OMEdit, Papyrus)

- Graphical **composition** of FMUs

- **Distributed** simulations utilizing TLM master

- SSP support for composite models

MODELICA

OMSens – Simultaneous Param-based Sensitivity Analysis and Robust Optimization (work in progress)

Paper at
EOOLT 2017
(prototype)

- 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

MODELICA

Interactive Control of Simulations using OPC-UA

- OPC-UA is an industry standard for industrial automation

- OPC-UA in OpenModelica can be used to:

    – Control simulations in real-time

    – Change inputs, parameters

    – Interactive plotting

    – Open source clients are available (C++, Python, etc)

    – More lightweight than controlling FMUs

DEMO Movie!

MODELICA

DEMO of Interactive Control of Simulations using OPC-UA
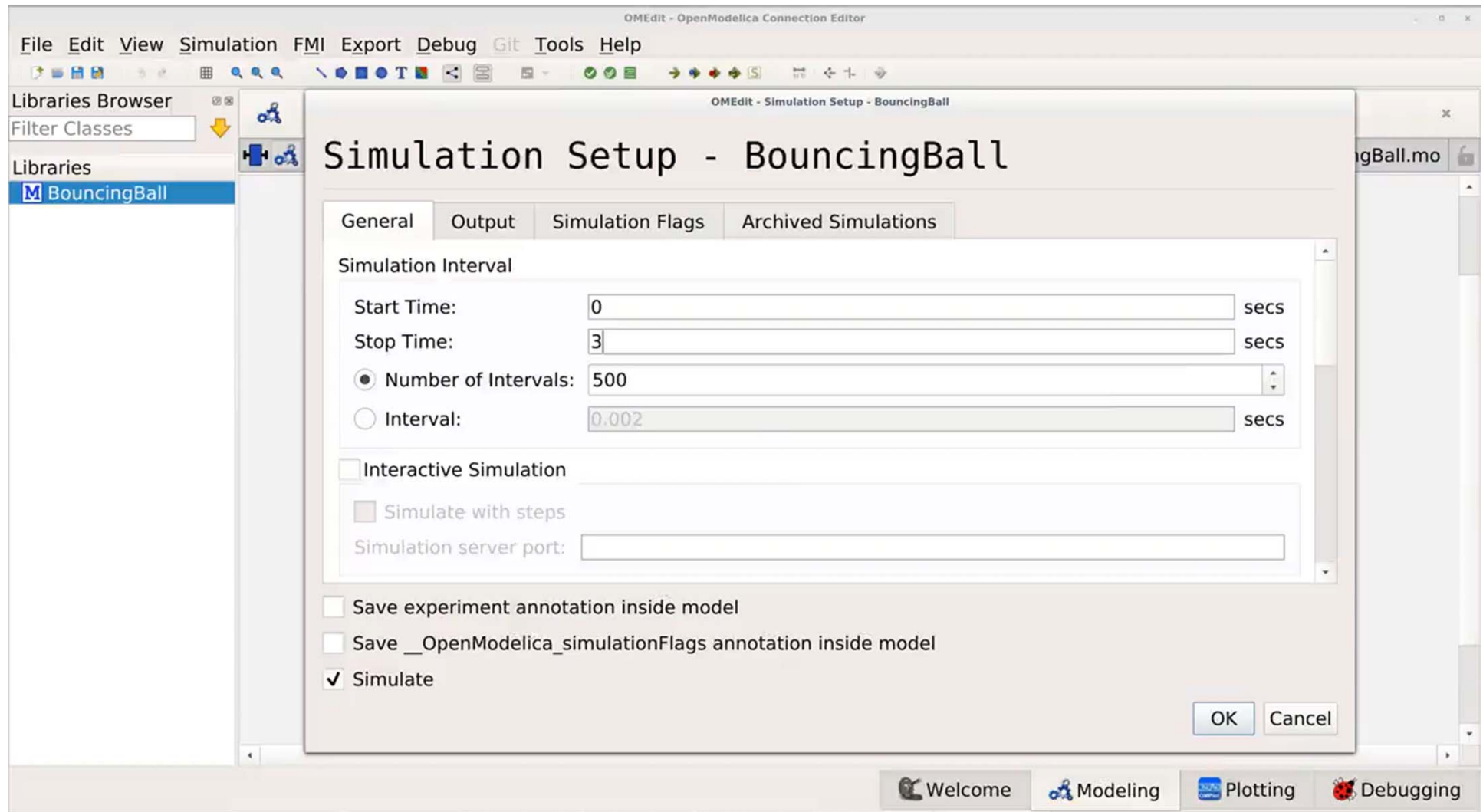
Encryption and Protection Annotations
(work in progress by Adeel)

- Encryption done with public/private key pair and the encrypted library files (*.moc) are bundled in a zip file (.mol).

- OMC decrypts the Modelica code in memory by using the decryption key.

- Uses Modelon/MathCore Library Encryption module

- Full support for Protection Access annotation in OMEdit allowing user to restrict model usage.

MODELICA
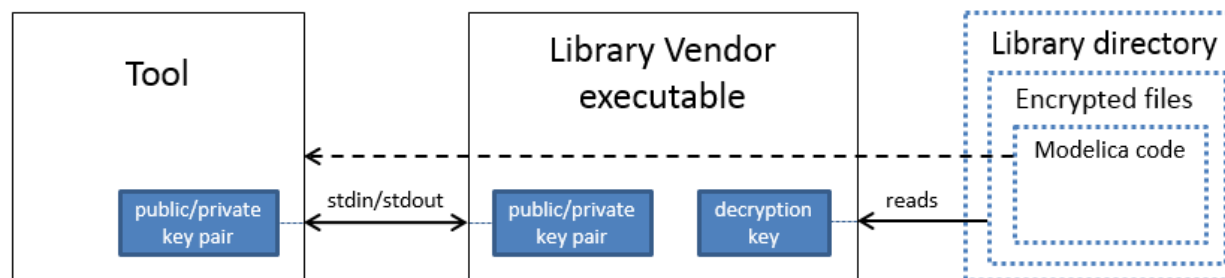
OMSysIdent (name pending, work in progress)
System Parameter Identification

- A new module which provides **parameter estimation** for (composite) models compiled to FMUs

- It uses the **Ceres Solve**r (developed at Google) for the solution of the **underlying optimization** problem

- The goal is to have an **API** that can be conveniently used from popular scripting languages such as Python

- The prototype has been developed on Linux, the work is currently ported to Windows

- It is planned to make it available within the first half of this year

MODELICA

OpenModelica – Outlook for 2018

- **Main goa**l: OpenModelica 2.0.0 release with significantly improved **coverage** for **libraries**, and significantly improved compiler and simulation **performance**, tool **robustness** and **quality**, including support for large-scale models
- Spring 2018. Release of OM 1.13.0 with **GUI** support for **replaceable** in libraries
- Whole 2018. Development of more **Industrial Use Cases**
- Summer 2018. Finalizing **new frontend** modules with significantly improved flattening for enhanced coverage and performance
- Spring 2018. **OMSens** – multiparameter sensitivity analysis and optimization
- Spring 2018. **OMSysIdent** – parameter system identification module
- Further Enhanced Equation model **debugging** support
- Further enhanced **embedded** system code generation and development support
- **Encryption** support by OpenModelica for use of commercial libraries with OM
- Enhanced **FMI** support, FMI Composition, in OMSimulator 2.0
- Matlab scripting API to OpenModelica
- Enhanced MetaModelica 3.0 documentation & environment with improved ease-of-use; consolidation; Investigation of Julia interfacing

MODELICA

# The OpenModelica Open Source Environment
www.openmodelica.org

- Advanced Interactive Modelica compiler (OMC)
  - Supports most of the Modelica Language
  - **Modelica** and **Python scripting**

- 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
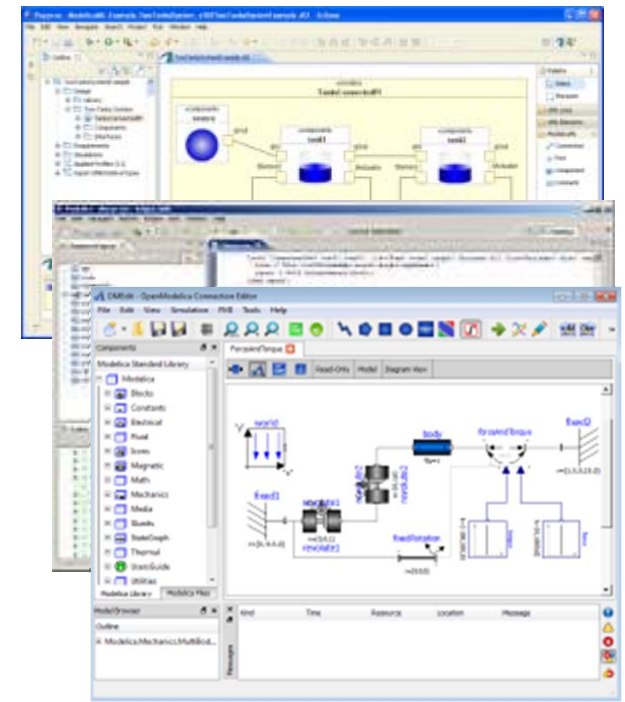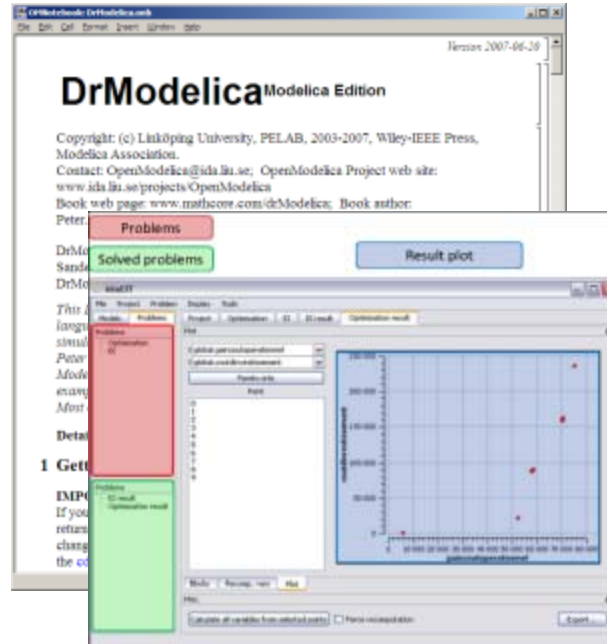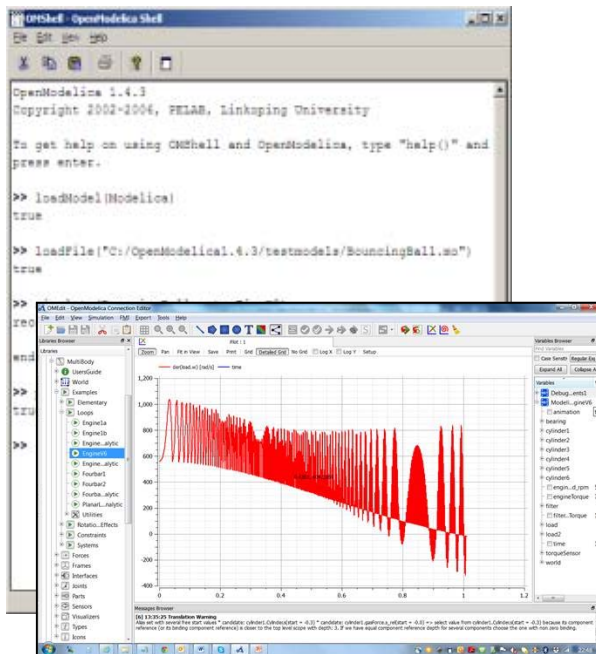
Current Main Industrial OpenModelica Usage
(not including research usage)

- 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

- ABB – fluid sub-model of a district heating plant is running in production

# Bosch Rexroth Control Edge Designer and Testing Framework
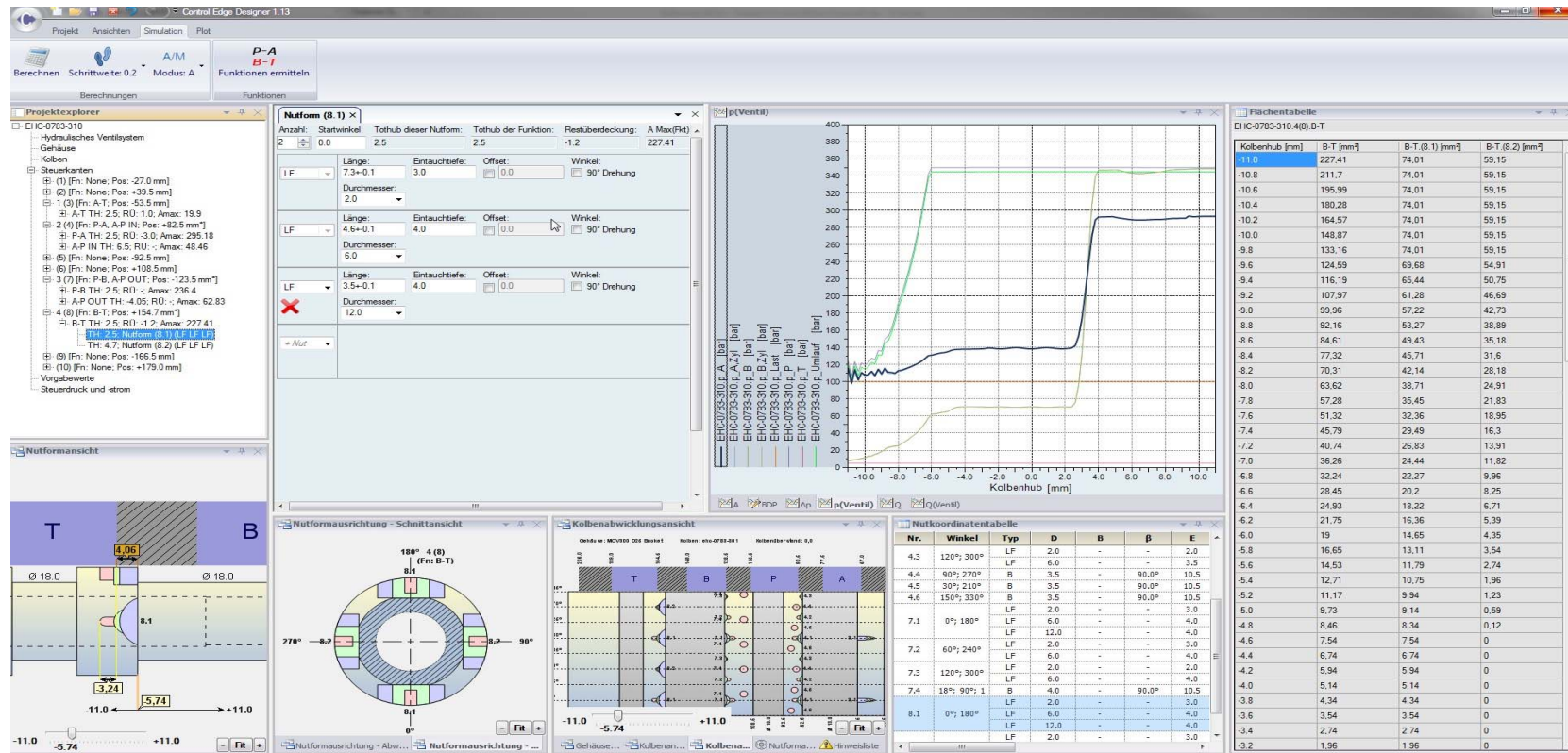
Bosch Rexroth Controller Code Generation Based on FMI

| Simulation Tool | Code Export | IEC Function Block | PLC |
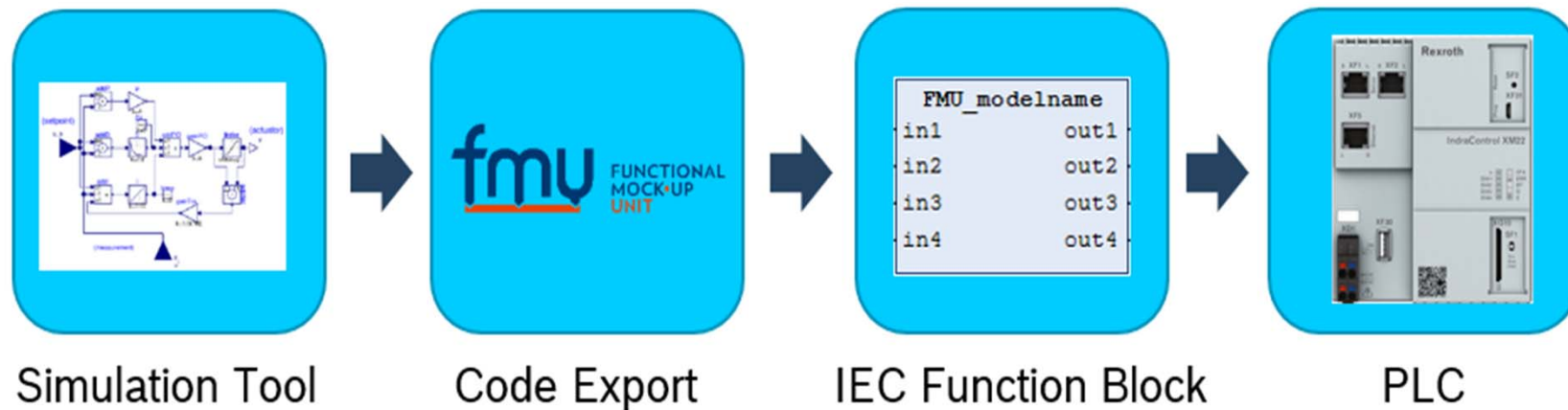
Large OpenModelica Industrial Use Case:
## ABB Industry Use of OpenModelica FMI 2.0 and Debugger

- ABB OPTIMAX® provides advanced model based control products for power generation and water utilities
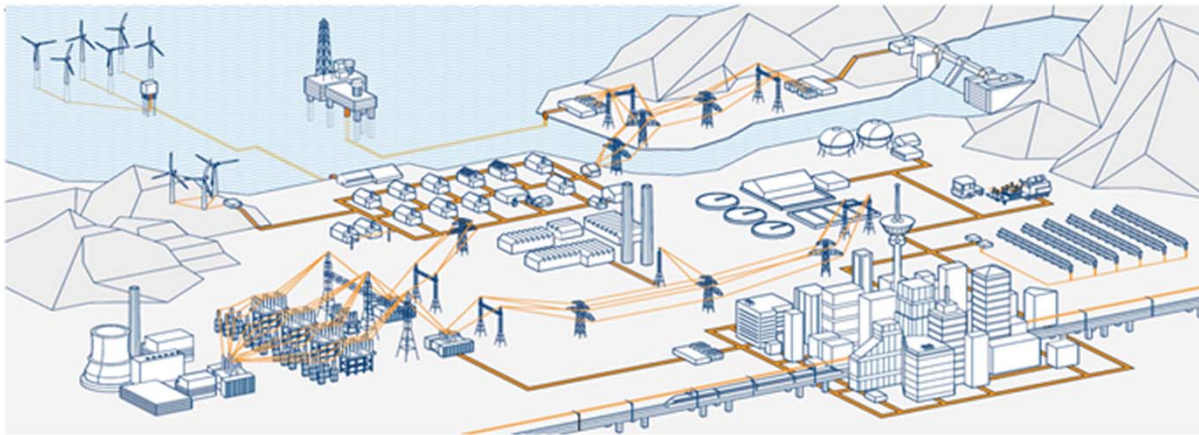
- ABB: "*ABB uses several compatible Modelica tools, including OpenModelica, depending on specific application needs.*"

- 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.
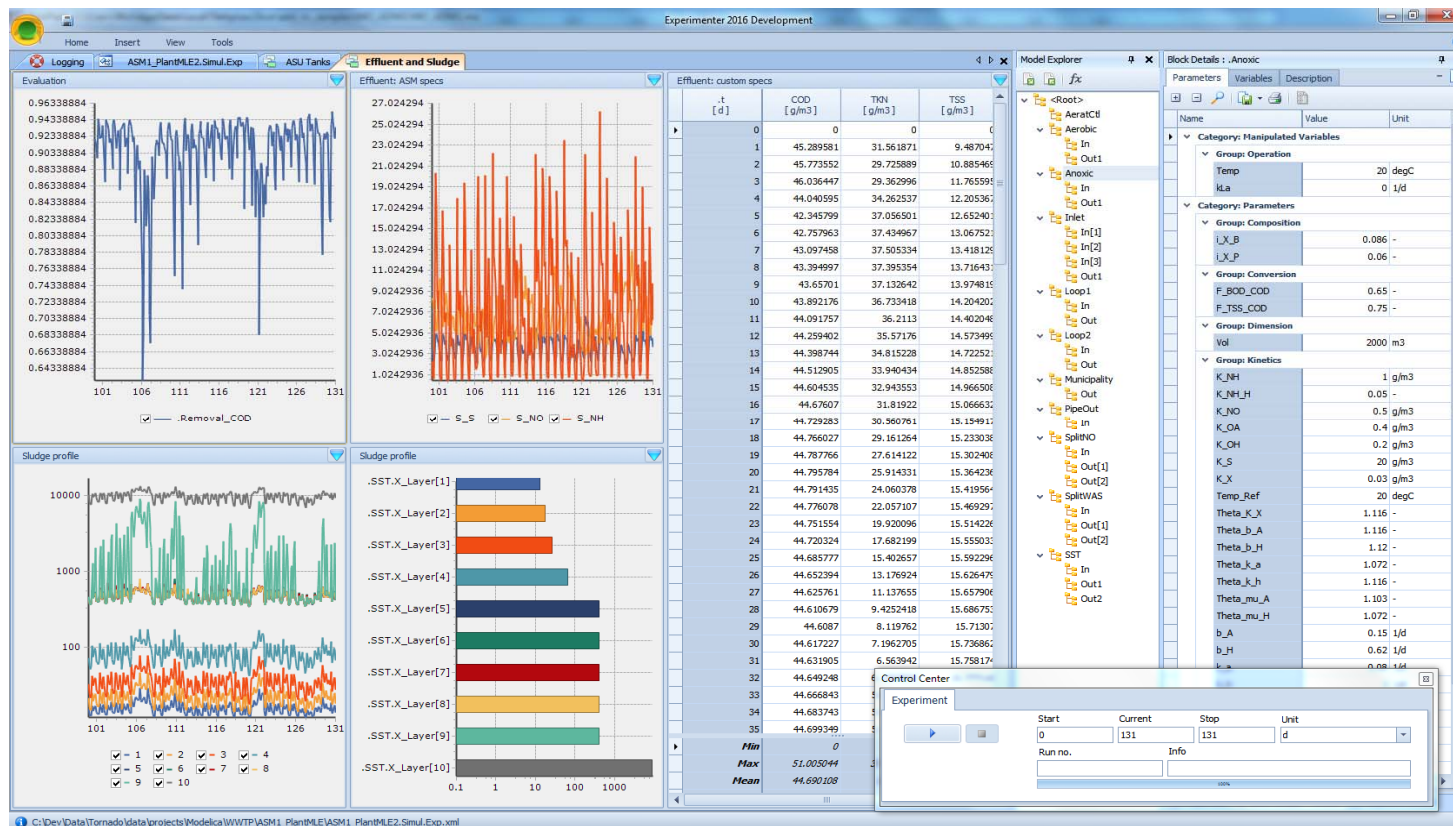
The Open Source Modelica Consortium

MODELICA

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.

MODELICA

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

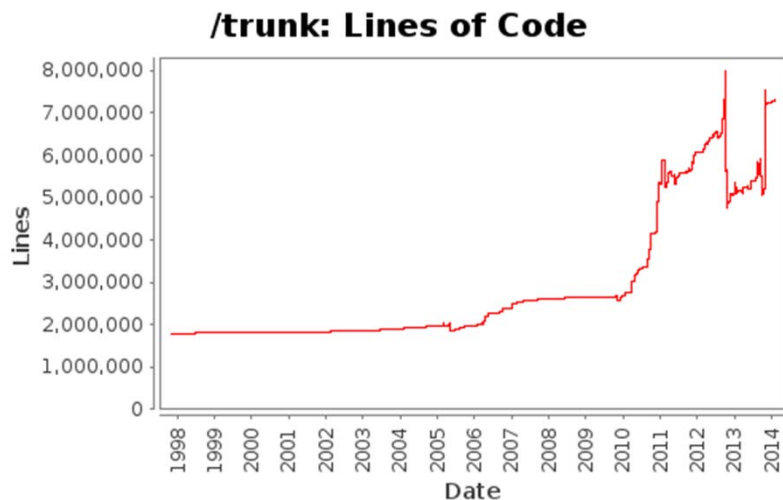- Technical University of Braunschweig, the Institut of Thermodynamik, Germany

MODELICA

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

OSMC 53 Organizational Members, Febr 2018
(initially 7 members, 2007)

Companies and Institutes

- ABB AB, Sweden
- Berger IT-Cosmos, Germany
- Bosch Rexroth AG, Germany
- Brainheart Energy AB, Sweden
- 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
- Scilab Enterprises, France
- SKF, Göteborg, Sweden
- TLK Thermo, Germany
- Siemens Turbo, Sweden
- Sozhou Tongyuan, China
- Talent Swarm, Spain
- VTI, Linköping, Sweden
- VTT, Finland
- Wolfram MathCore, Sweden

Universities

- FH Bielefeld, Bielefeld, Germany
- University of Bolivar, Colombia
- TU Braunschweig, Germany
- University of Calabria, Italy
- Univ California, Berkeley, USA
- 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
- KTH, Stockholm, Sweden
- 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
- Univ College SouthEast Norway
- Tsinghua Univ, Beijing, China
- Vanderbilt Univ, Nashville, USA

MODELICA

Open Source Modelica Consortium
Individual Members

(72 individual members, 5 February 2018)

- 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, 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

MODELICA

Open Source Modelica Consortium – OSMC Board of Directors 2017

- **Rüdiger Franke**, OSMC Chairman; Manager, ABB AG, Germany
- **Oliver Lenord**, OSMC Vice Chairman; Manager, Bosch, 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
- **Jan Brugård**, CEO, Wolfram MathCore AB, Sweden/USA
- Adrian Pop, adjoined to the Board, Tech coordinator, OSMC

MODELICA

OSMC Board – 3 Meetings Jan 1 2017 – Dec 31 2017

Meeting dates

- 170511
- 170921
- 171215

Board Work

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

OSMC Enhanced Business Models, Bylaws Update

**Extra Annual Meetings
for Bylaws update**

- 170628
- 170921

**Two New Business
Options for Members of OSMC**

- Directly Funded
  Development (DFD)

- Maintenance and support
  agreement (MSA)

MODELICA

Some Supporting Research Projects 2017

- PARADOM, German national project including ABB, Bosch-Rexroth, Siemens AG,TU Dresden, FHBielefeld

- ITEA3 project OPENCPS, started Dec 2015
(Open Cyber-Physical System Model-Driven Certified Development)
Sweden, France, Finland, Hungary

- Swedish project RTISIM, started Dec 2015

- New ITEA3 project EMPHYSIS, Sweden joined Dec 2017

- H2020 project PreFlexMS, 2015-2018

MODELICA

Special Thanks

- The developers who worked very hard during 2017 and modelers who tested and gave important feedback

- The OpenModelica consortium organizational members for support including ABB, Bosch-Rexroth, Wolfram-MathCore, RTE, Siemens Turbo Machinery, EDF, etc...

- Master students and PhD students who made important contributions.

Conclusions and Summary 2017/Jan 2018

- Feb 6, 2017. OpenModelica **1.11.0 release**
Much faster performance for large models. Faster OMEdit. Stable 64 bit on Windows, 3D animation in Omedit, More robust OMEdit, etc.

- October 31, 2017. OpenModelica **1.12.0 release**. Enhanced FMI/TLM simulation with OMSimulator, faster lookup, state machines graphical editing, tool interop with ZeroMQ, Enhanced OMPython, Linux binary builds, etc.

- 2018. Good prospects for the future – towards a standard high quality compliant open source Modelica implementation in Modelica, increased tool support for integrated systems engineering.

Questions?

www.openmodelica.org

MODELICA