OpenModelica.org
Presentation, Status and Future Developments

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2021-02-02

Open Source Modelica Consortium
PELAB, Linköping University
RISE, Research Institutes of Sweden
OpenModelica
• What is OpenModelica?
• The past

OpenModelica Technical Overview
• OMC, OMSHELL, OMNotebook, OMEdit, ModelicaML, OMSimulator, OMPython, OMJulia, OMMatlab

OpenModelica Development Environment
• MetaModelica
• The Eclipse Environment (MDT)

OpenModelica Latest Developments (2020-2021)
OpenModelica is ... its developers, testers, bug reporters, contributors and OSMC members

Thank you!

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, tmtnuomas, 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, rfranke, mflehmig, crupp2, kbalzereit, marchartung, Andreas, Karim, adrpo
What is OpenModelica? (I)

- Advanced Interactive Modelica compiler (OMC)
  - Supports MSL v. 3.2.1/3.2.2/MSL trunk
- Basic and advanced environments for creating models
  - OMSHELL - an interactive command handler
  - OMNotebook - a literate programming notebook
  - OMEdit - Connection Editor, *Transformational and Algorithmic Debugger, 3D Viewer*
  - OMPLOT - OpenModelica Plotting
  - OMOptim - OpenModelica Optimization Editor
  - OMPython/OMJulia/OMMatlab - OpenModelica Python/Julia/Matlab Environment
  - MDT - an advanced textual environment in Eclipse
  - OMSimulator - co-simulation of composite models using FMUs or via TLM
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
  - Should be replaced by OMEdit
- ModelicaML UML/SysML integration
What is OpenModelica? (III)

- Open-source community services
  - Website and Support Forum
  - Source versioning (github.com)
  - Trac with bug database
  - Development courses
  - Mailing lists
What is OpenModelica? (IV)

- Open-source community services
  - Extensive testing (unit & library coverage: 77 libraries, 17001 models) with interactive result comparison. 9 test servers currently
    - [https://libraries.openmodelica.org/branches/overview-combined.html](https://libraries.openmodelica.org/branches/overview-combined.html)
    - Linux (GCC & CLANG), Windows (MinGW GCC), Mac OS (GCC) - (deprecated after 1.16)
    - Platforms: x86, x86_64, ARM
    - 3 runtimes: FMI, C runtime, C++ runtime
  - ~10,449 tests ran on each pull request via Hudson
  - Automatic nightly builds for Window & Linux & Mac OS (deprecated after 1.16)
What is OpenModelica? (V)

- An incubator platform for research
  - 9 PhDs since 2004 (Debugging, Parallelization, PDEs Extensions)
  - 36 Master’s theses since 2004
  - Both the students and the project benefit

- Master theses at PELAB 2006-2018
  - 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
  - PDE-solver using ParModelica

- 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, VTT, Equa, Evonik, ABB
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
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
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
OpenModelica Roadmap – Past

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**
  - OMEdit - 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
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 Roadmap - Past

- **2014 - 2017 - Most focus on libraries support & performance**
  - MSL 3.2.1 (100% build/98% 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**
  - ~9000 commits in subversion from Feb. 2014 to Feb., 2016
  - Bug fixes
  - Release 1.9.2 (Linux, Mac, Windows)
2018 - 2019 - focus on performance, scalability, bug fixes

OMC & Clients
- Performance & scalability improvements
- Bug fixes to OMC, OMEdit, FMI

OMSimulator
- Combined FMI & TLM support, SSP support
- OMEdit GUI support

OMJulia
- API to access OpenModelica from Julia

General
- From Feb 2018 - Feb 2019
  - 30+ contributors
  - 800 commits (OMCompiler)
  - 969 commits (OMSimulator)
  - 213 commits (OMEdit)
- Releases 1.13.0, 1.13.1, 1.13.2
OpenModelica Roadmap - Past

- 2018 - 2019 - focus on performance, scalability, bug fixes

- New Front-End - status
  - The new front-end ~90% complete, (see #4138 on Trac)
  - 100+ times faster, 5+ times less memory consumption (no array expansions, no expansion of for loops in equations)
  - The new front-end also brings better support for libraries
  - Developed in line with MCP-0019: Flattening
  - Currently 423/424 models from MSL 3.2.3 pass the new front-end
  - Last year 107/387 models from MSL 3.2.3 passed the new front-end

- New Front-End - remaining work
  - Expandable connectors (add virtual nodes)
  - Making the backend cooperate with the new way the DAE is produced
  - Support for state machines
  - (Support for MetaModelica)
OpenModelica Roadmap - Past

- 2018 - 2019 - focus on performance, scalability, bug fixes

- OMEdit - better Modelica support
  - Much more stable OMEdit, a lot of bug fixes and new usability features
  - Auto completion support
  - Support for OMSimulator

- Redeclare and Replaceable Support
  - Waiting for the new front-end to become mature enough so we don’t frustrate users
OpenModelica Roadmap - Past

- 2019 - 2020 - focus on performance, scalability, bug fixes
- OMC & Clients
  - Performance & scalability improvements
  - Bug fixes to OMC, OMEdit, FMI
- OMSimulator
  - Combined FMI & TLM support, SSP support
  - OMEdit GUI support

General

- From Feb 2019 - Feb 2020
  - 30+ contributors
  - 929 commits (OpenModelica/OMCompiler/OMEdit)
  - 100 commits (OMSimulator)
- Releases 1.13.2, 1.14.1
OpenModelica Testing (I)

- **Testing procedure**
  - [https://libraries.openmodelica.org/branches/overview-combined.html](https://libraries.openmodelica.org/branches/overview-combined.html)
  - Run tests on previous OpenModelica version until 1.8.1
  - Detect both model regression and performance regression, all information saved in a database
  - 77 libraries, 17001 models with interactive result comparison.
    - 9 dedicated test servers
    - Linux (GCC & CLANG), Windows (MinGW GCC), Mac OS (GCC) (to be deprecated)
    - Platforms: x86, x86_64, ARM

**Statistics**
- 5 runtimes: FMI, C runtime, C++ runtime, newInst, daeMode

Number of libraries 77
Number of models 17001

**Tested branches**

<table>
<thead>
<tr>
<th>Branch</th>
<th>Version</th>
<th>Build time</th>
<th>Execution time</th>
<th># Simulate</th>
<th># Total</th>
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</thead>
<tbody>
<tr>
<td>v1.8.1-rml</td>
<td>1.8.1</td>
<td>2019-04-06 07:30:16 2 days, 7:02:18</td>
<td>1461</td>
<td>12322</td>
<td></td>
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<tr>
<td>v1.9.1</td>
<td>1.9.1</td>
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<td>742</td>
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<tr>
<td>v1.9.2</td>
<td>1.9.2</td>
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<td>4291</td>
<td>16441</td>
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<tr>
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<td>5762</td>
<td>10832</td>
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<tr>
<td>v1.9</td>
<td>v1.9.7-v1.9.7.3+g6347e1f61</td>
<td>2021-01-23 04:51:36 1 day, 15:49:42</td>
<td>5267</td>
<td>16441</td>
<td></td>
</tr>
<tr>
<td>v1.11</td>
<td>v1.11.0-v1.11.0.8+gbda991e5b</td>
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<td>5395</td>
<td>16441</td>
<td></td>
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<td></td>
</tr>
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<td>12372</td>
<td>15079</td>
<td></td>
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<tr>
<td>v1.14</td>
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<td>12575</td>
<td>15079</td>
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<td>12408</td>
<td>15079</td>
<td></td>
</tr>
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<td>2021-01-29 21:59:28 2 days, 15:46:18</td>
<td>13692</td>
<td>16441</td>
<td></td>
</tr>
</tbody>
</table>

10 hours faster
2021-02-01 v1.18-dev - total 516 - build 509 (98%) - sim 493 (95%)

Up 2% since last year
OpenModelica Testing (III)

- 2021-02-01 v1.16-dev - total 586 - build 573 (98%) - sim 560 (95%)
- Up 5% / 8% since last year
OpenModelica Statistics (I)

- Moved the source code to github May 2015
- Mature code base: https://github.com/OpenModelica
- ~9000K+ lines of code and tests

- From Feb 2017 - Feb 2018
  - 20 contributors
  - 794 commits (OMCompiler)

- From Feb 2018 - Feb 2019
  - 30+ contributors
  - 800 commits (OMCompiler)
  - 969 commits (OMSimulator)
  - 213 commits (OMEdit)

- From Feb 2019 - Feb 2020
  - 30+ contributors
  - 800 commits (OMCompiler)
  - 459 commits (OMSimulator)
  - 213 commits (OMEdit)
OpenModelica Statistics (II)

Feb 5, 2018 – Feb 3, 2019

Contributions to master, excluding merge commits

### #1
- **perost**
  - 320 commits
  - 29,544 ++ 11,752 --

### #2
- **sjoelund**
  - 96 commits
  - 3,869 ++ 7,322 --

### #3
- **adrpo**
  - 85 commits
  - 5,528 ++ 1,383 --

### #4
- **wibraun**
  - 77 commits
  - 4,847 ++ 3,954 --

### #5
- **rfranke**
  - 74 commits
  - 2,090 ++ 1,099 --

### #6
- **hkiel**
  - 31 commits
  - 473 ++ 412 --
OpenModelica Statistics (III)

Feb 12, 2019 – Feb 3, 2020

Contributions to master, excluding merge commits

- **perost**
  - 196 commits
  - 15,583 ++ 5,499 --

- **adeas31**
  - 185 commits
  - 256,216 ++ 237,761 --

- **sjoelund**
  - 175 commits
  - 31,182 ++ 37,645 --

- **adrpo**
  - 124 commits
  - 214,824 ++ 197,720 --
OpenModelica Statistics (IV)

Feb 3, 2020 – Feb 1, 2021

Contributions to master, excluding merge commits

perost
173 commits 57,347 ++ 68,228 --

OpenModelica-Hudson
141 commits 141 ++ 141 --

adeas31
100 commits 20,791 ++ 18,229 --

adrpo
95 commits 469,449 ++ 18,274 --

sjoeld
71 commits 869,332 ++ 7,561 --

AnHeuermann
70 commits 10,874 ++ 5,635 --
Outline

- OpenModelica
  - What is OpenModelica?
  - The past

- OpenModelica Technical Overview
  - OMC, OMSHELL, OMNotebook, OMEdit, ModelicaML, OMSimulator, OMPython, OMJulia, OMMatlab

- OpenModelica Development Environment
  - MetaModelica
  - The Eclipse Environment (MDT)

- OpenModelica Latest Developments (2020-2021)
OMShell & OMNotebook

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.plt"
end record

>> plot(h)
true

>>

DrModelica Modelica Edition
Copyright (c) Linkoping University, PELAB, 2003-2007, Wiley-IEEE Press,
Modelica Association.
Contact: OpenModelica, www.ida.liu.se/
Book web page: Peter.Fritzon@.../DrModelica adulte
DrModelica Author: Sandelin, Peter Fritzon
This DrModelica language as used for this simulation. It is
Peter Fritzon, "OpenModelica" (2006) example and example
Most of the text

Detailed Copy

1 Getting Started

IMPORTANT
If you end a command returned in an output window, you must change the direction of the run using the command:

>> simulate(VanDerPol, startTime=0, stopTime=25);

To illustrate the behavior of the model, we give a command to simulate the Van der Pol oscillator during 25 seconds starting at time 0.

Plot by OpenModelica

Plot by OpenModelica

0 0.5 1.0 1.5 2.0 2.5 3.0
0.0 0.2 0.4 0.6 0.8 1.0

Plot by OpenModelica

0 0.5 1.0 1.5 2.0 2.5 3.0
0 1

Plot by OpenModelica
The OMC Compiler

- Implemented mainly in MetaModelica (401 packages) and a C/C++ runtime
- Is available as a dynamic library (faster than CORBA/ZMQ)
- Used from OMEdit, OMNotebook, OMSHELL, OMOptim, OMPython, MDT
- Automatically generated API that can be used from QT
Outline

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

- OpenModelica Technical Overview
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- OpenModelica Development Environment
  - MetaModelica
  - The Eclipse Environment

- OpenModelica Latest Developments (2019-2020)
- **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 union types
Creation of Modelica projects using wizards
Creating Modelica projects (II)

Modelica project
Creating Modelica packages using wizards

Creation of Modelica packages using wizards
Creating Modelica classes

Creation of Modelica classes, models, etc, using wizards
Code browsing

Parse error detection on file save.
Error detection (II)

Semantic error detection on compilation
Code assistance (I)

Code Assistance on imports
Code assistance (II)

Code Assistance on assignments
Code assistance (III)

Code Assistance on function calls
Code indentation

```modelica
// 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.Const.nts.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 1 - tomorrow at ModProd 2021!
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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OpenModelica Development Environment

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OpenModelica Latest Developments (2020-2021)
2020 - 2021 - focus on performance, scalability, bug fixes

OMC & Clients
- Performance & scalability improvements
- Bug fixes to OMC, OMEdit, FMI
- First replaceable support in OMEdit
- New Fronted by default in 1.16.x
- Better FMI export

OMSimulator
- Combined FMI & TLM support, SSP support
- OMEdit GUI support

General
- From Feb 2020 - Feb 2021
  - 33+ contributors
  - 878 commits (OpenModelica/OMCompiler/OMEdit)
  - 139 commits (OMSimulator)
- Releases 1.16.x
New Front-End - status

- The new front-end ~98% complete, (see #4138 on Trac)
- 100+ times faster, 5+ times less memory consumption (no array expansions, no expansion of for loops in equations)
- The new front-end also brings better support for libraries
- Developed in line with MCP-0019: Flattening
- Currently 424/424 models from MSL 3.2.3 pass the new front-end
- Two years ago 107/387 models from MSL 3.2.3 passed

New Front-End - remaining work

- Small issues remaining with array modifiers
- Some issues remaining with replaceable support (Buildings library)
- Making the backend cooperate with the new way the DAE is produced
- Support for state machines
- (Support for MetaModelica)
OMEdit

- **Faster** OMEdit using the new frontend
- A lot of bug fixes and new usability features
- Auto completion support
- GUI for OMSimulator, SPP
- Supports the standard Windows installation
- Encryption support

OMSimulator

- Better OMEdit support
- Improved SSP support
Latest Developments (2020-2021) (IV)

- **OMEdit - Redeclarable and Replaceable Support**
  - Support for redeclare/replaceable is available since 1.16.x
  - The new front-end is mature enough to not frustrate users
  - Edit the parameters of replaceable will be available in 1.18.x

- **OpenModelica on Windows**
  - Use clang to speed up builds and compile bigger models - available with 1.17.x
Future 2021+

- OMC / OMEdit - new API for instance hierarchy editing
  - Faster model display and graphical editing
  - Use the new front-end to instantiate the Model (once!)
  - Give the instance tree (including typed annotations) to OMEdit
    - automatically generated C++ classes for walking the tree
  - Allow OMEdit to edit the instance tree directly
    - Propagate the instance tree edits to the top level class
    - Build a simulation from the changed instance tree

- Web Browser Editor and OMSimulator in the cloud
  - Part of HUBCAP project
  - POC should be available soon

- Julia instead of MetaModelica?
  - OpenModelica front-end translated to Julia
  - Back-end in Julia, support for VSS ongoing
  - Talk by John Tinnerholm (already presented)
Thank You!

Questions?

asodja, sjoelund.se, sebco011, lochel, wbraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levsu, mahge930, x05andfe, mohsen, mutaro, 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, abhinuk, 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, rfranke, mflehmig, crupp2, kbalzereit, marchartung, Andreas, Karim, adrpo.

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