OpenModelica.org

Presentation, Status and Future Developments

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Open Source Modelica Consortium
Programming Environment Laboratory
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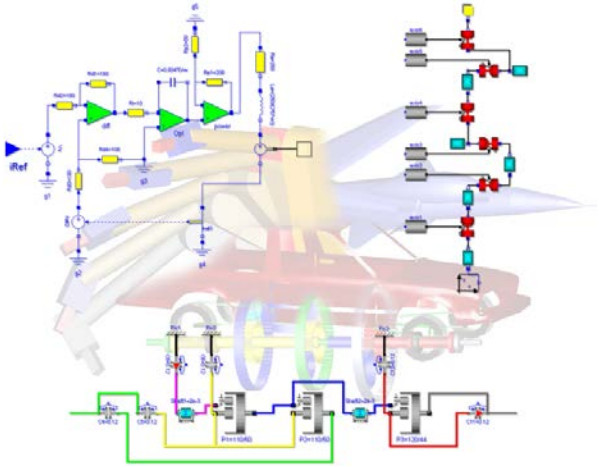

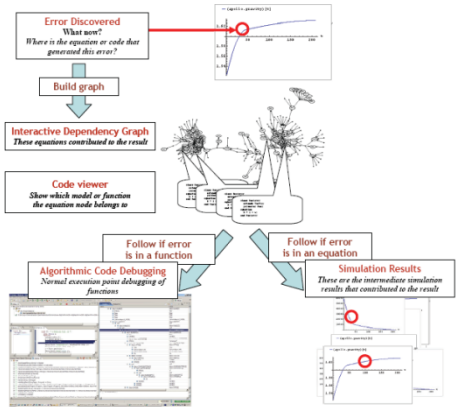

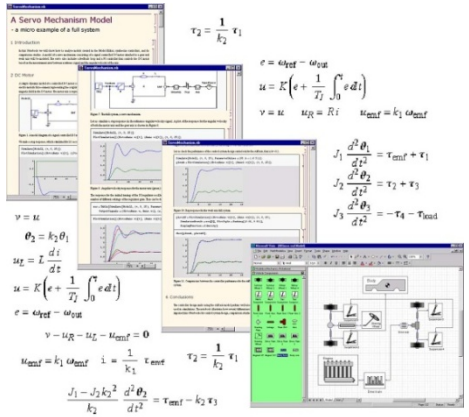

www.OpenModelica.org

OPEN SOURCE MODELICA CONSORTIUM

OpenModelica

MODELICA

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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 (2018-2019)

What is OpenModelica? (0)

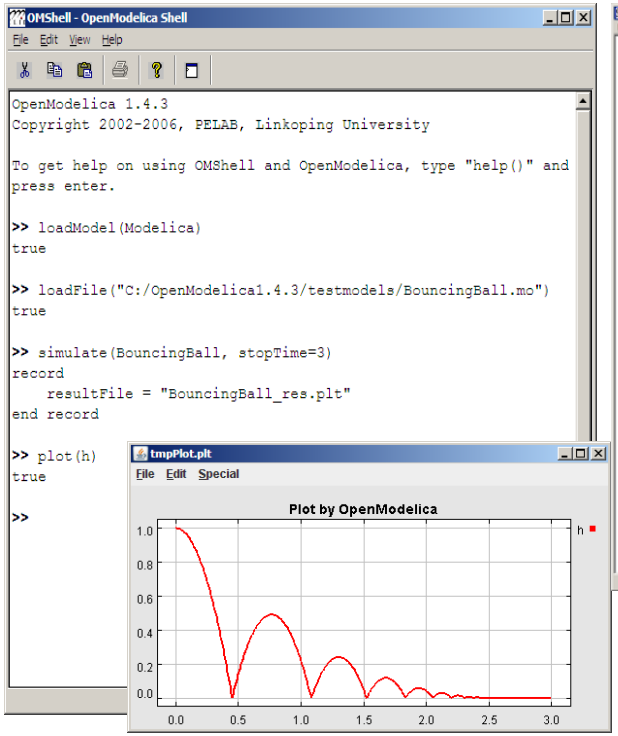
OpenModelica is … *its developers, testers, bug reporters, contributors and OSMC members*

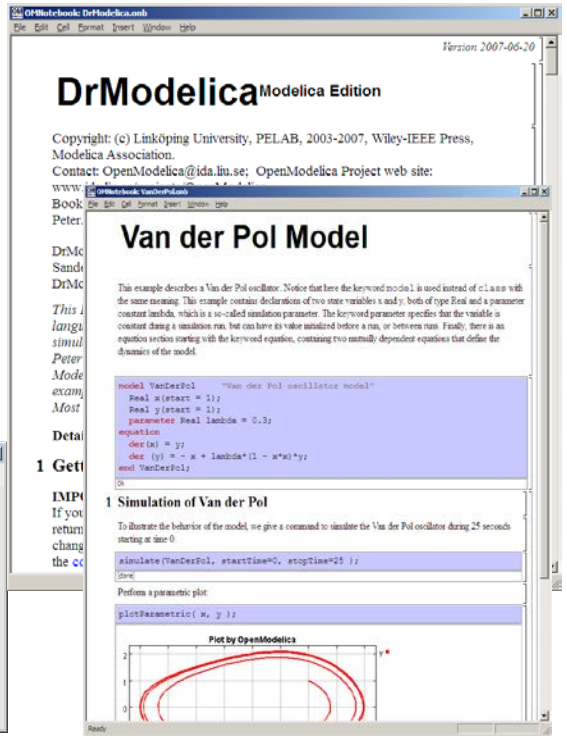
Thank you!

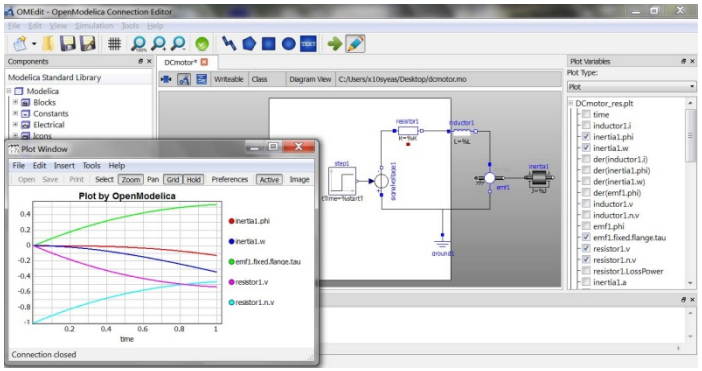
asodja, sjoelund.se, sebco011, lochel, wbraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levsa, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florosx, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka, 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, 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, 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

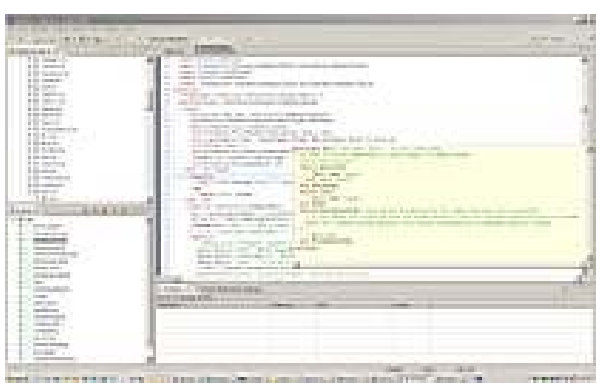


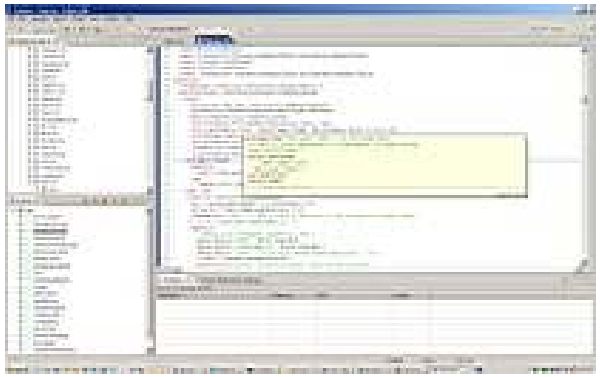


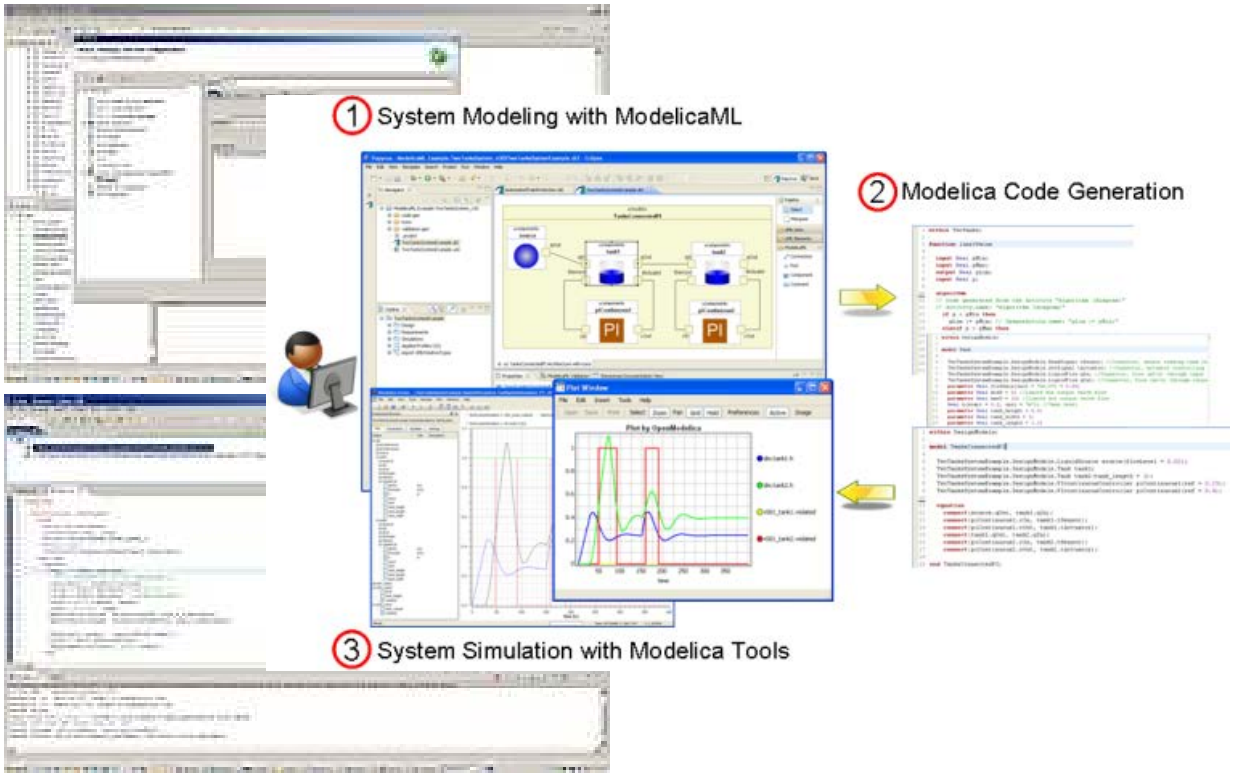


What Is OpenModelica? (II)

- **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**

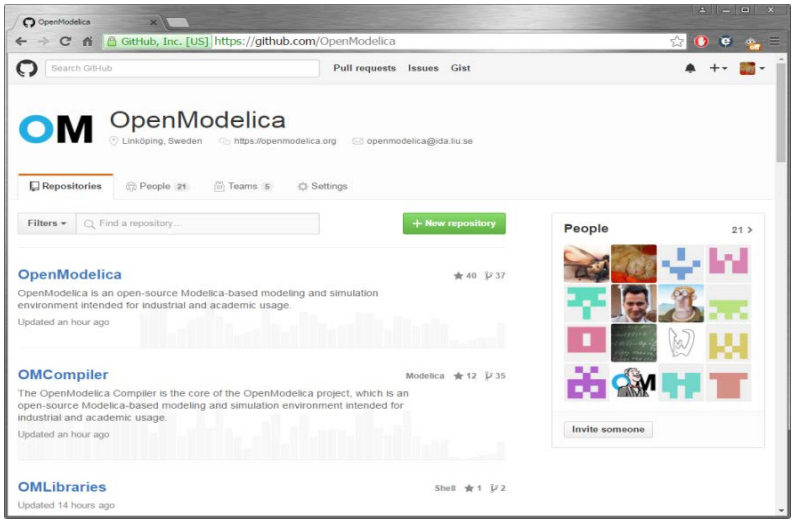


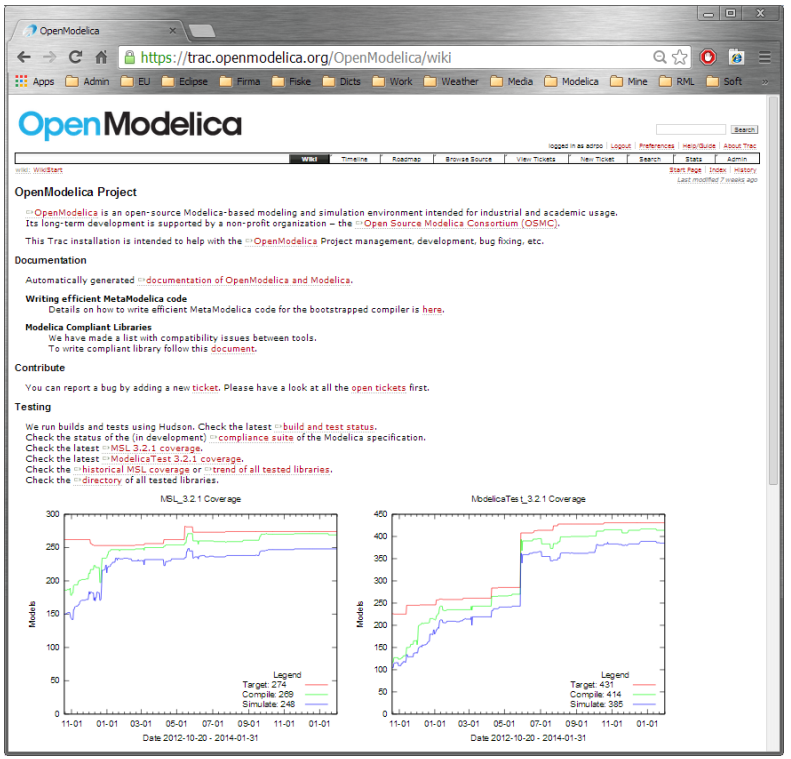




What is OpenModelica? (III)

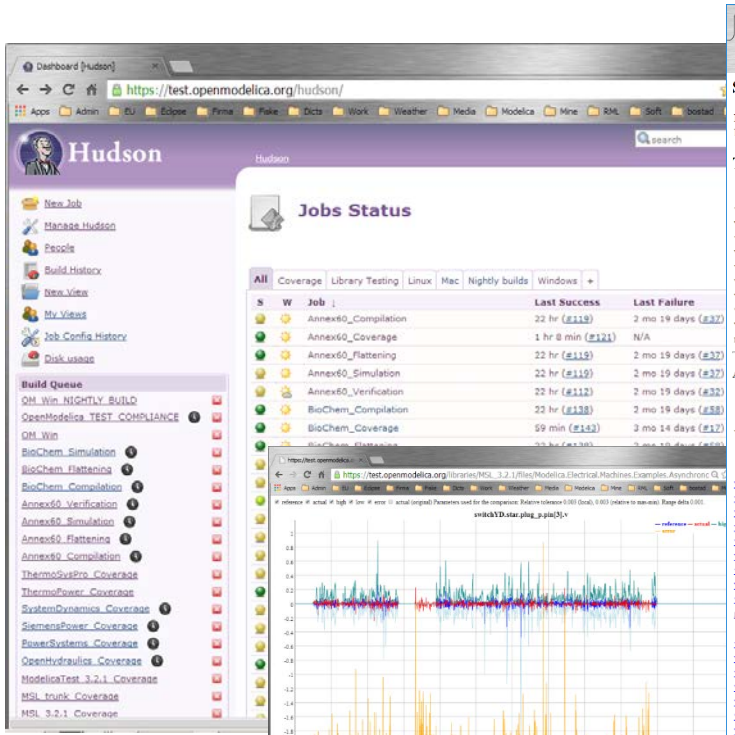
- Open-source community services
  - Website and Support Forum
  - Source versioning (github.com)
  - Trac with bug database
  - Development courses
  - Mailing lists

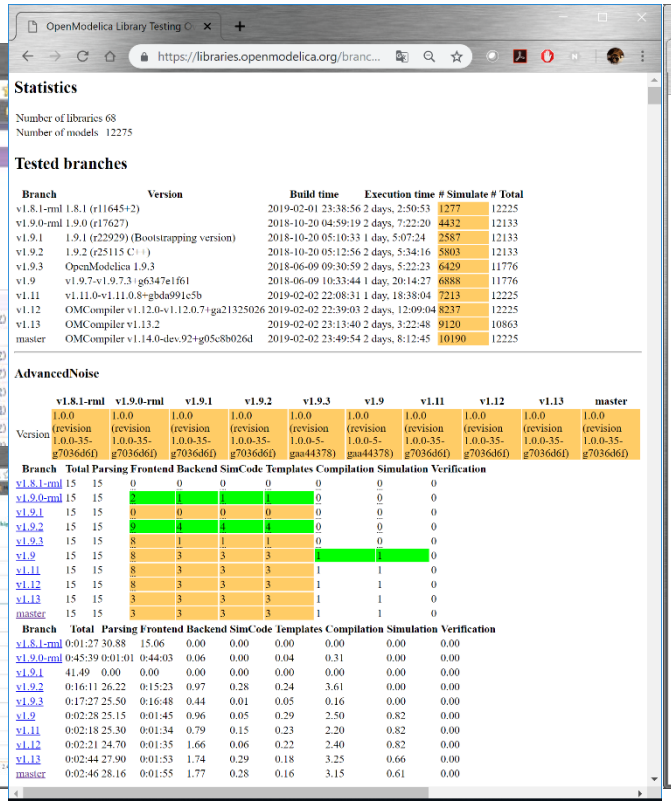


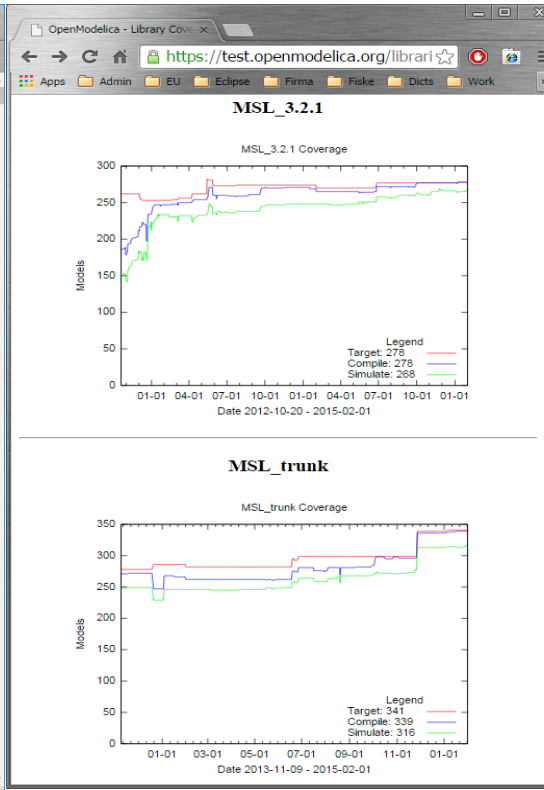


What is OpenModelica? (IV)

- Open-source community services
  - Extensive testing (unit & library coverage: 68 libraries, 12275 models) with interactive result comparison. 9 test servers currently
    - https://libraries.openmodelica.org/branches/overview-combined.html
    - Linux (GCC & CLANG), Windows (MinGW GCC), Mac OS (GCC)
    - Platforms: x86, x86_64, ARM
    - 3 runtimes: FMI, C runtime, C++ runtime
  - ~3910 tests ran on each pull request via Hudson
  - Automatic nightly builds for Window & Linux & Mac OS







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

OpenModelica Roadmap - Past

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

OpenModelica Roadmap - Past

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

OpenModelica Roadmap – Past

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

OpenModelica Roadmap – Past

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 reconcilation)
  - 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)

OpenModelica Testing (I)

- Testing procedure developed by Martin Sjölund
  - 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
  - 68 libraries, 12275 models with interactive result comparison.
    - 3 dedicated test servers
    - Linux (GCC & CLANG), Windows (MinGW GCC), Mac OS (GCC)
    - Platforms: x86, x86_64, ARM
    - 5 runtimes: FMI, C runtime, C++ runtime, newInst, daeMode

Statistics

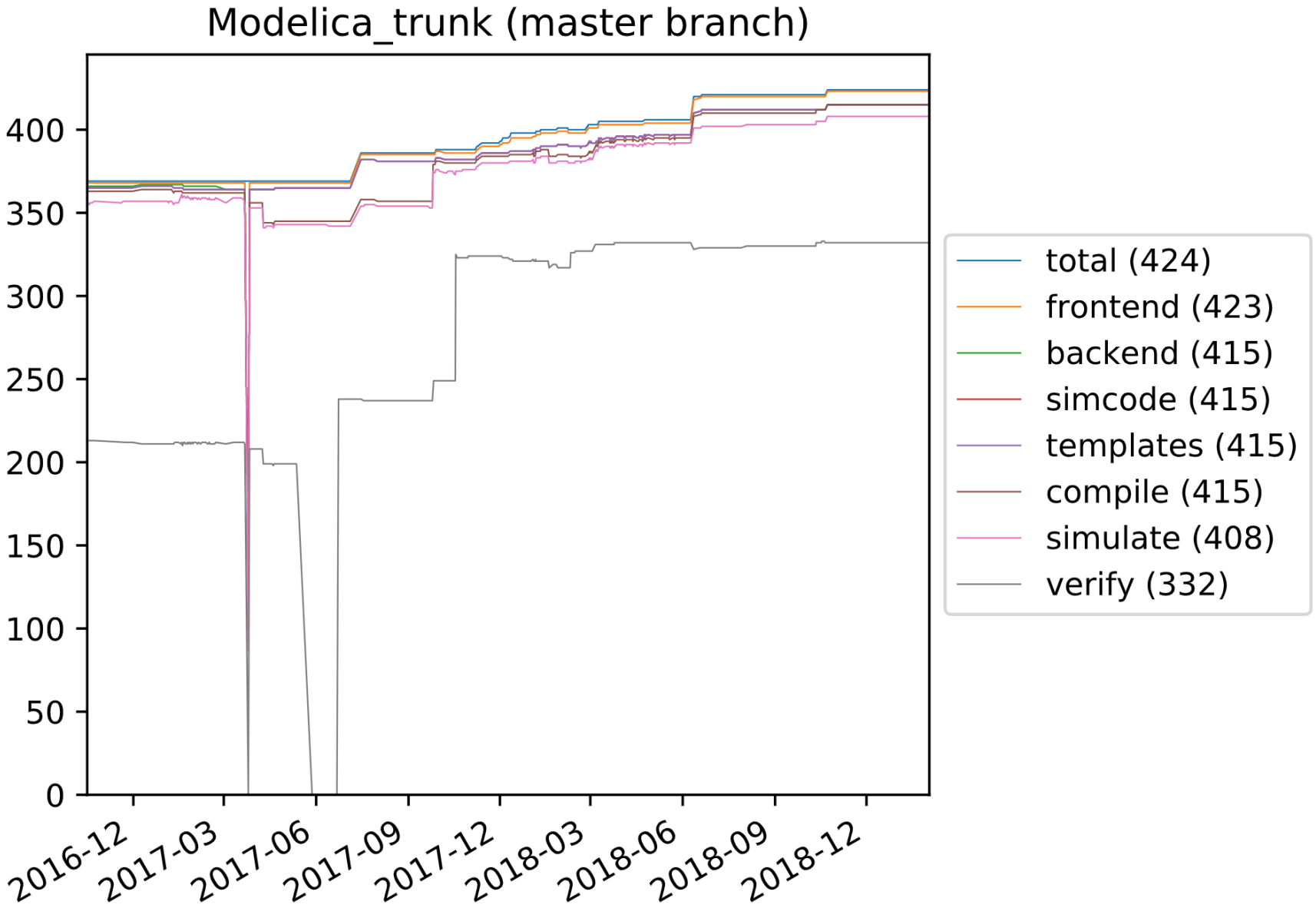
Number of libraries 68
Number of models 12275

Tested branches

Branch	Version	Build time	Execution time	# Simulate	# Total
v1.8.1-rml	1.8.1 (r11645+2)	2019-02-01 23:38:56	2 days, 2:50:53	1277	12225
v1.9.0-rml	1.9.0 (r17627)	2018-10-20 04:59:19	2 days, 7:22:20	4432	12133
v1.9.1	1.9.1 (r22929) (Bootstrapping version)	2018-10-20 05:10:33	1 day, 5:07:24	2587	12133
v1.9.2	1.9.2 (r25115 C++)	2018-10-20 05:12:56	2 days, 5:34:16	5803	12133
v1.9.3	OpenModelica 1.9.3	2018-06-09 09:30:59	2 days, 5:22:23	6429	11776
v1.9	v1.9.7-v1.9.7.3+g6347e1f61	2018-06-09 10:33:44	1 day, 20:14:27	6888	11776
v1.11	v1.11.0-v1.11.0.8+gbda991e5b	2019-02-02 22:08:31	1 day, 18:38:04	7213	12225
v1.12	OMCompiler v1.12.0-v1.12.0.7+ga21325026	2019-02-02 22:39:03	2 days, 12:09:04	8237	12225
v1.13	OMCompiler v1.13.2	2019-02-02 23:13:40	2 days, 3:22:48	9120	10863
master	OMCompiler v1.14.0-dev.92+g05c8b026d	2019-02-02 23:49:54	2 days, 8:12:45	10190	12225

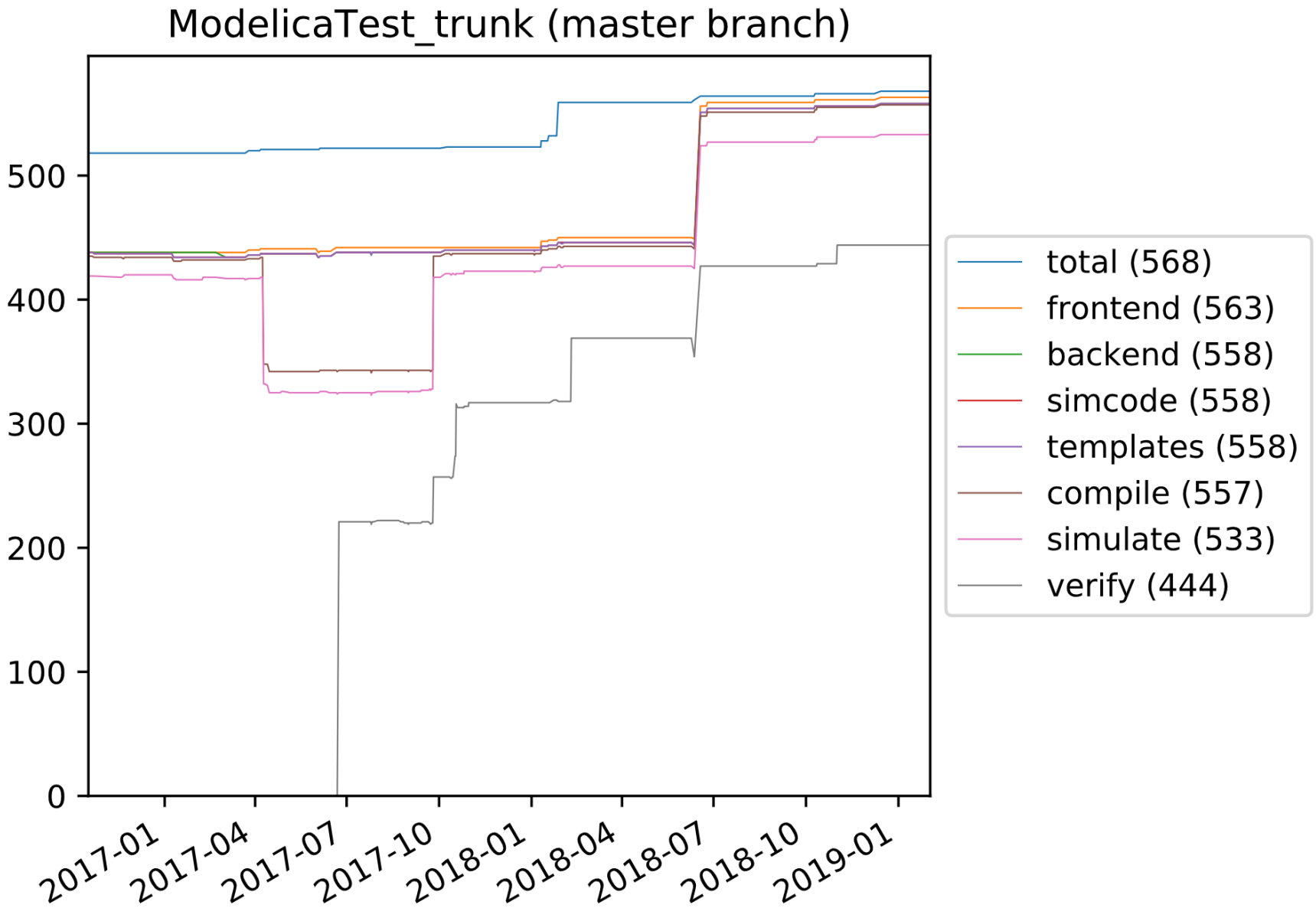
OpenModelica Testing (II)

- 2019-02-04 v1.14-dev - total 424 - build 415 (98%) – sim 408 (96%)



OpenModelica Testing (III)

- 2019-02-04 v1.14-dev - total 568 - build 557 (98%) - sim 533 (93%)



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)

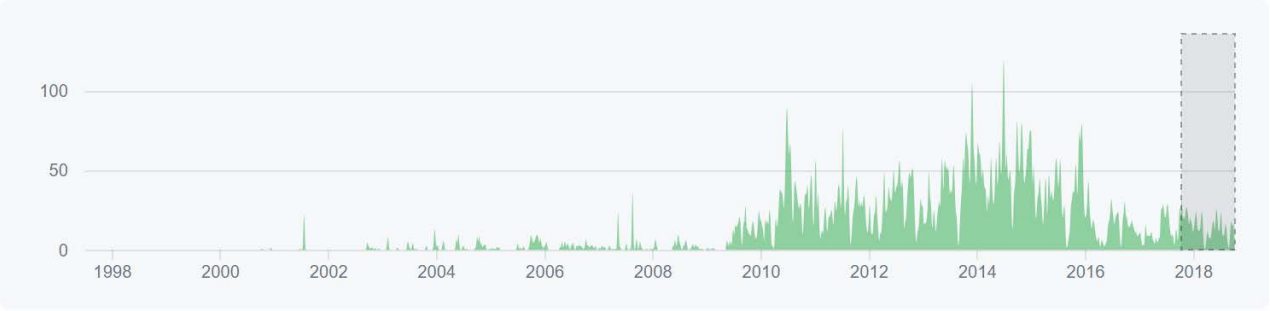
- From Feb 2018 – Feb 2019
  - 30+ contributors
  - 800 commits (OMCompiler)
  - 969 commits (OMSimulator)
  - 213 commits (OMEdit)

OpenModelica Statistics (II)

Feb 5, 2018 – Feb 3, 2019

Contributions: Commits

Contributions to master, excluding merge commits



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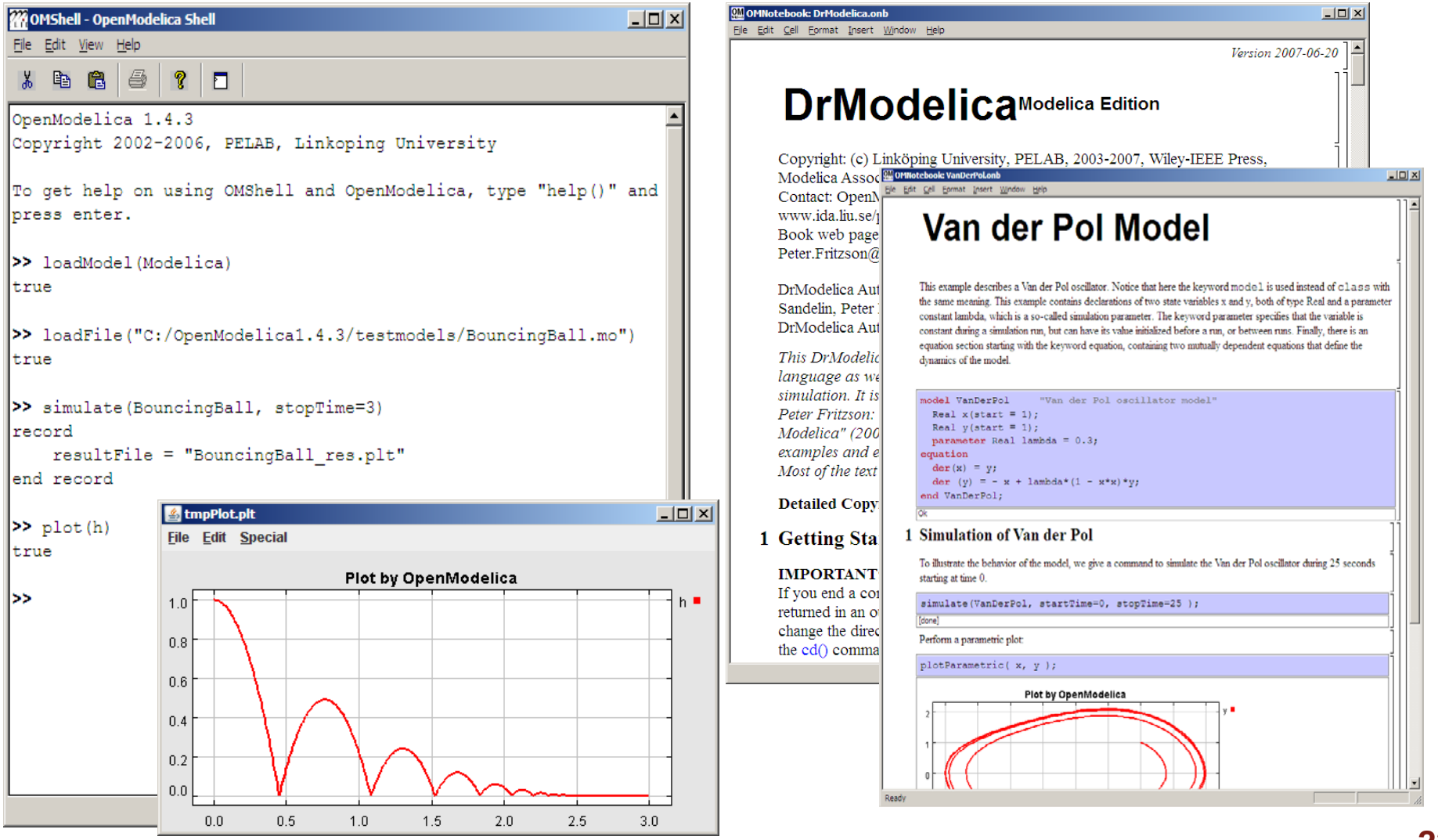
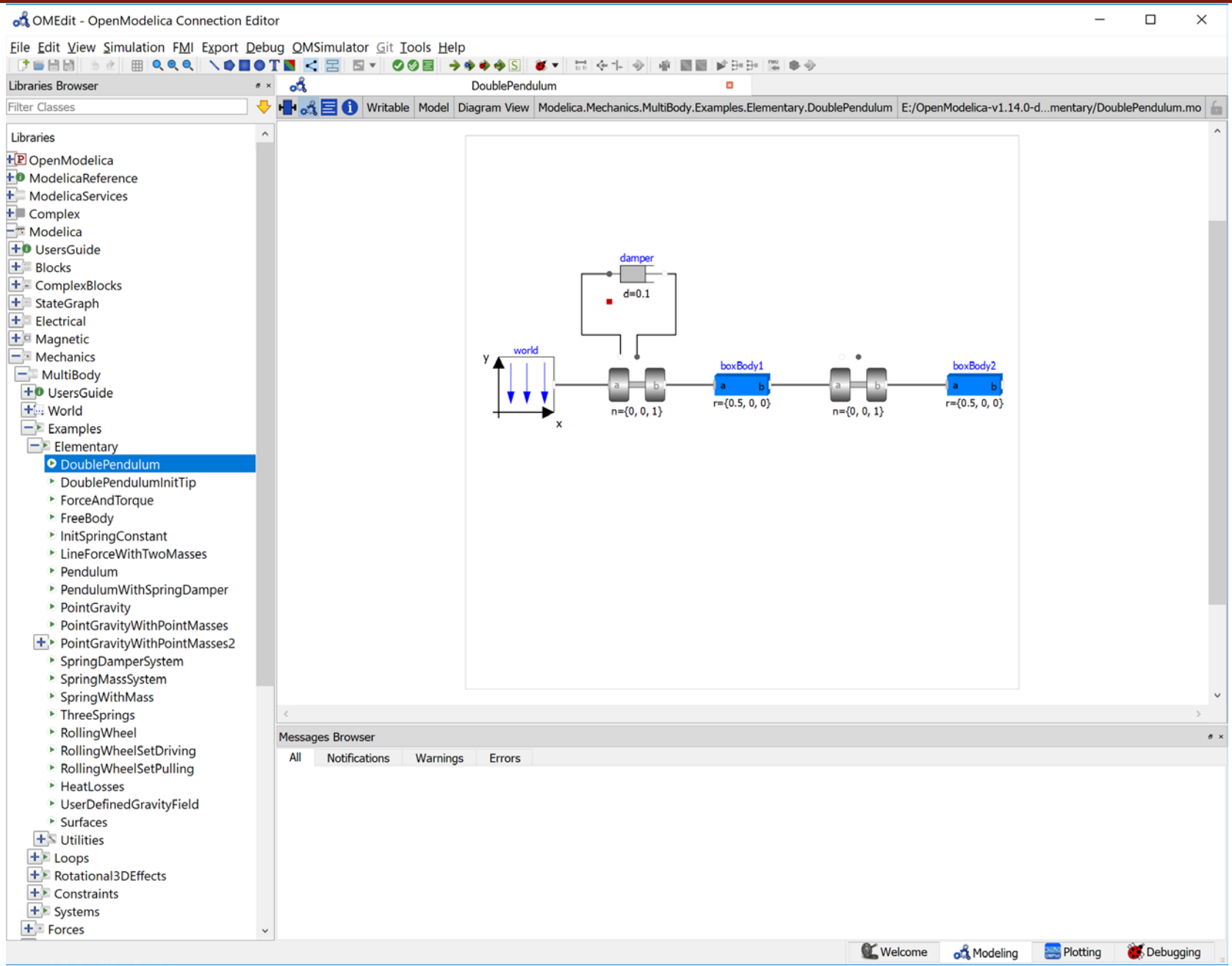
OMShell & OMNotebook



OMEdit- OpenModelica Connection Editor



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

Modelica->AST->SCode->DAE->C Code

```
// Parse the file and get an AST back
ast = Parse.parse(modelicaFile);

// Translate to simplified C code
scode = SCode.absyn2SCode(ast);

// flatten the simplified code
(cache, dae1) = Inst.instantiate(Env.emptyCache, scode);

// Call the function that optimizes the DAE
optimizeDae(scode, ast, dae, dae, lastClassName);
```

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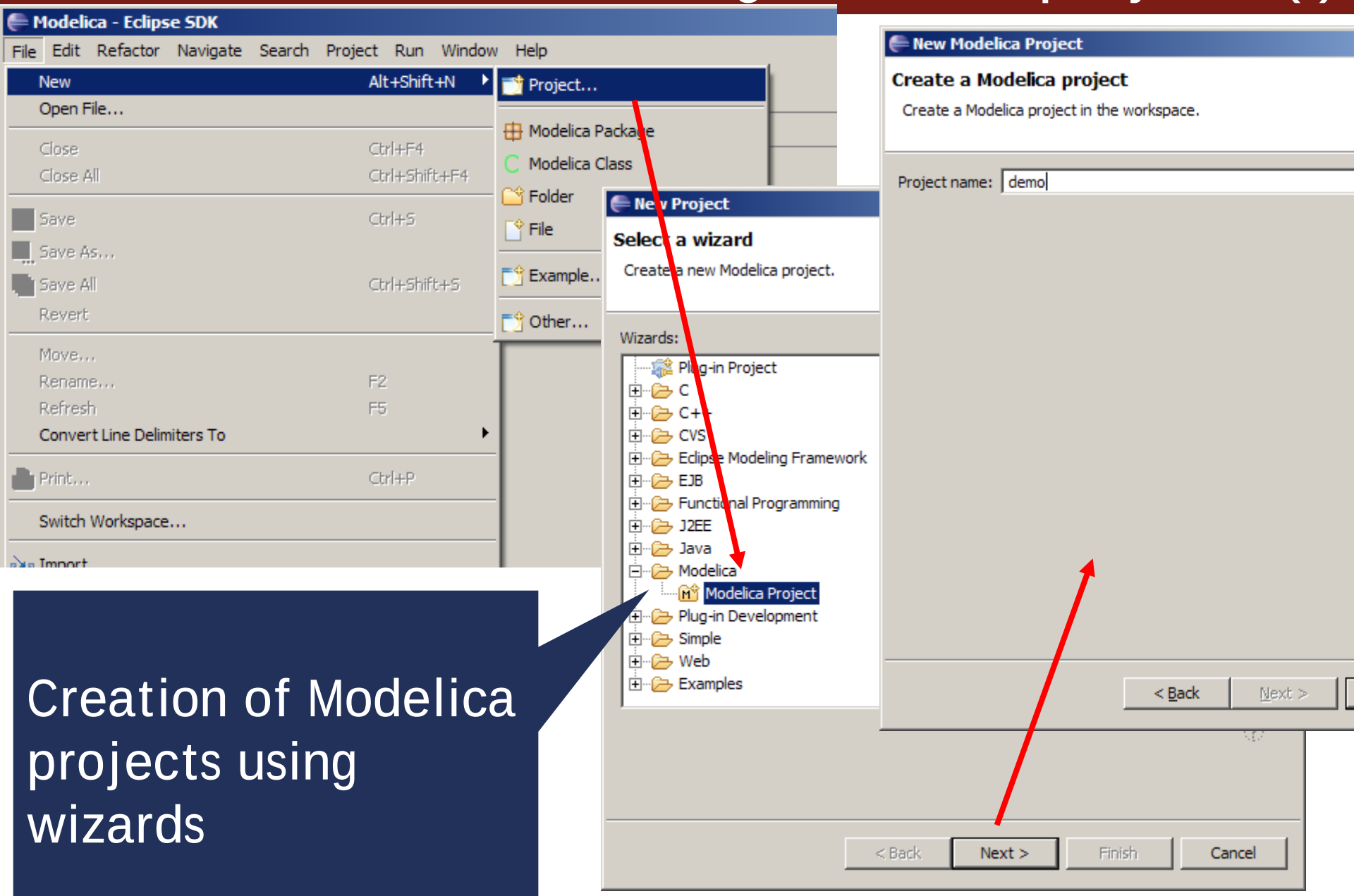
  - The Eclipse Environment
- OpenModelica Latest Developments (2017-2018)

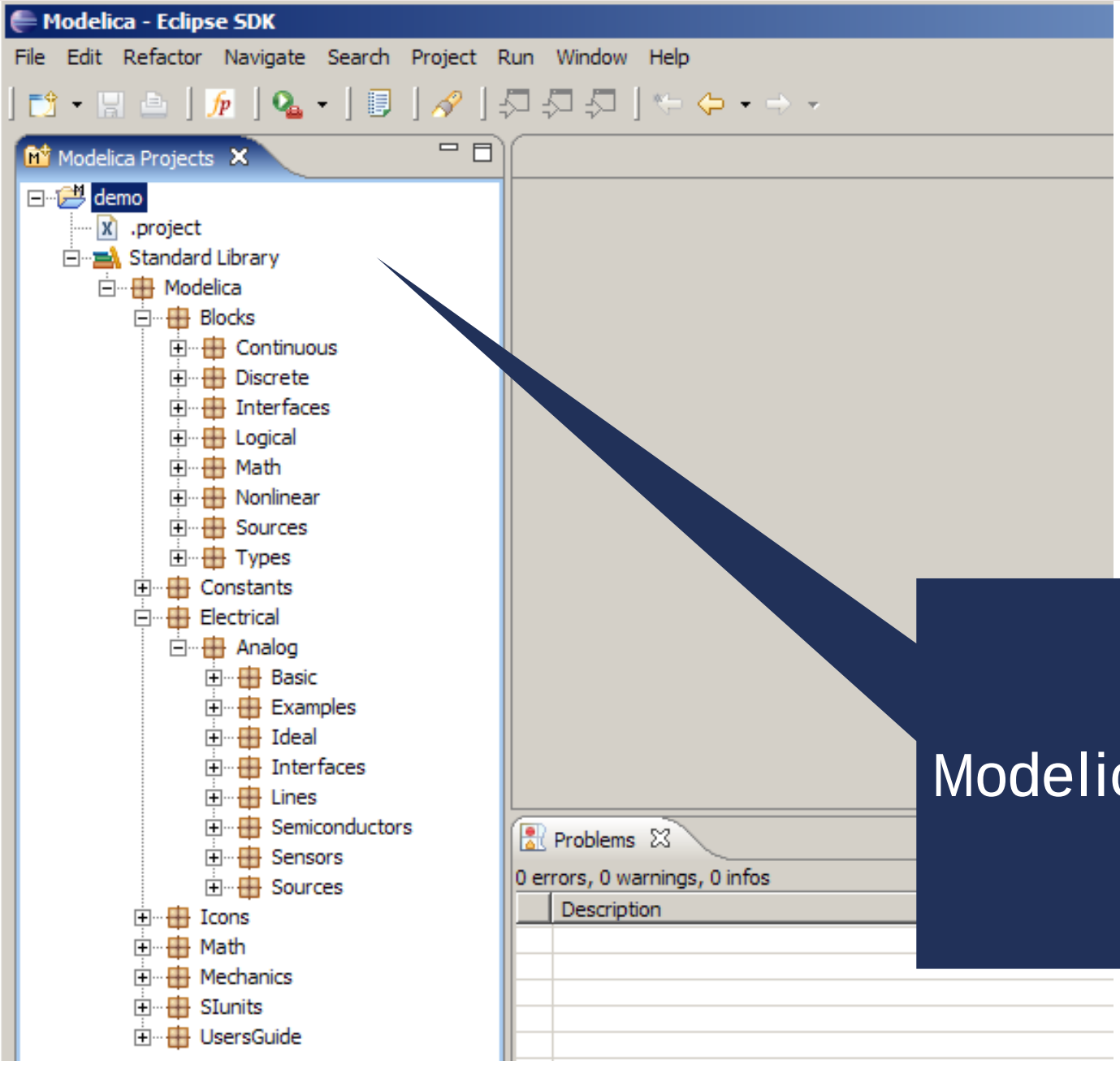
- OMC
  - Implemented mainly in MetaModelica and C/C++
- Modelica
  - classes, models, records, functions, packages
  - behavior is defined by equations or/and functions
  - equations
    - differential algebraic equations and conditional equations
- MetaModelica extensions
  - local equations
  - pattern equations
  - match expressions
  - high-level data structures: lists, tuples, option and uniontypes

MDT - Creating Modelica projects (I)



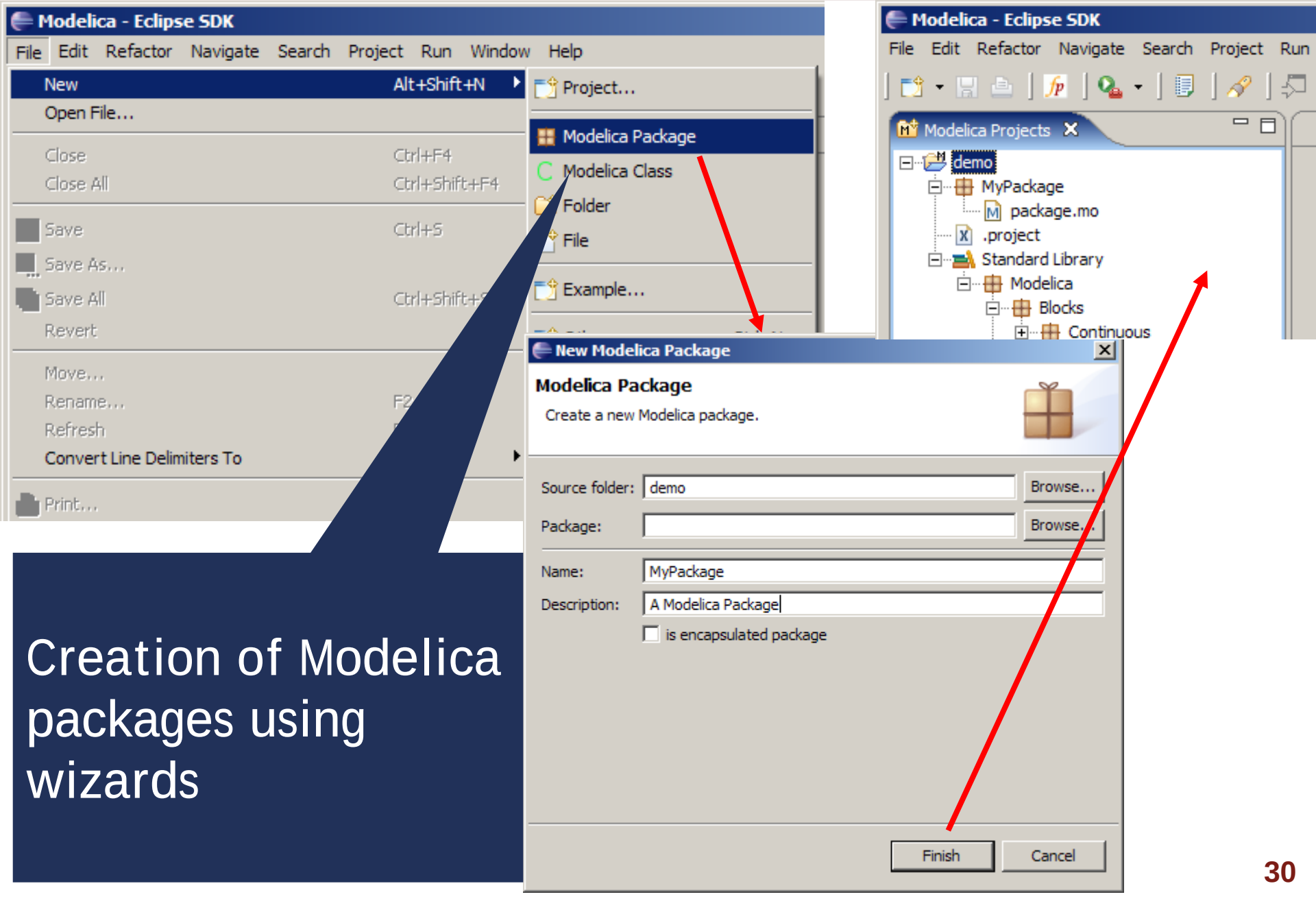
Creation of Modelica projects using wizards

Creating Modelica projects (II)



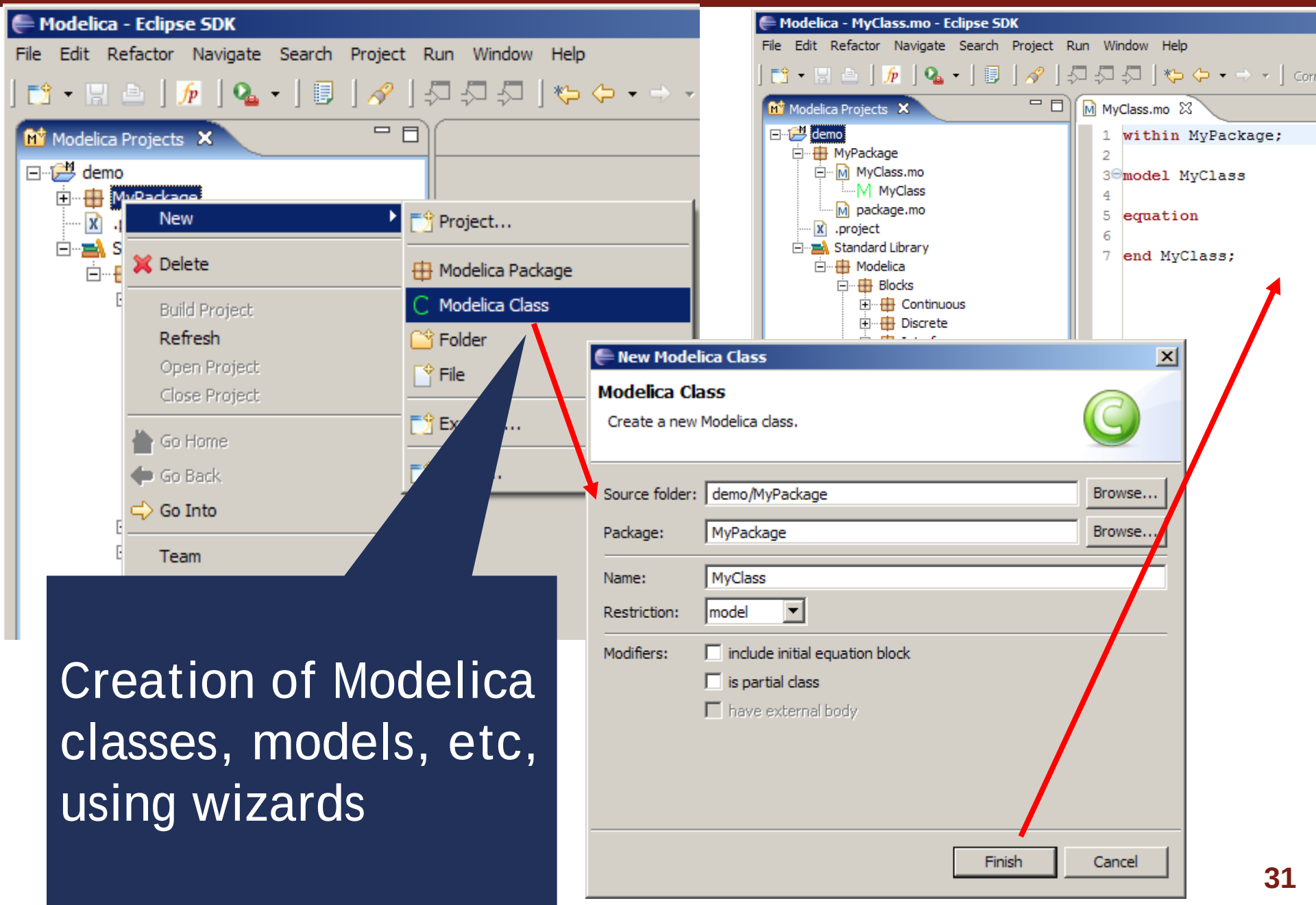
Modelica project

Creating Modelica packages



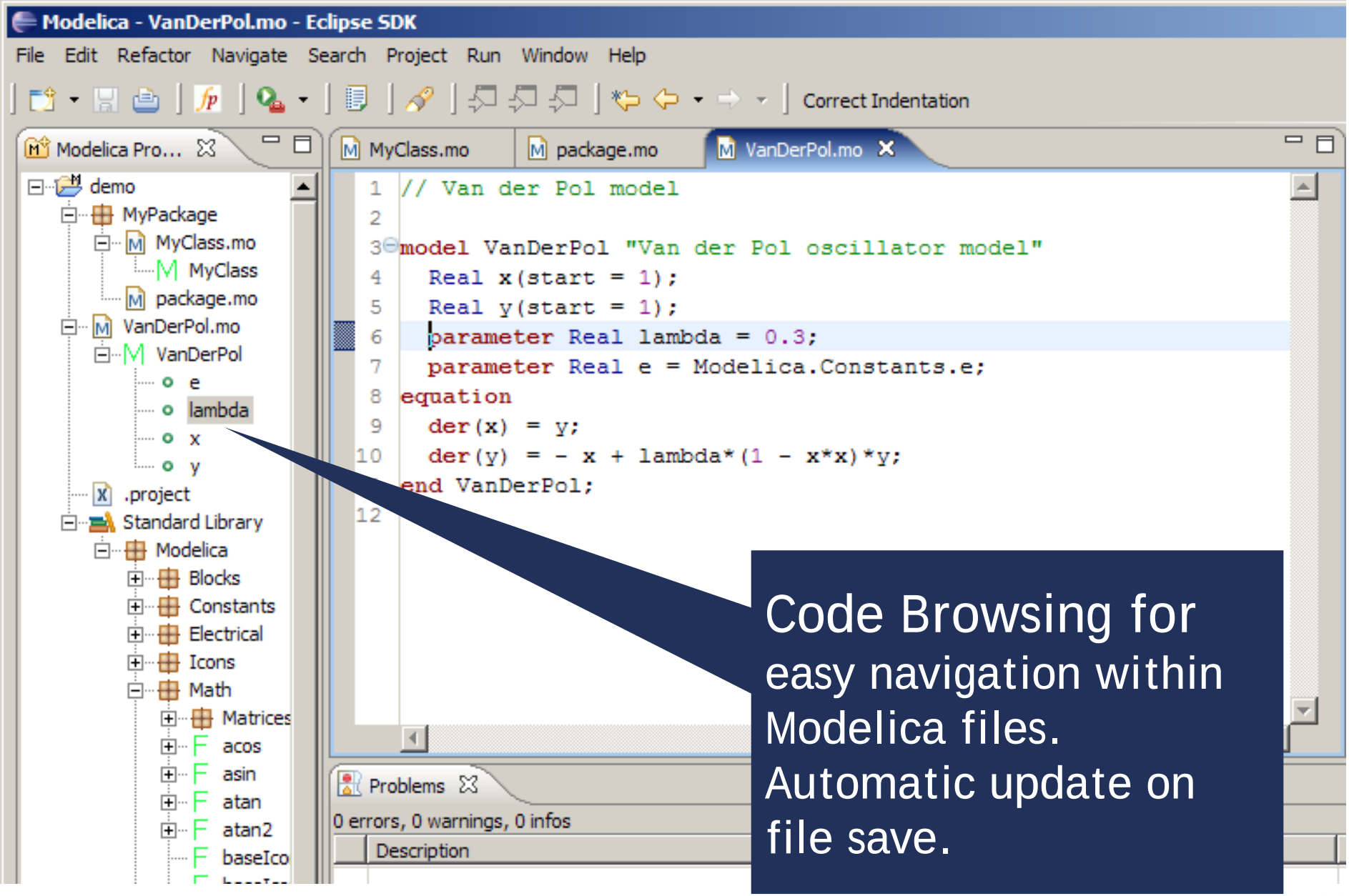
Creation of Modelica packages using wizards

Creating Modelica classes



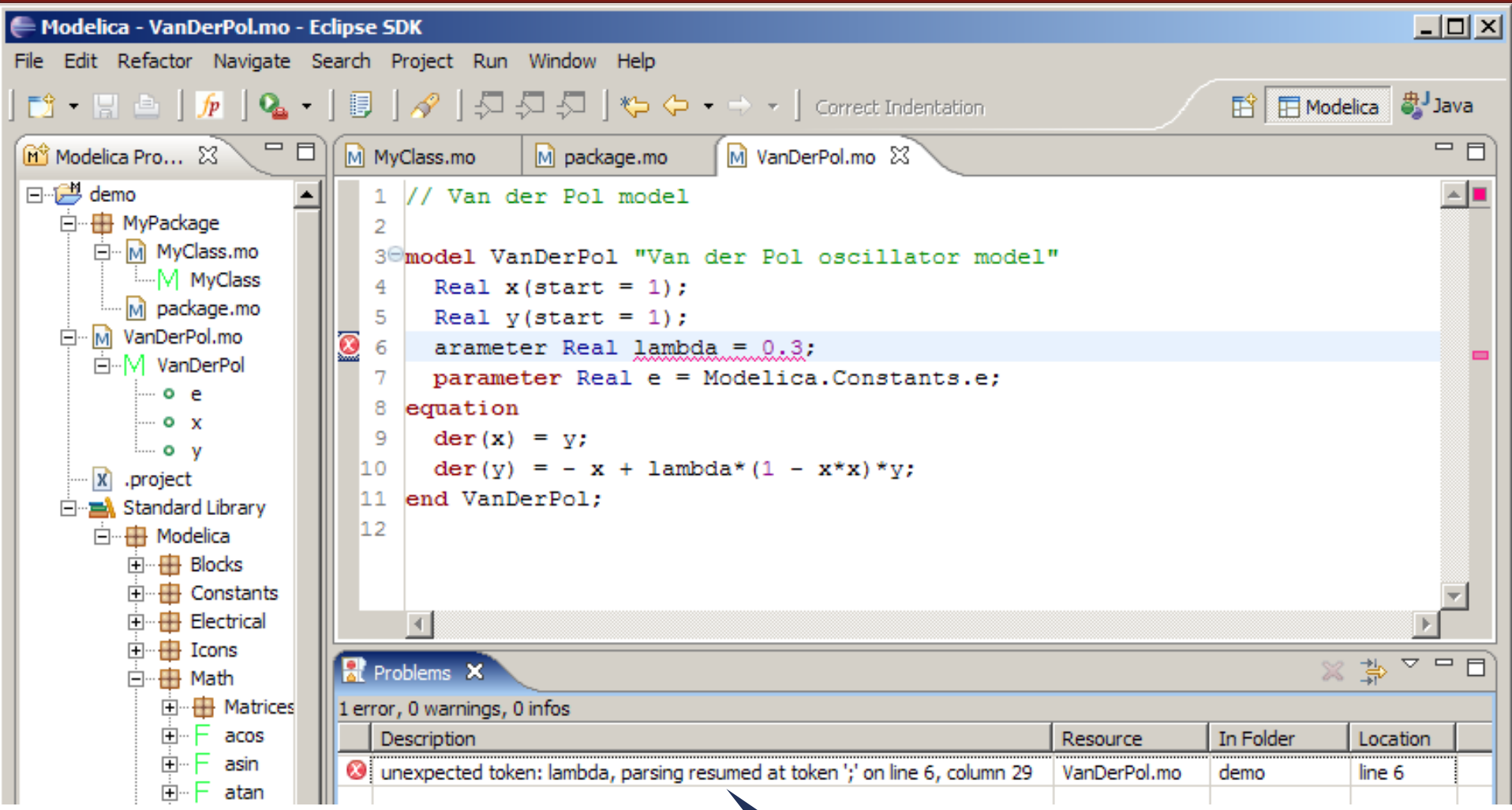
Creation of Modelica classes, models, etc, using wizards

Code browsing



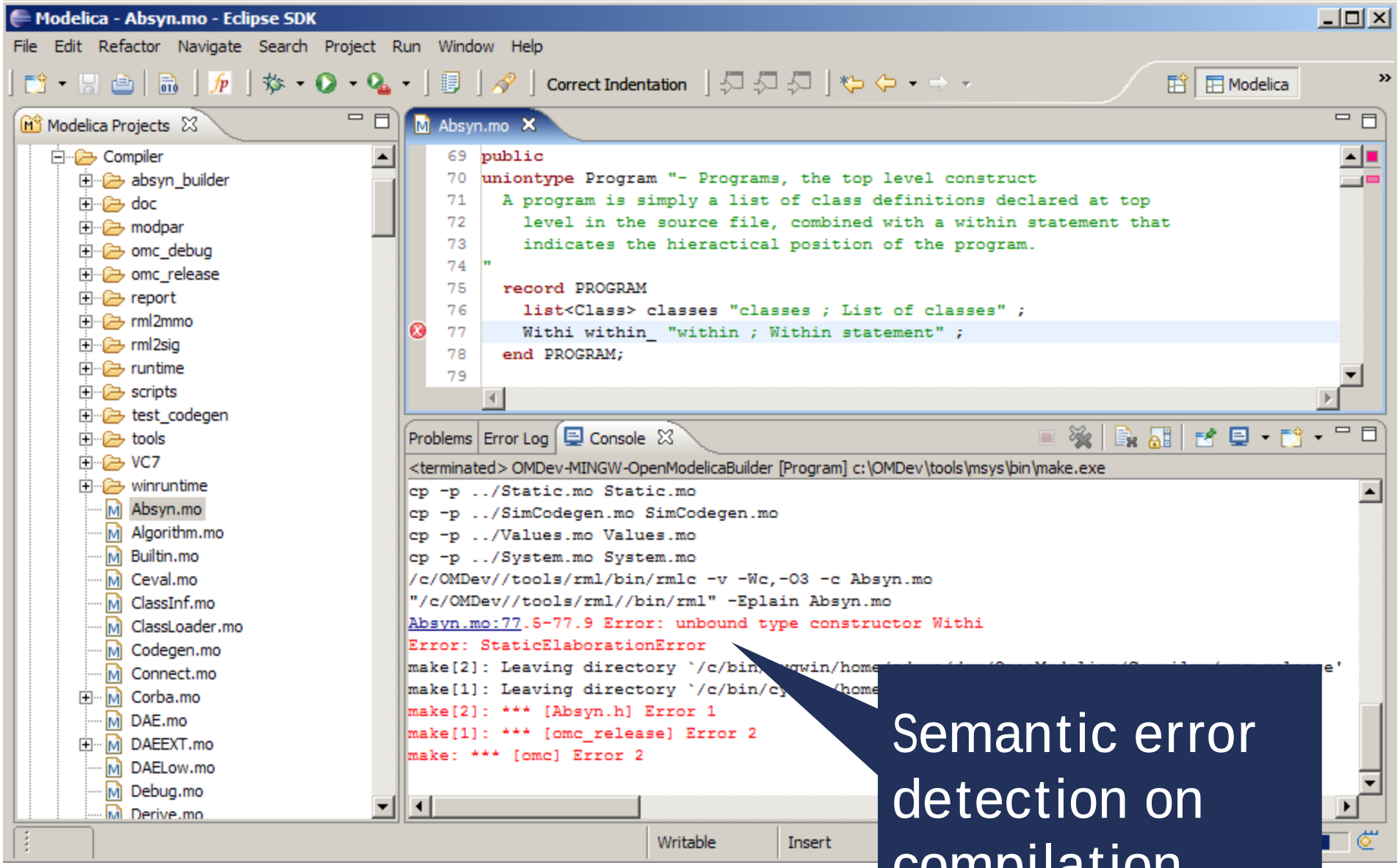
Code Browsing for easy navigation within Modelica files. Automatic update on file save.

Error detection (I)

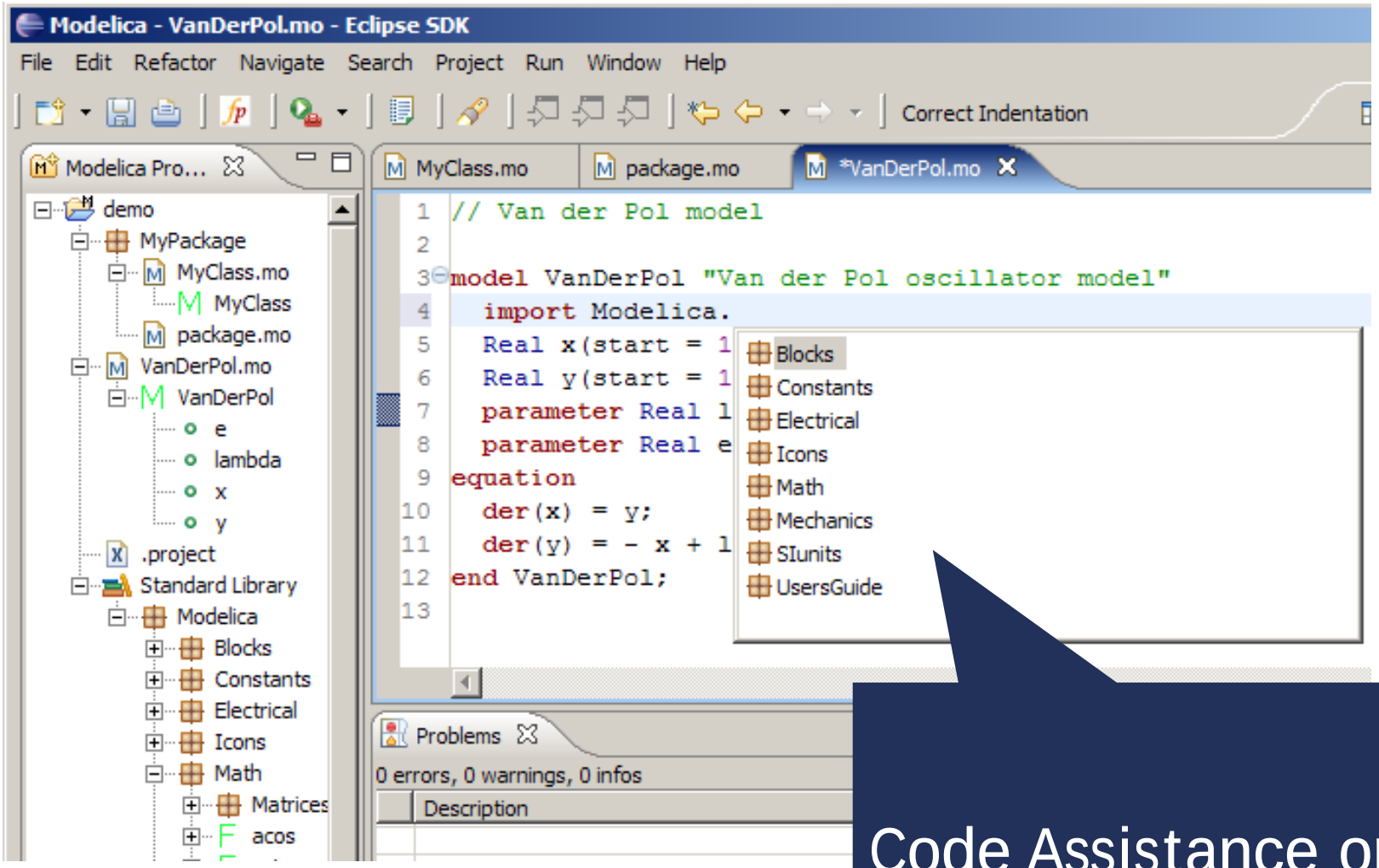


Parse error detection on file save

Error detection (II)

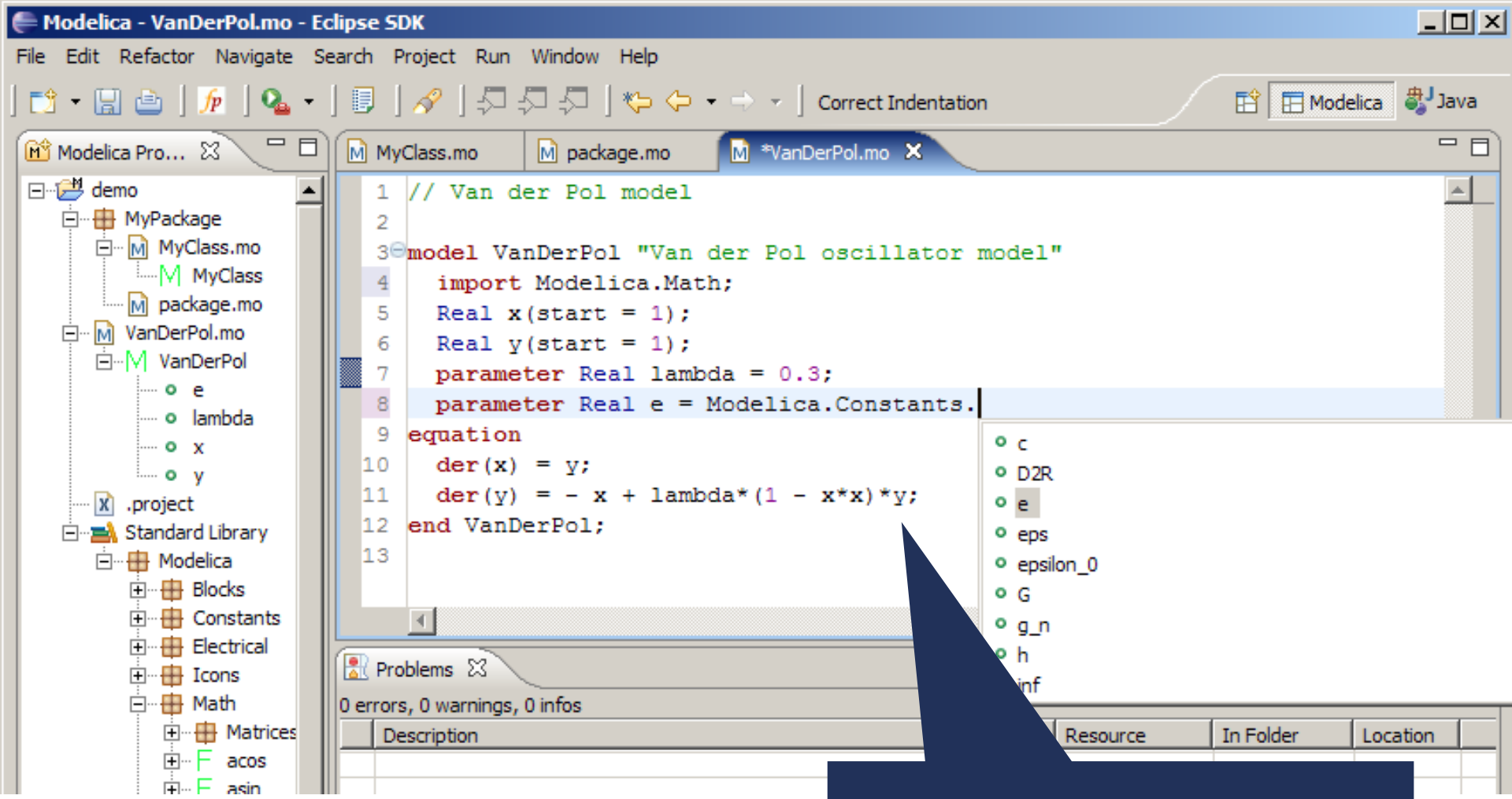


Code assistance (I)



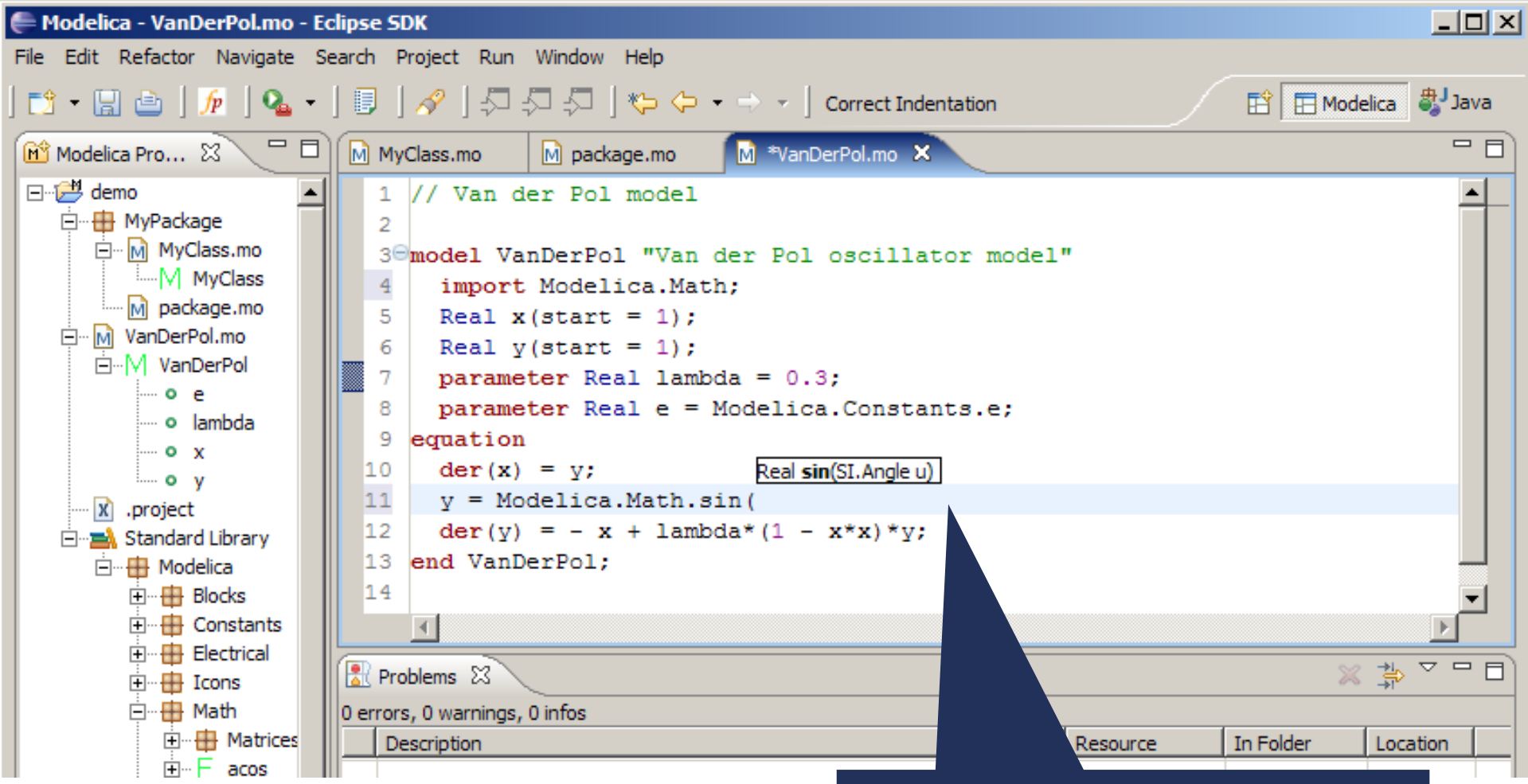
Code Assistance on imports

Code assistance (II)



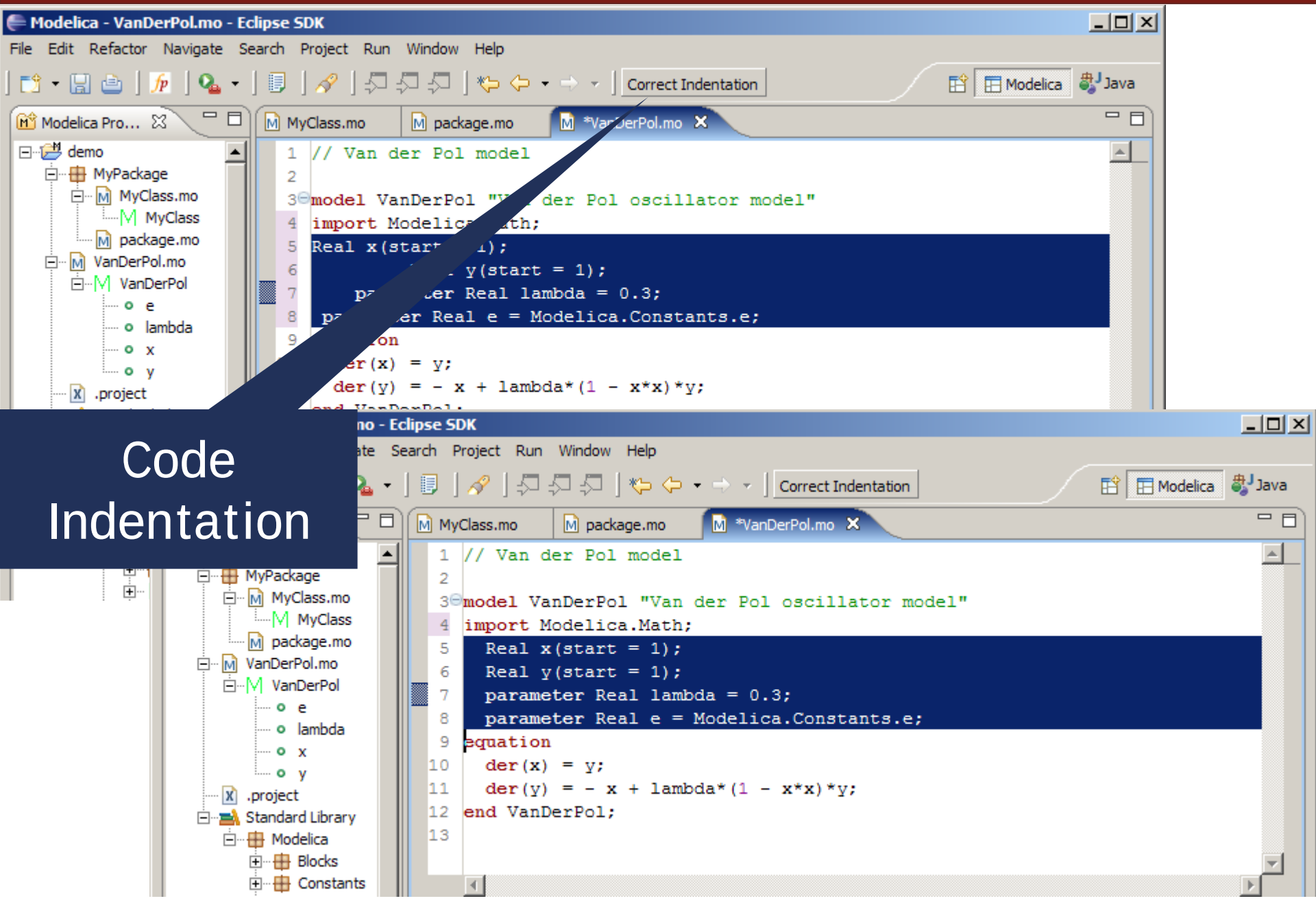
Code Assistance on assignments

Code assistance (III)



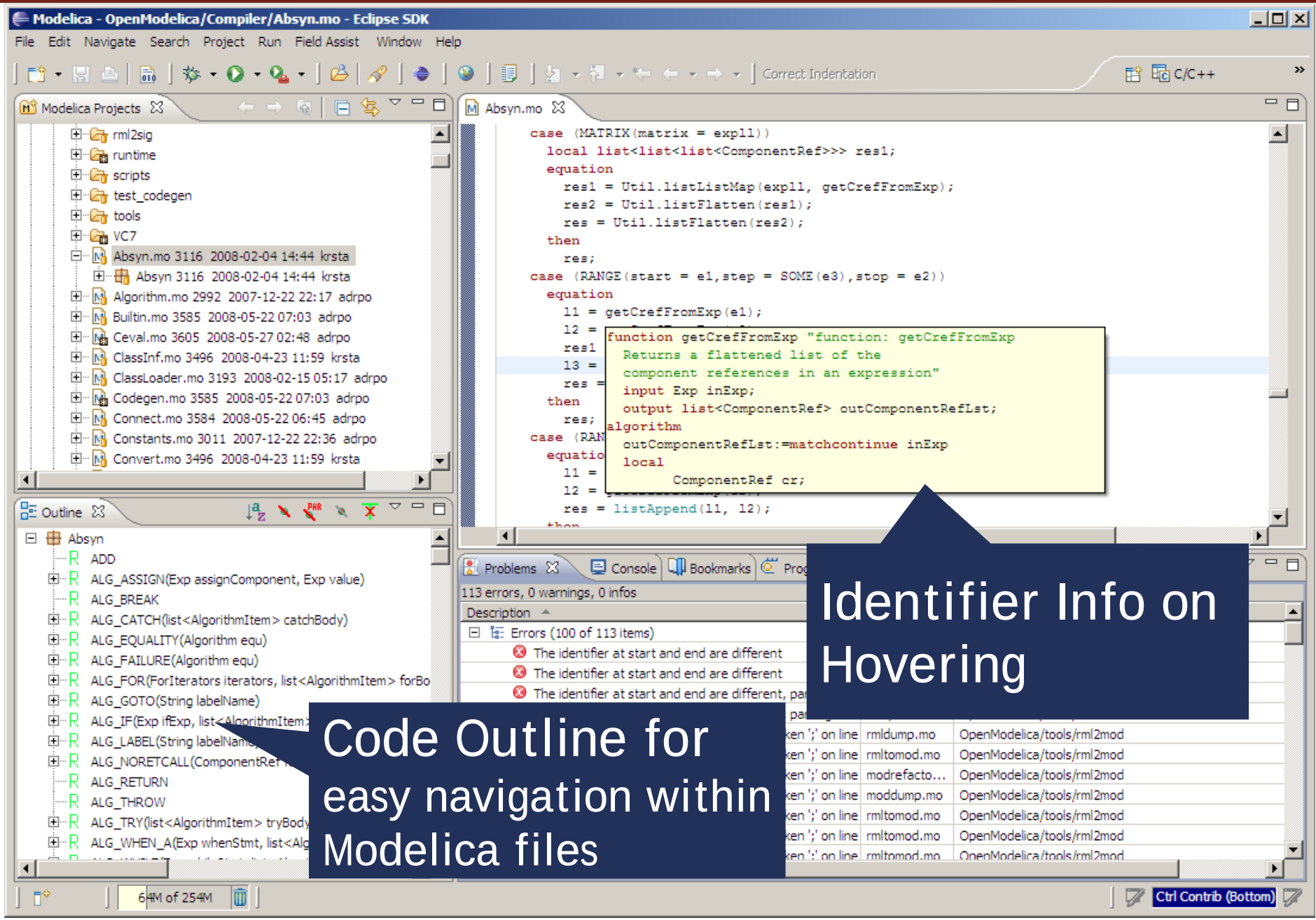
Code Assistance on function calls

Code indentation

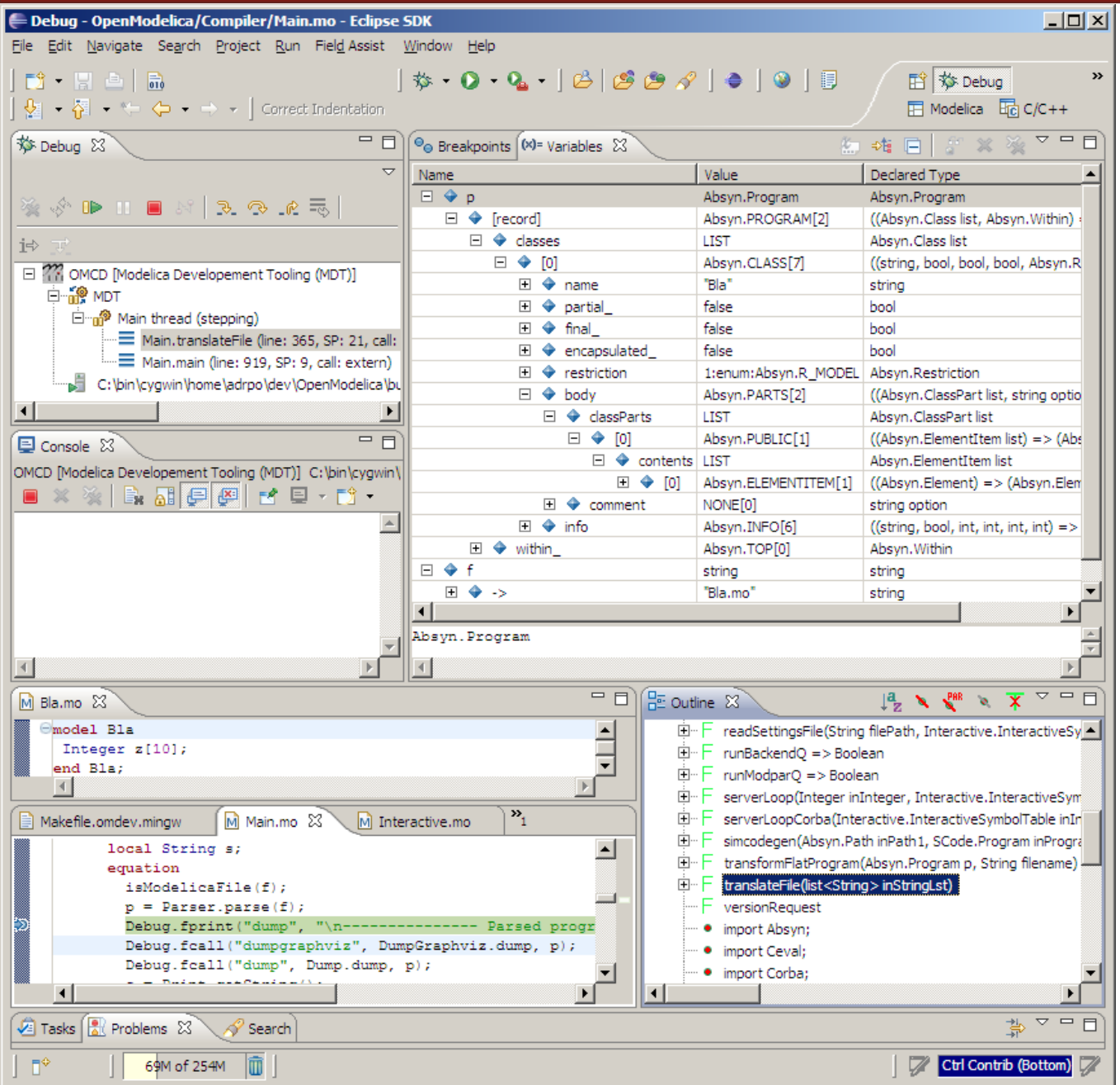


Code Indentation

Code Outline and Hovering Info

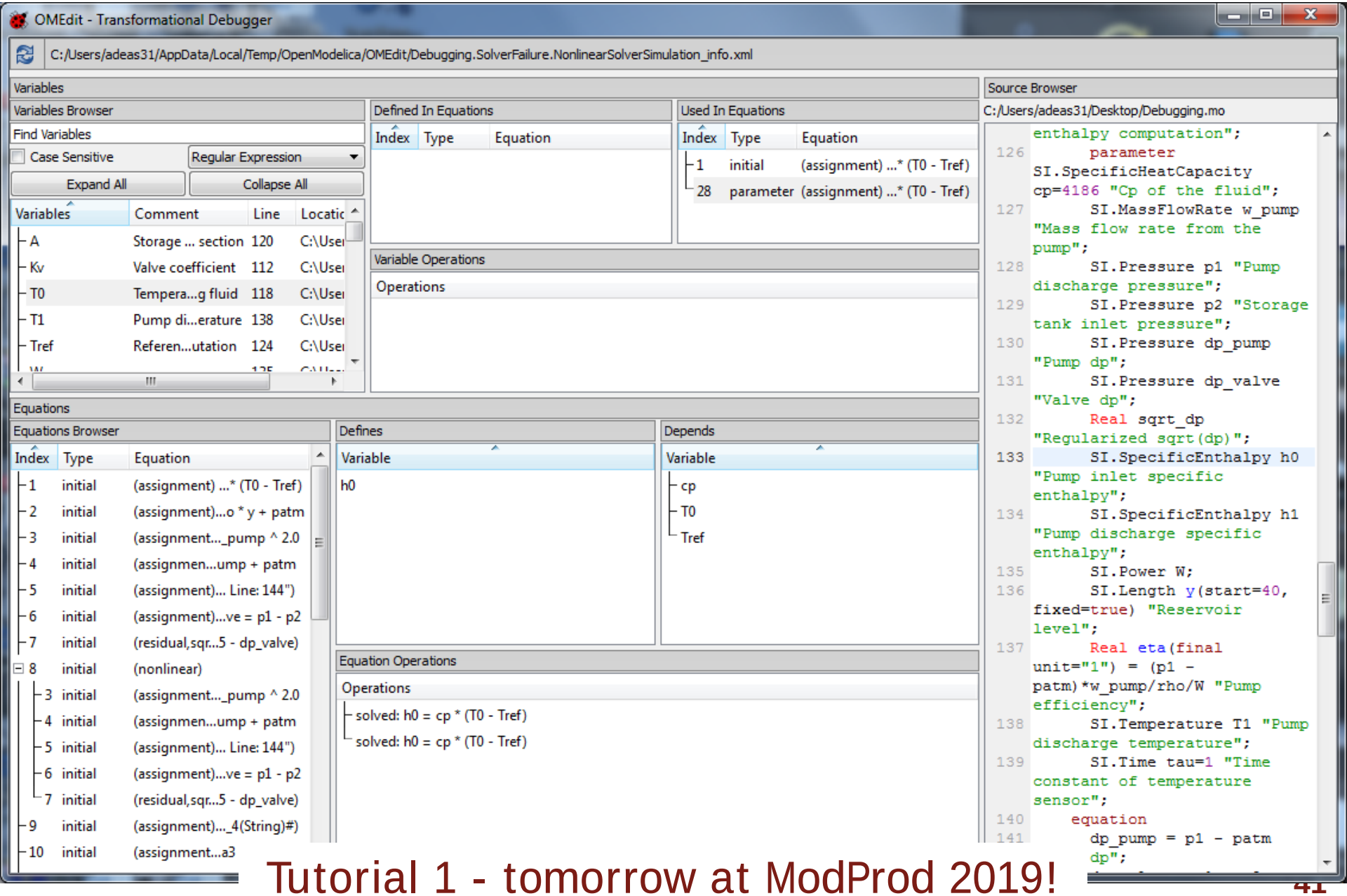


Eclipse Debugging Environment



- Type information for all variables
- Browsing of complex data structures
- GDB based

OMEdit Debugging Environment



Tutorial 1 - tomorrow at ModProd 2019!

Eclipse environment for ModelicaML

1 System Modeling with ModelicaML

2 Modelica Code Generation

3 System Simulation with Modelica Tools

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 (2018-2019)

Latest Developments (2018-2019) (I)

- 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

Latest Developments (2018-2019) (II)

- 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)

Latest Developments (2018-2019) (III)

- 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
    - Support for redeclare/replaceable is implemented
    - Waiting for the new front-end to become mature enough so we don't frustrate users

Future 2019+

- OMC / OMEdit – new API for instance hierarchy editing
  - Concept testing – work in progress
  - Use the new front-end to instantiate the Model
  - Give the instance tree 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

- Julia instead of MetaModelica?
  - Concept testing – work in progress
  - Change the entire compiler from MetaModelica to Julia
  - Benefits
    - Access to Julia libraries, graph and numerical algorithms, etc
    - Support for variable structure systems (call OpenModelica compiler at runtime if everything is implemented in Julia)

Thank You!

Questions?

asodja, sjoelund.se, sebcoO11, lochel, wbraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levsa, mahge930, xO5andfe, mohsen, nutaro, xO2lucpo, florosx, xO6hener, xO7simbj, stebr461, xO8joekl, xO8kimja, Dongliang Li, jhare950, x97davka, krsta, edgarlopez, hanke, henjo, wuzhu.chen, fbergero, harkaO11, tmtuomas, bjozac, AlexeyLebedev, xO6klasj, ankar, kajny, vasaie_p, niemisto, donida, hkiel, davbr, otto@mathcore.com, Kaie Kubjas, xO6krino, afshe, xO6mikbl, leonardo.laguna, petfr, dhedberg, g-karbe, xO6henma, abhinnk, azazi, xO2danhe, rruusu, x98petro, mater, g-bjoza, xO2kajny, g-pavgr, xO5andre, vaden, jansilar, ericmeyers, xO5simel, andsa, leist, choeger, Ariel.Liebman, frisk, vaurich, mwalther, mtiller, ptauber, casella, vitalij, hkiel, jank, rfranke, mflehmig, crupp2, kbalzereit, marchartung, adrpo

OpenModelica Project

http://www.OpenModelica.org