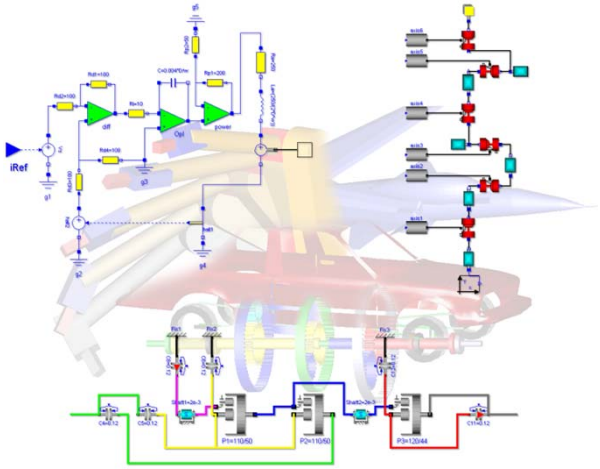
Technical Overview of OpenModelica and its Development Environment

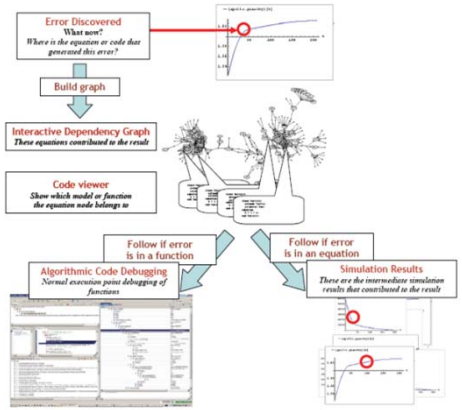
Adrian Pop

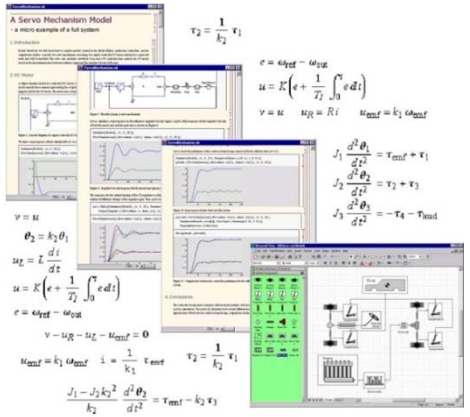
2012-02-06

Open Source Modelica Consortium
Programming Environment Laboratory
Department of Computer and Information Science
Linköping University

www.OpenModelica.org







OPEN SOURCE MODELICA CONSORTIUM

OpenModelica

MODELICA

pelab

LINKÖPINGS UNIVERSITET

Outline

- OpenModelica
  - What is OpenModelica?
  - The past and present
- OpenModelica Technical Overview
  - OMC, OMShell, OMNotebook,
  - OMEdit, ModelicaML, SimForge
- OpenModelica Development Environment
  - MetaModelica (RML/OMC)
  - The Eclipse Environment (MDT)
- OpenModelica Latest Developments (2011-2012)

What is OpenModelica? (0)

OpenModelica is ... *its developers*

Thank you!

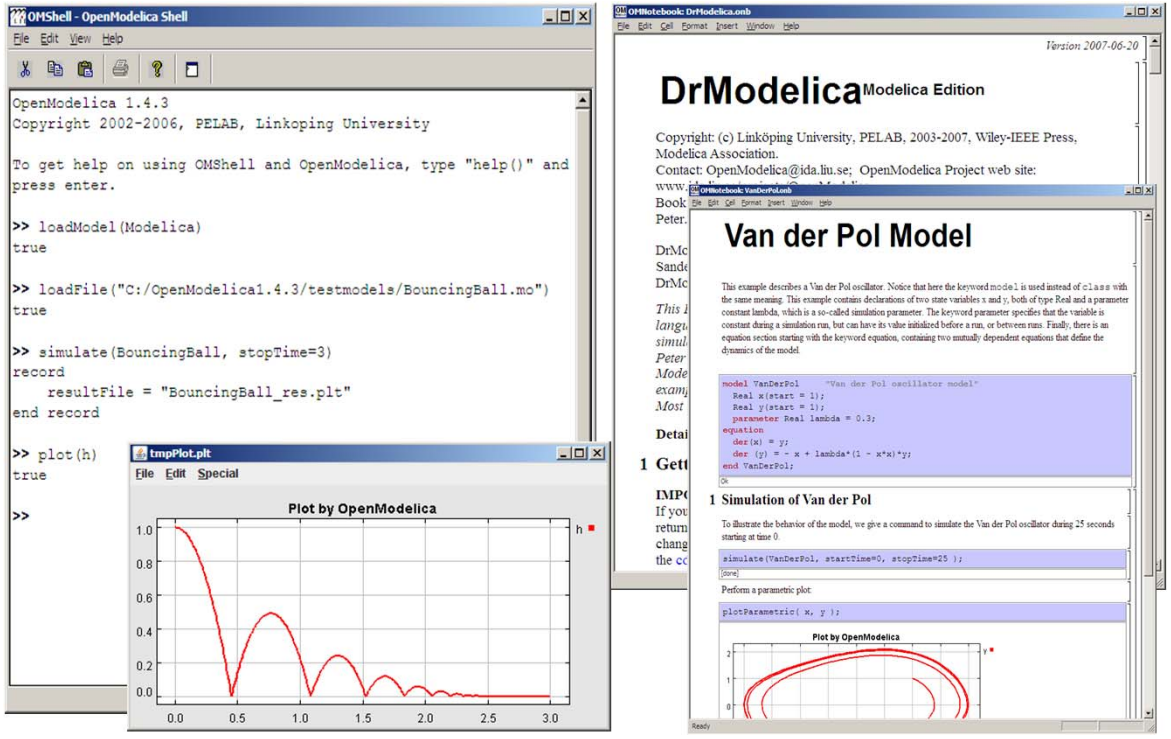
asodja, sjoelund.se, sebco011, lochel, wbraun, niklwors, hubert.thieriot, petar, perost, Frenkel TUD, Unknown, syeas460, adeas31, ppriv, ricli576, haklu, dietmarw, levsa, mahge930, x05andfe, mohsen, nutaro, x02lucpo, florosx, x06hener, x07simbj, stebr461, x08joekl, x08kimja, Dongliang Li, jhare950, x97davka,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

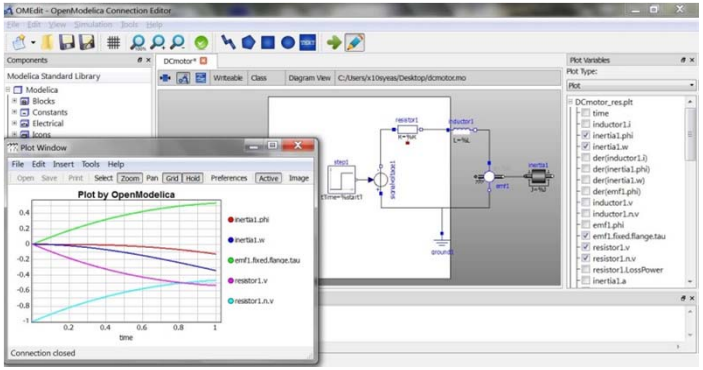
Developers (81)

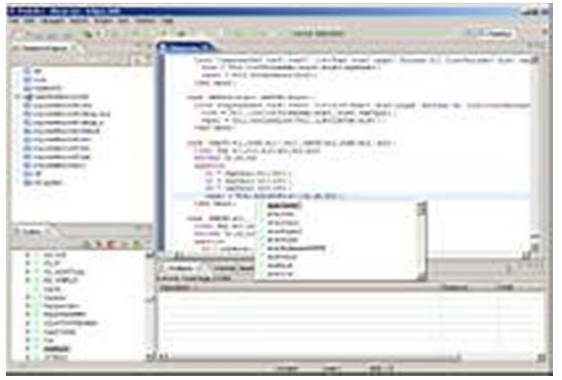
Martin
Per
Adeel
Jens
Willi
Lennart
Alexey
Mahder
Olena
Mohsen
Kristian
Hubert
Niklas
Kaie
Kiel
Peter *
Leonardo
Filippo
Xenofon
Frederico
Edgar
Kaj
Levon
Stefan
Rickard
Bjorn
David
Otto
Eric
...
Adrian

What is OpenModelica? (I)

- Advanced Interactive Modelica compiler (OMC)
  - Supports MLS v. 3.1/MSL v. 3.2 (without Fluid)
- Basic and advanced environments for creating models
  - OMShell – an interactive command handler
  - OMNotebook – a literate programming notebook
  - OMEdit – Open Modelica Connection Editor
  - OMPlot – Open Modelica Plotting
  - OMOptim – Open Modelica Optimization Editor
  - MDT – an advanced textual environment in Eclipse

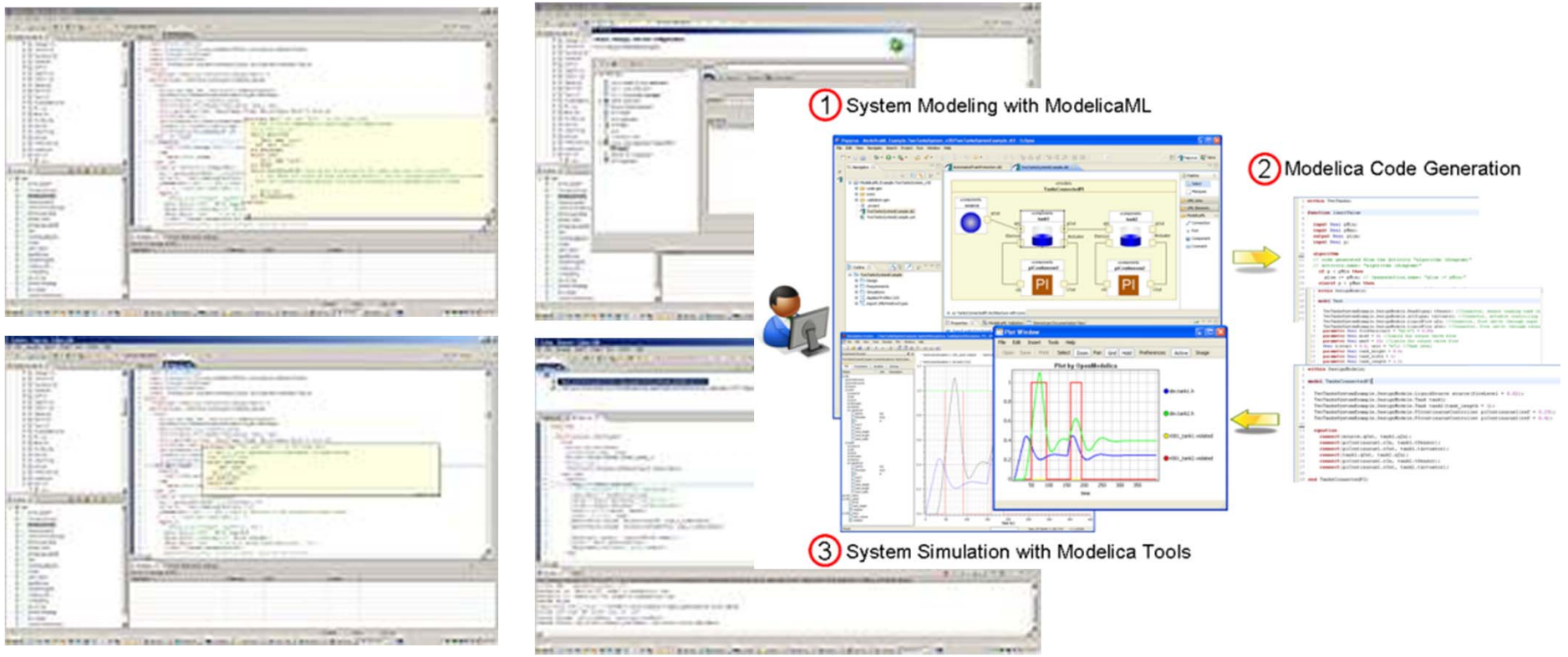






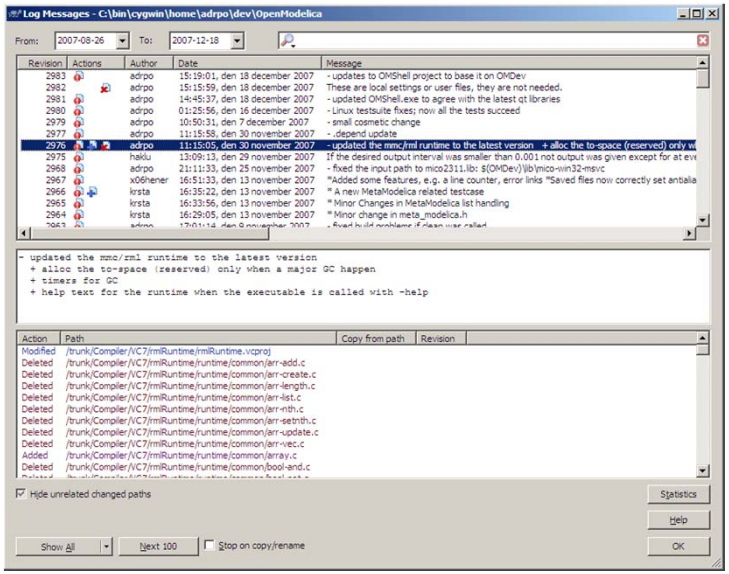
What Is OpenModelica? (II)

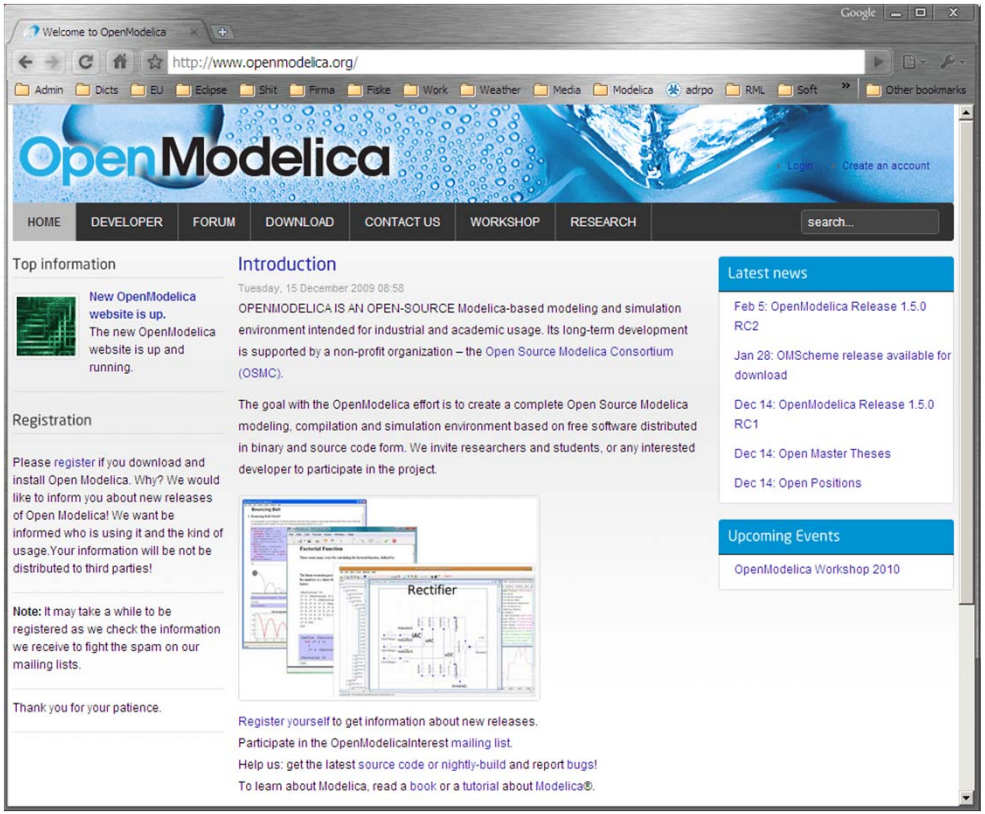
- **Advanced Eclipse-based Development Environment**
- **Modelica Development Tooling (MDT) - started in 2005**
  - Code Assistance, Debugging, Outline & a lot more
  - *Used heavily for OpenModelica development*
  - Used in many OpenModelica Development Courses (INRIA, PELAB)
- **ModelicaML UML/SysML integration**

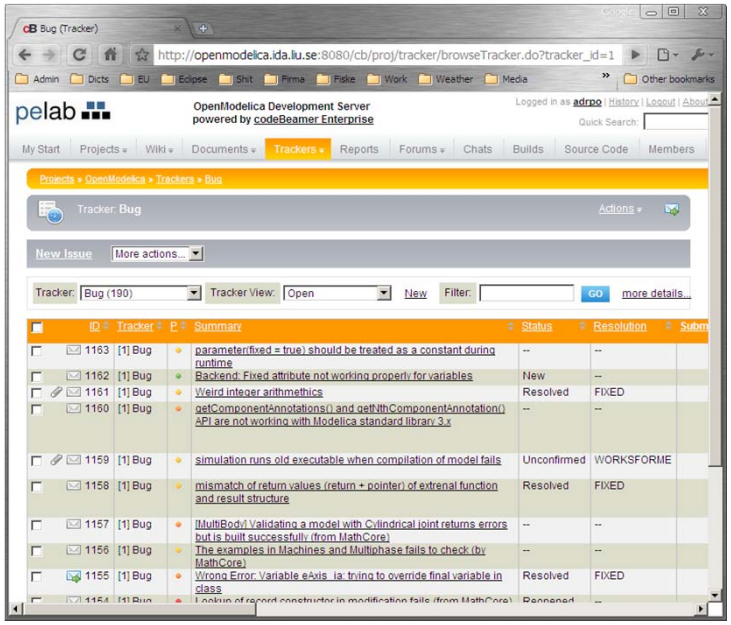


What is OpenModelica? (III)

- Open-source community services
  - Website and Support Forum
  - Version-controlled source base
  - Bug database (unfortunately)
  - Development courses
  - Mailing lists







What is OpenModelica? (IV)

- An incubator platform for research
  - 5 PhDs since 2004 (Debugging, Parallelization, PDEs Extensions)
  - 20 Master's theses since 2004
  - Both the students and the project benefit
- Master theses at PELAB 2006-2012
  - 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
- 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, InterCAX (MagicDraw SysML), VTT, Equa, Evonik

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

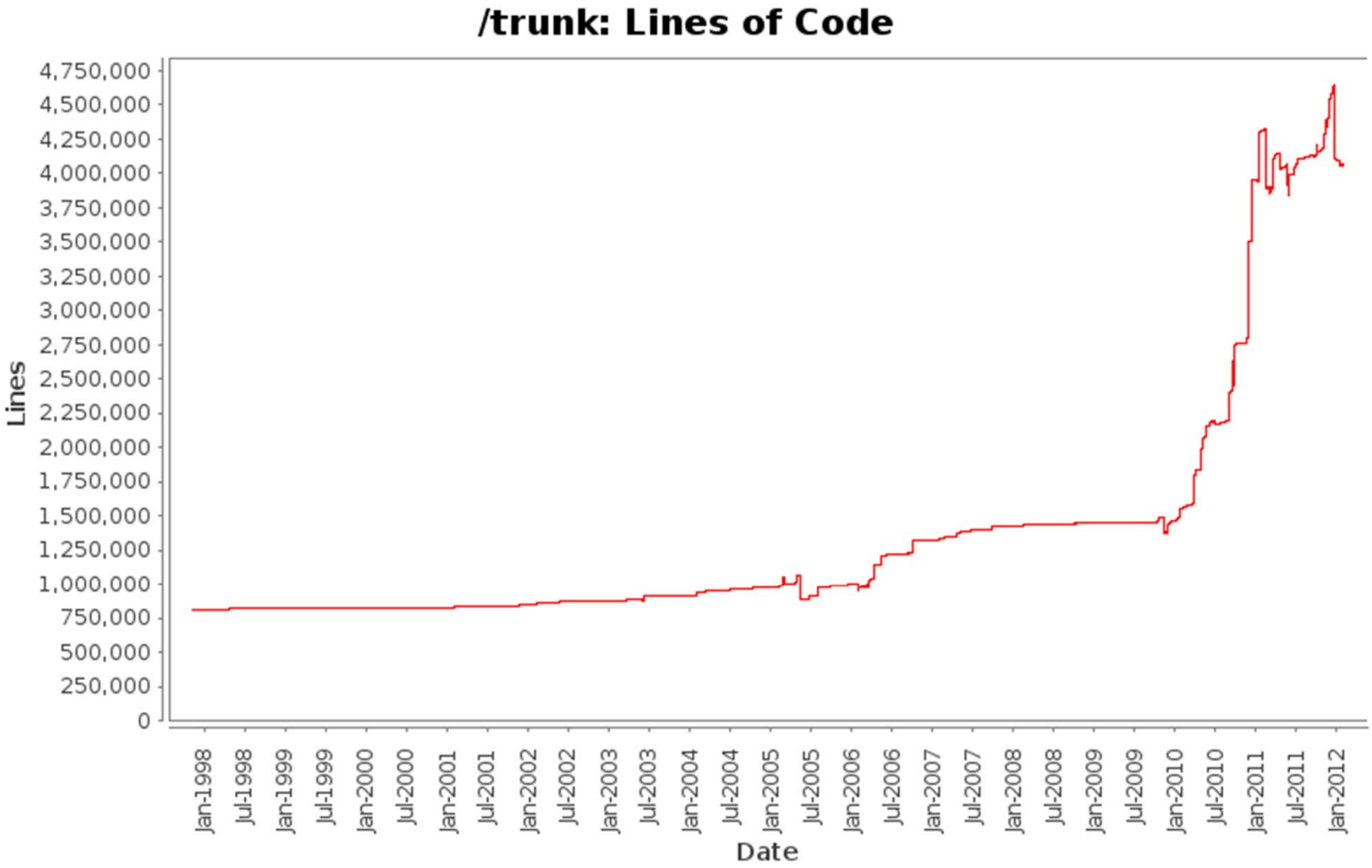
- Support for Modelica Standard Library 3.1 (Media & Fluid in works)
- Front-end
  - MultiBody flattening (OSMC)
  - Support for Modelica 3.x and 3.x annotations (OSMC)
  - Performance Enhancements
  - Stream connectors
  - Media & Fluid work is on the way
- Back-end
  - Back-end redesign (Jens, Willi, 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 & Present

2011 – 2012

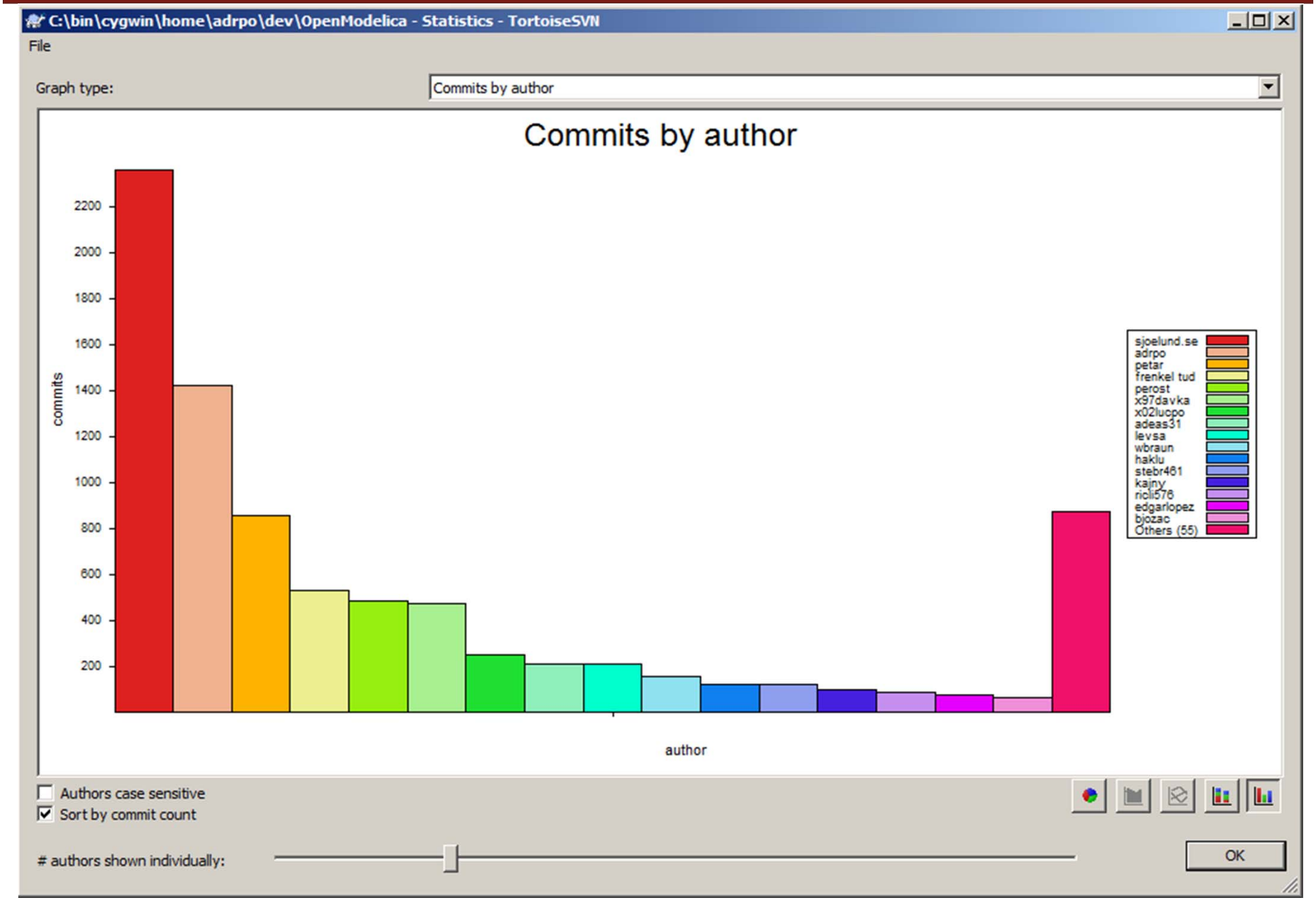
- Support for Modelica Standard Library 3.1 (Fluid in works)
- Media & Fluid are now partially supported (more work on the back-end is needed)
- Front-end
  - Performance Enhancements
  - Media & Fluid work
  - Operator overloading
  - New instantiation module started
- Back-end
  - Modular back-end 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
  - MDT GDB debugging based on GDB and the bootstrapped compiler
  - OMEdit – improvements
  - Bootstrapping OMC (98% finished) GC remaining
  - 2473 commits in subversion from 2011 to Feb. 7, 2012
  - 1037 forum posts (questions and answers)
  - Bug fixes ~190+ (OSMC)
  - Release 1.7.0, 1.8.0, 1.8.1 (Linux, Mac, Windows)
  - Downloads Windows (~31246) , Linux (~10245), Mac (~4543)
- More things I don't remember

OpenModelica Statistics (I)

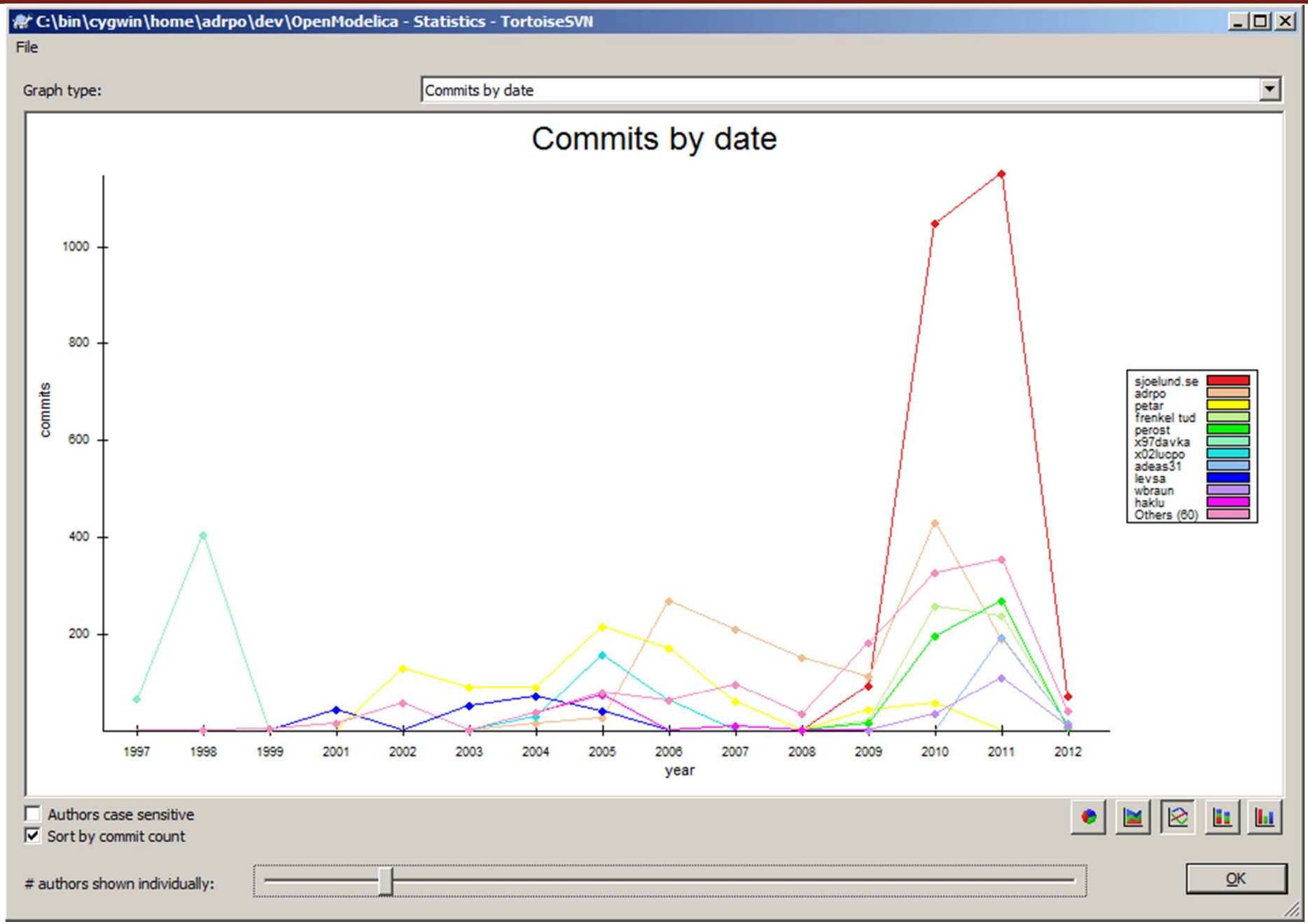


- Mature code base (http://build.openmodelica.org/omc/statsvn_trunk/)
- ~ 4500K lines of code and tests, steady increase

OpenModelica Statistics (II)



OpenModelica Statistics (III)



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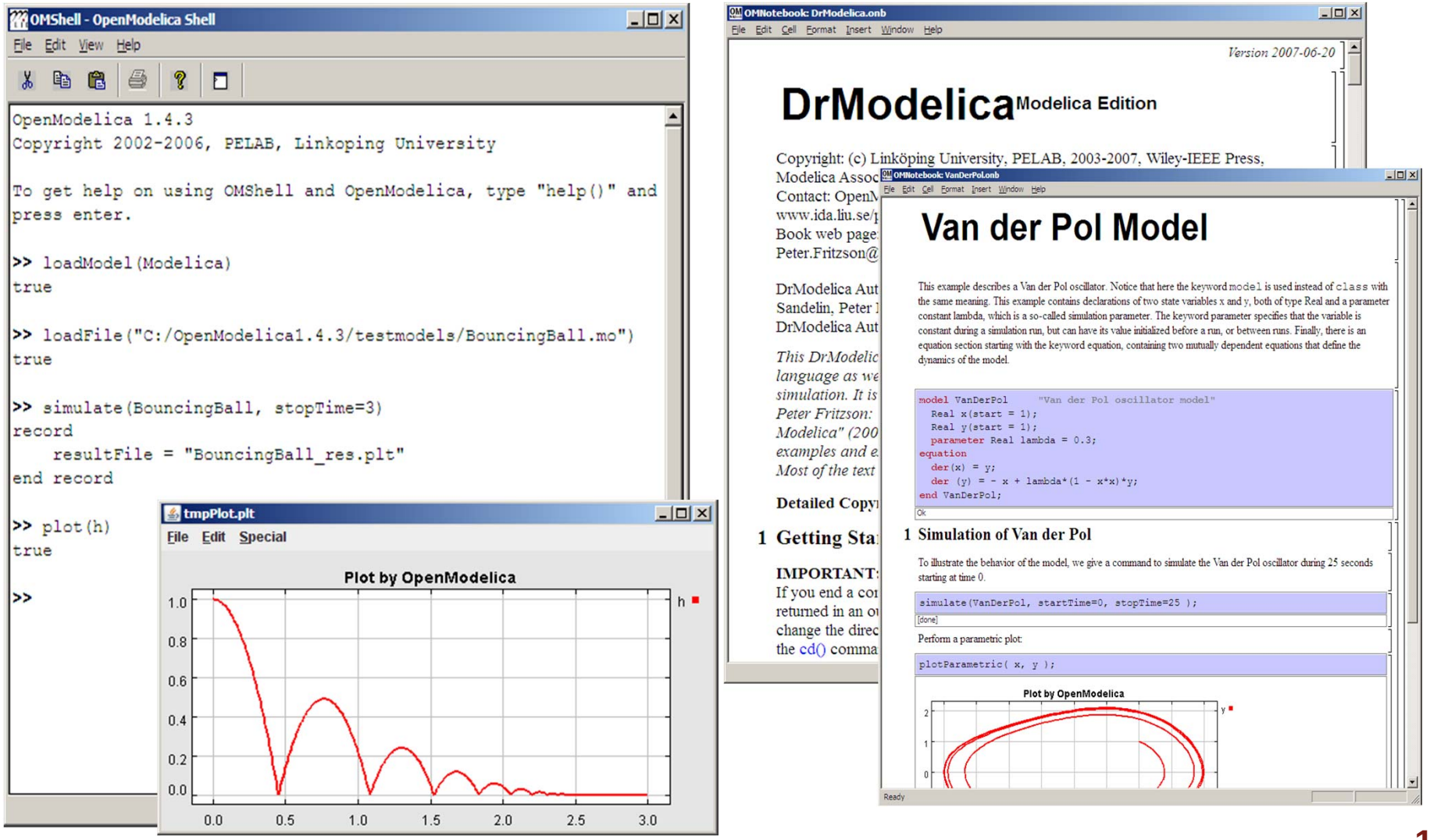
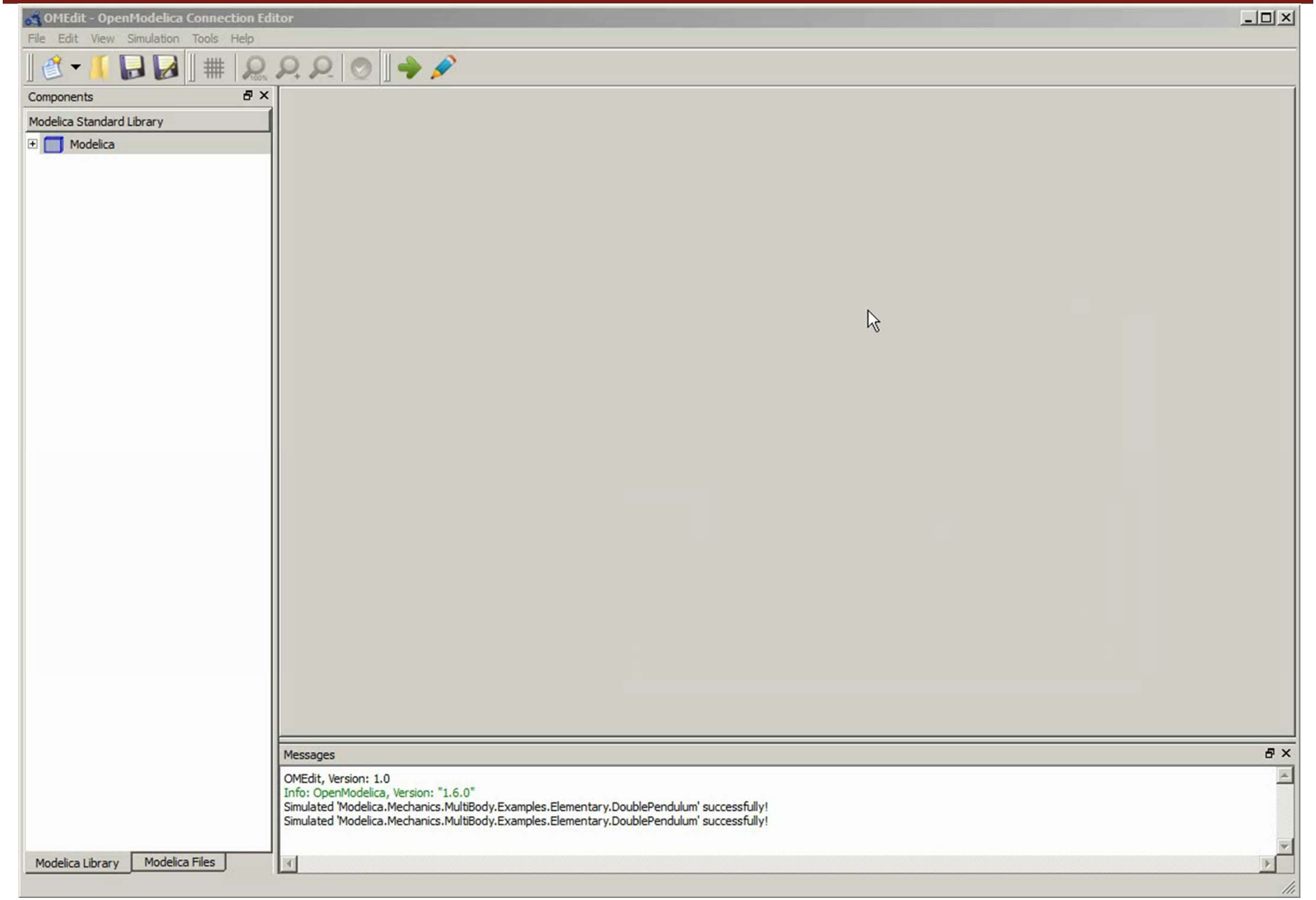
OMShell & OMNotebook

- Demo?

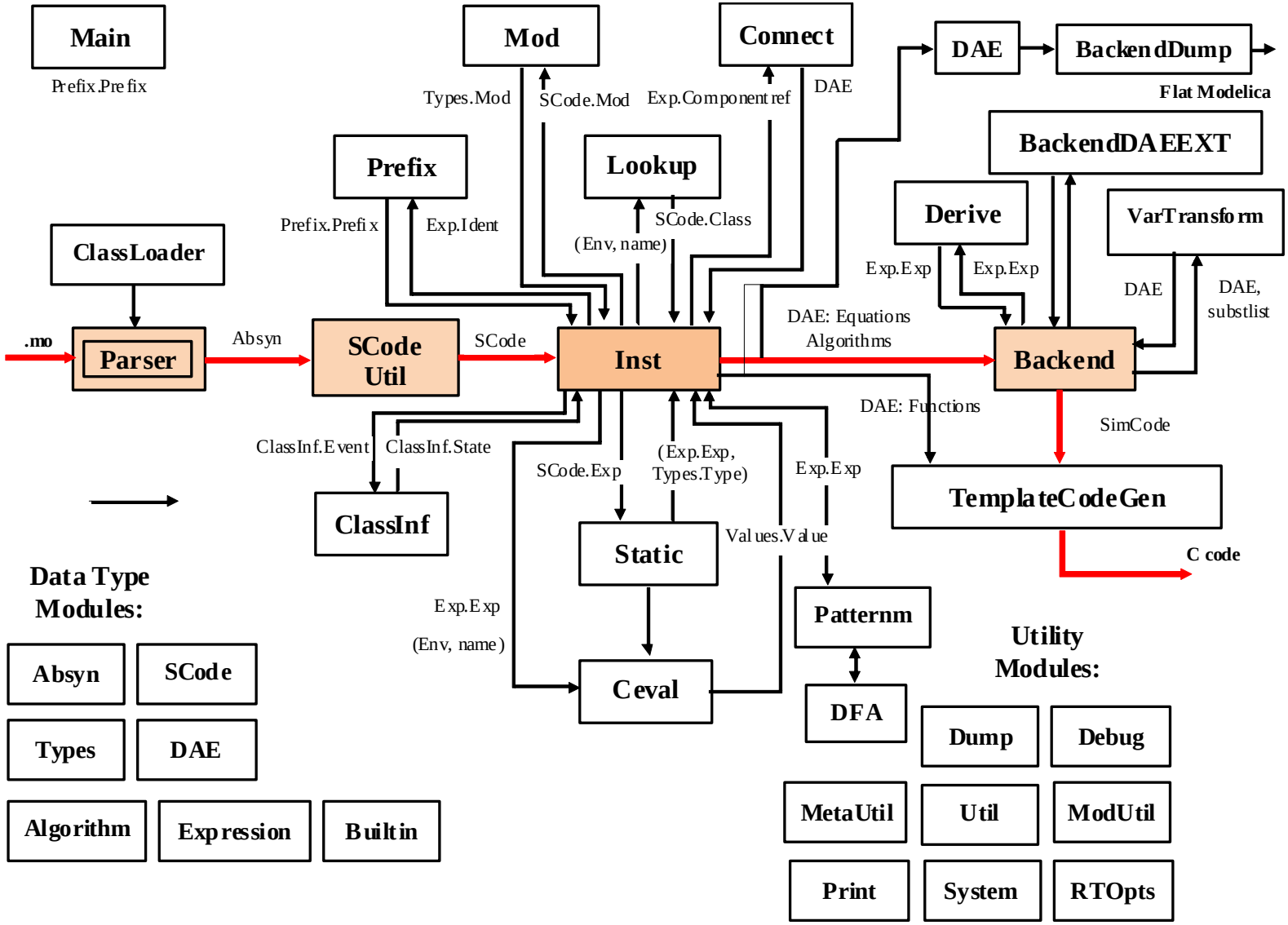


OMEdit - Demo? Maybe a movie!



The OMC Compiler

- Implemented mainly in MetaModelica and C/C++
- The compiler has 156 packages



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

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

// Elaborate the file
scode = SCode.elaborate(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);
```

Simulation Runtime Overview

- New simulation runtime
  - Work started in November at OpenModelica development week
  - Mainly C so that it supports FMI better
  - Better initialization
  - Better support for multithreading and parallel execution
  - Better support for Jacobians

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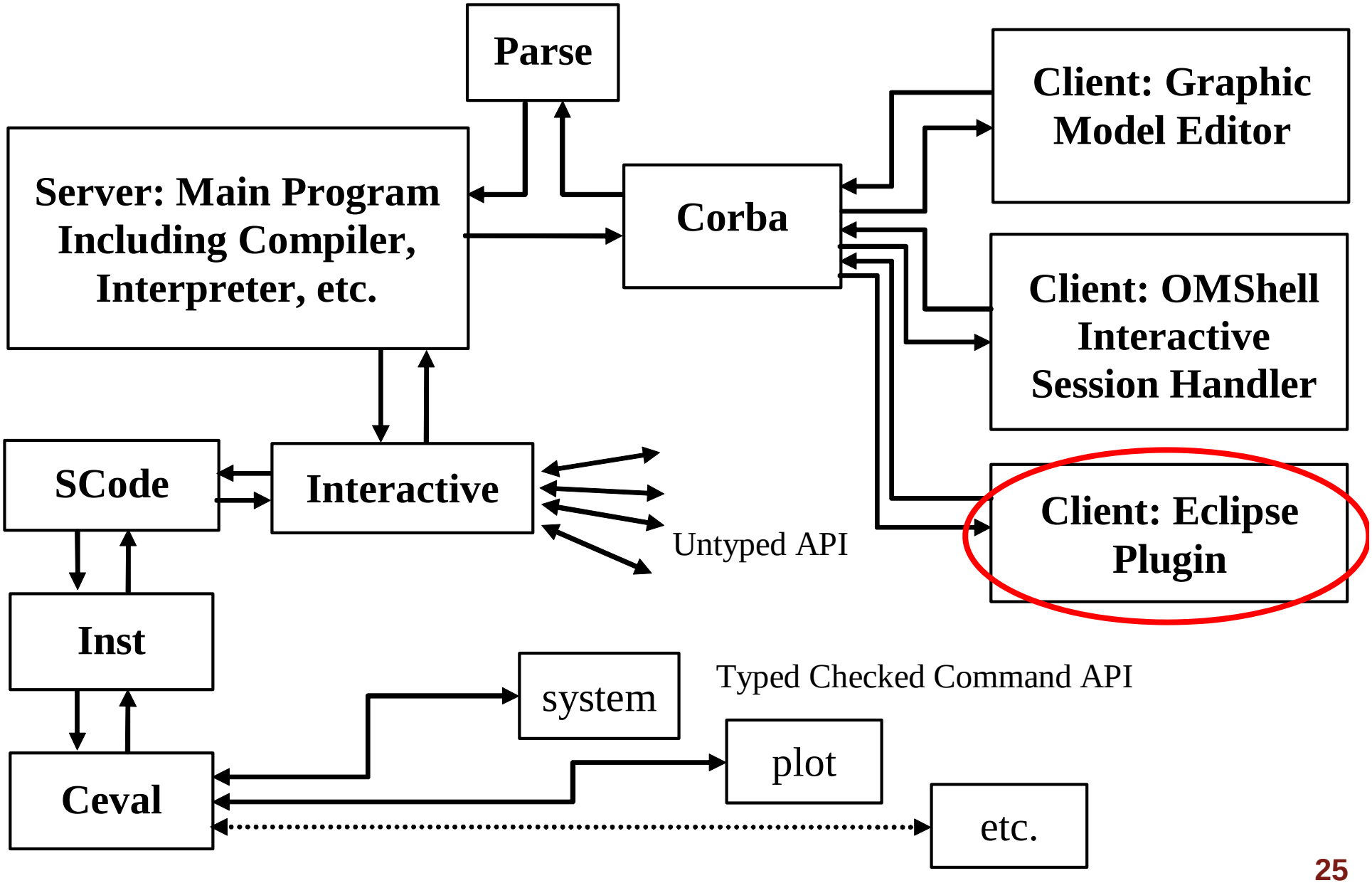
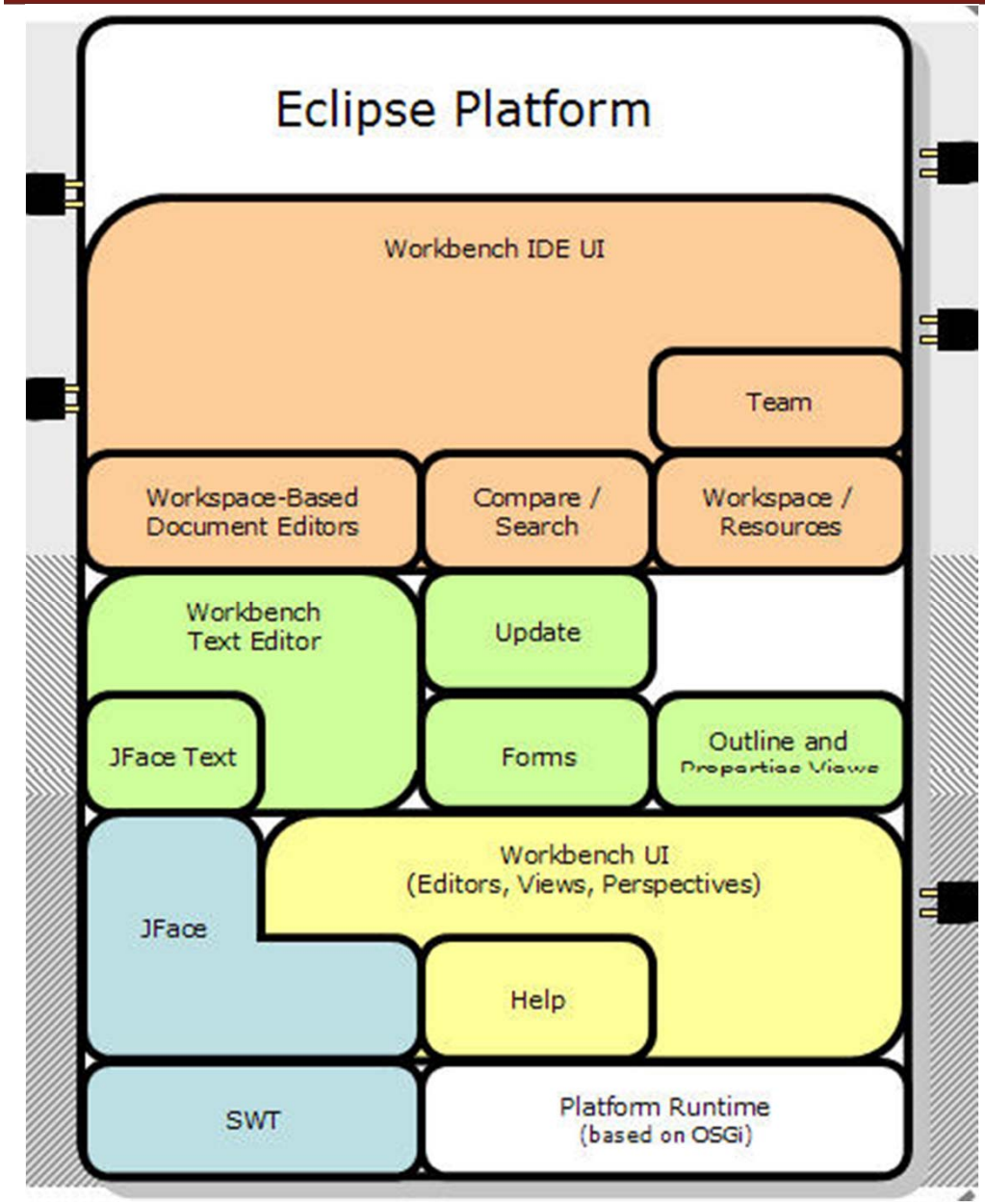
MetaModelica

- 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

OpenModelica Context



The MDT Eclipse Environment (I)



Modelica Browser

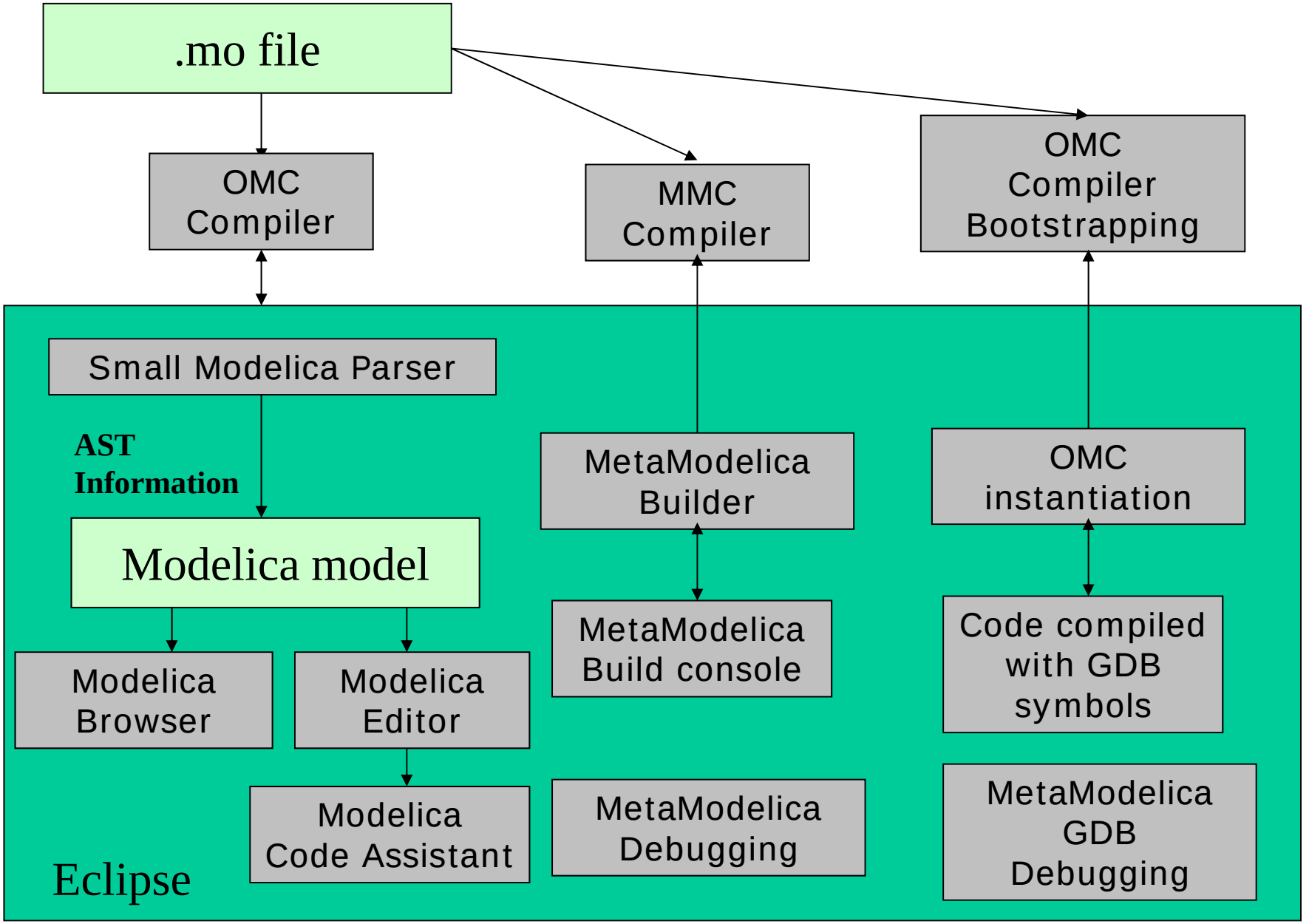
Modelica Editor

Modelica Code Assistant

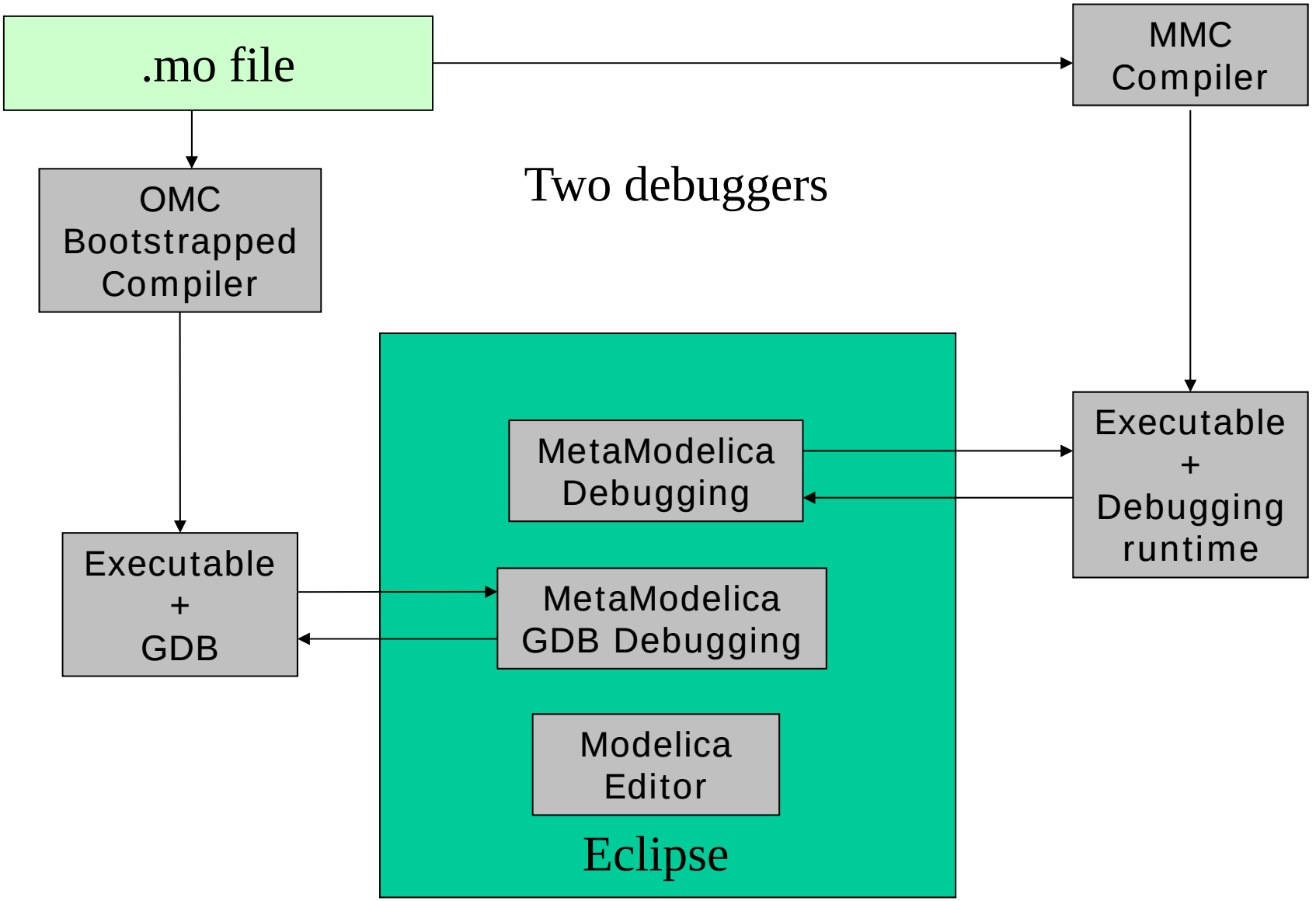
MetaModelica Debugging

Modelica Perspective

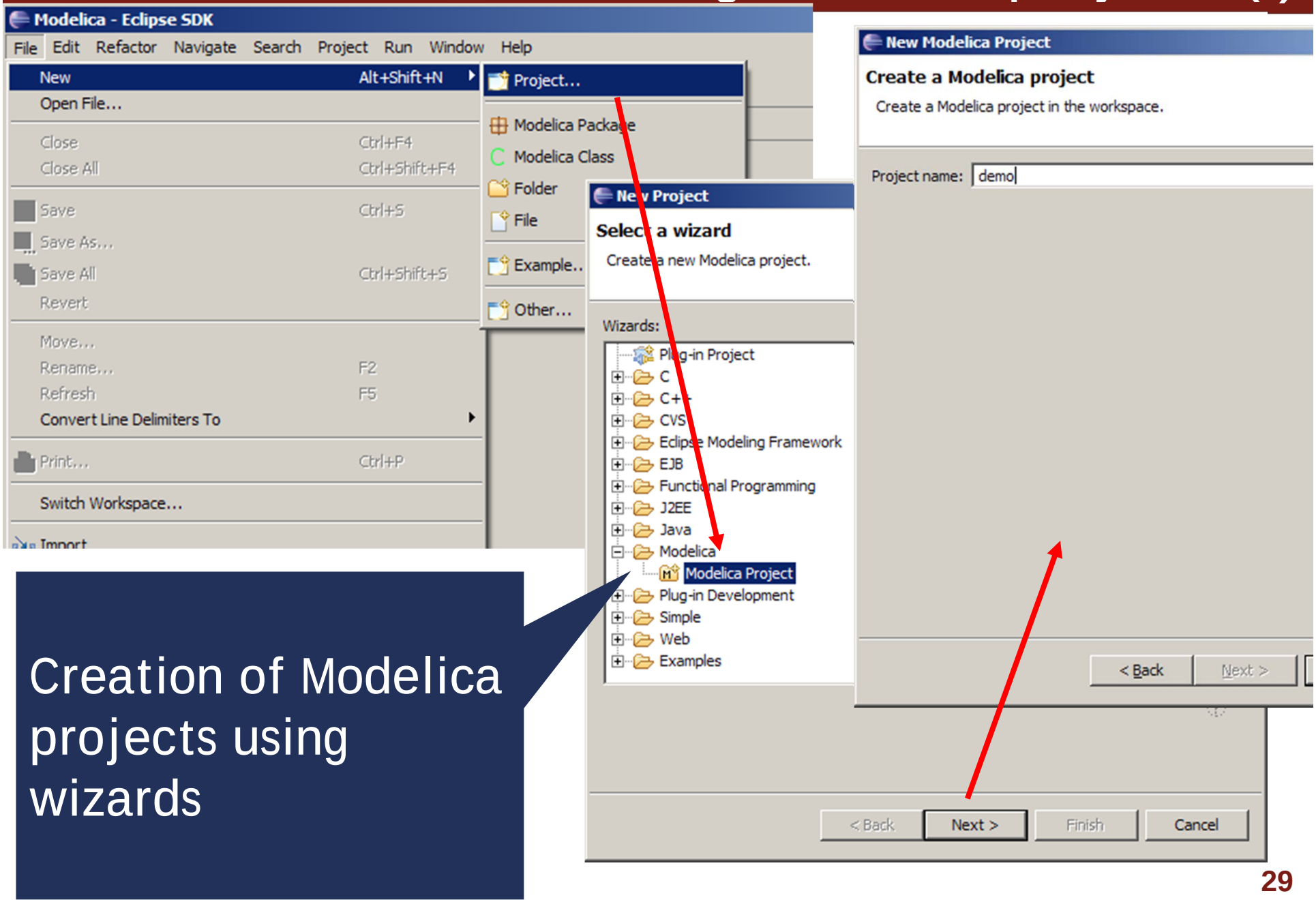
The MDT Eclipse Environment (II)



The MDT Eclipse Environment (III)

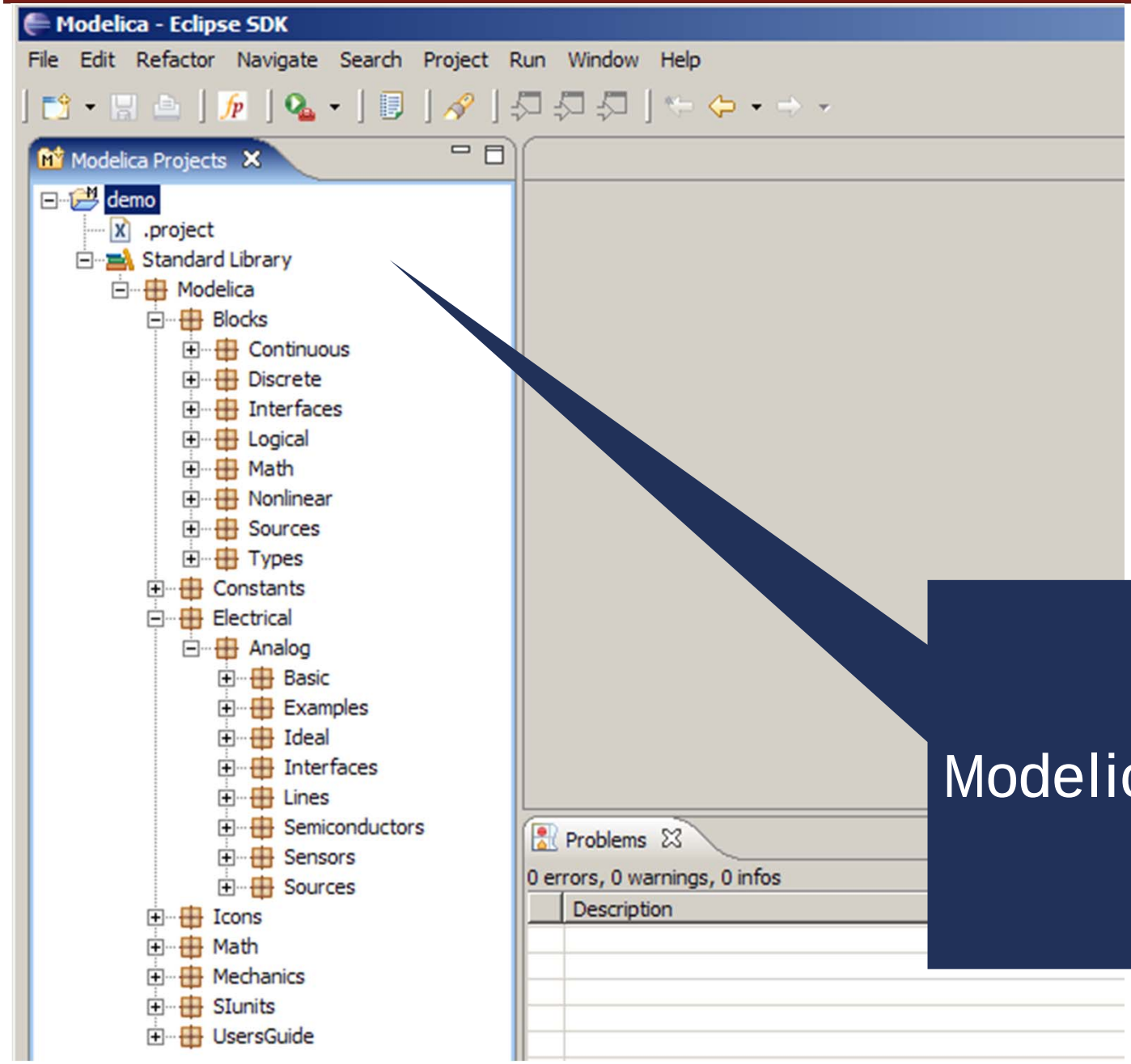


Creating Modelica projects (I)



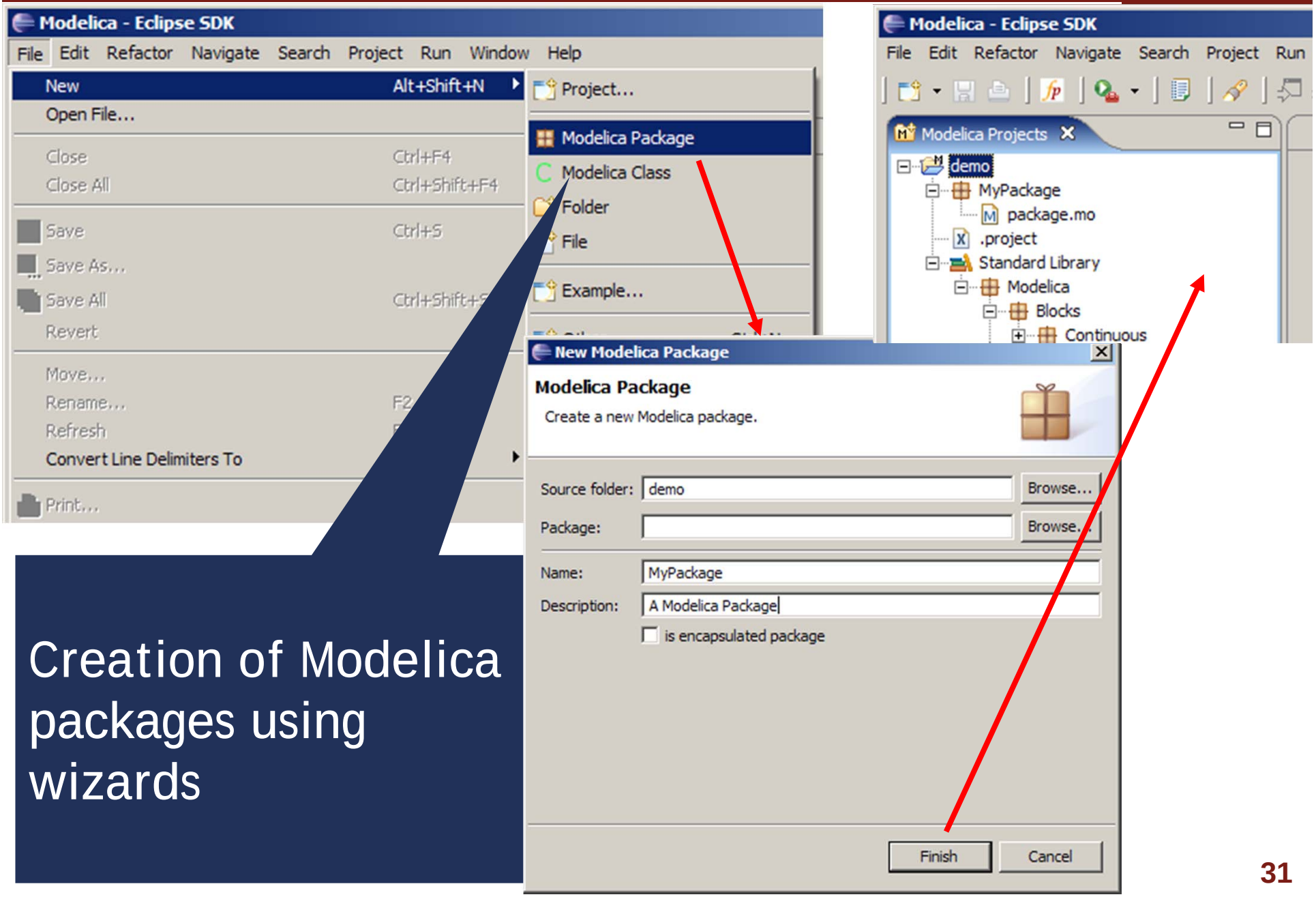
Creation of Modelica projects using wizards

Creating Modelica projects (II)



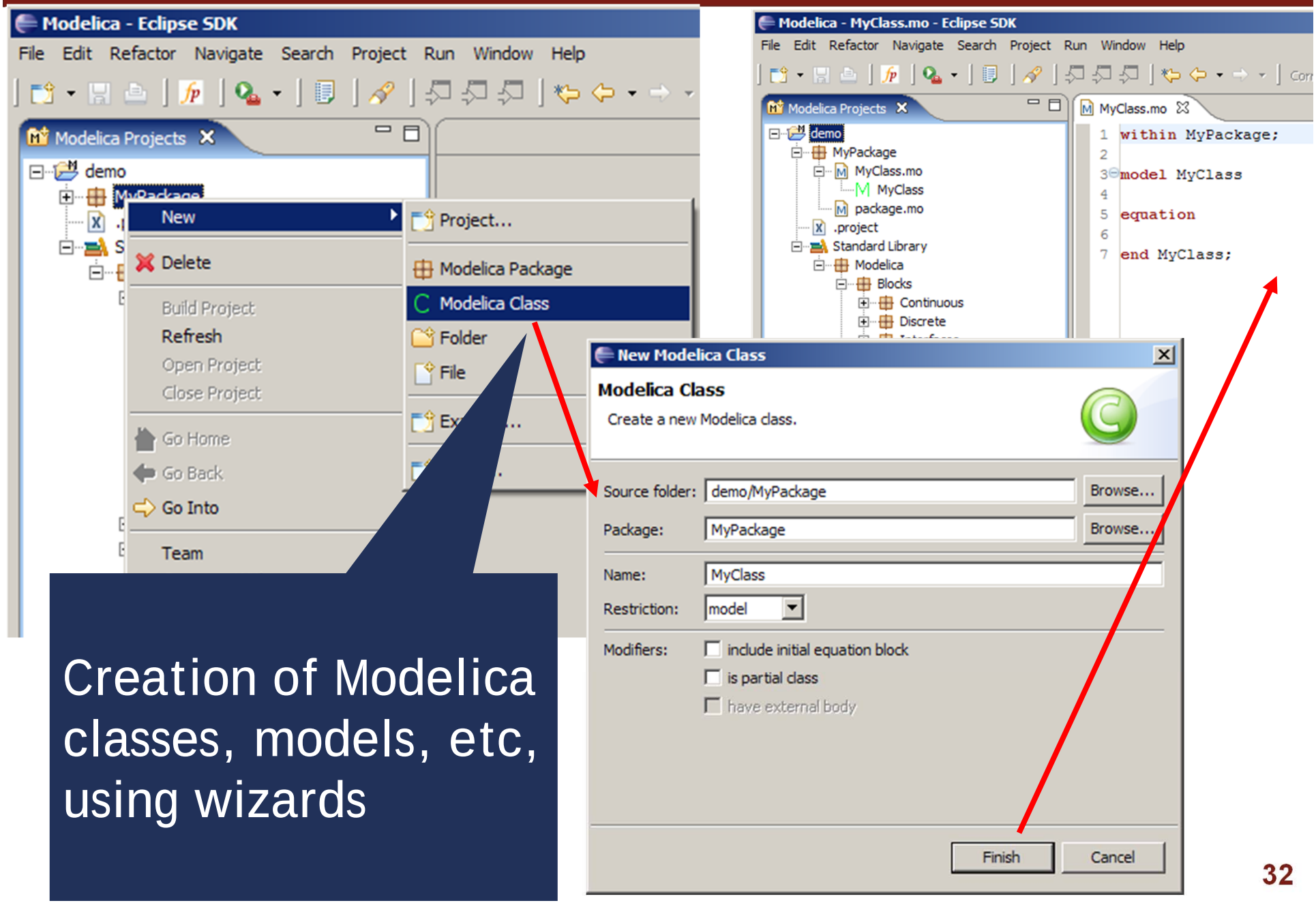
Modelica project

Creating Modelica packages



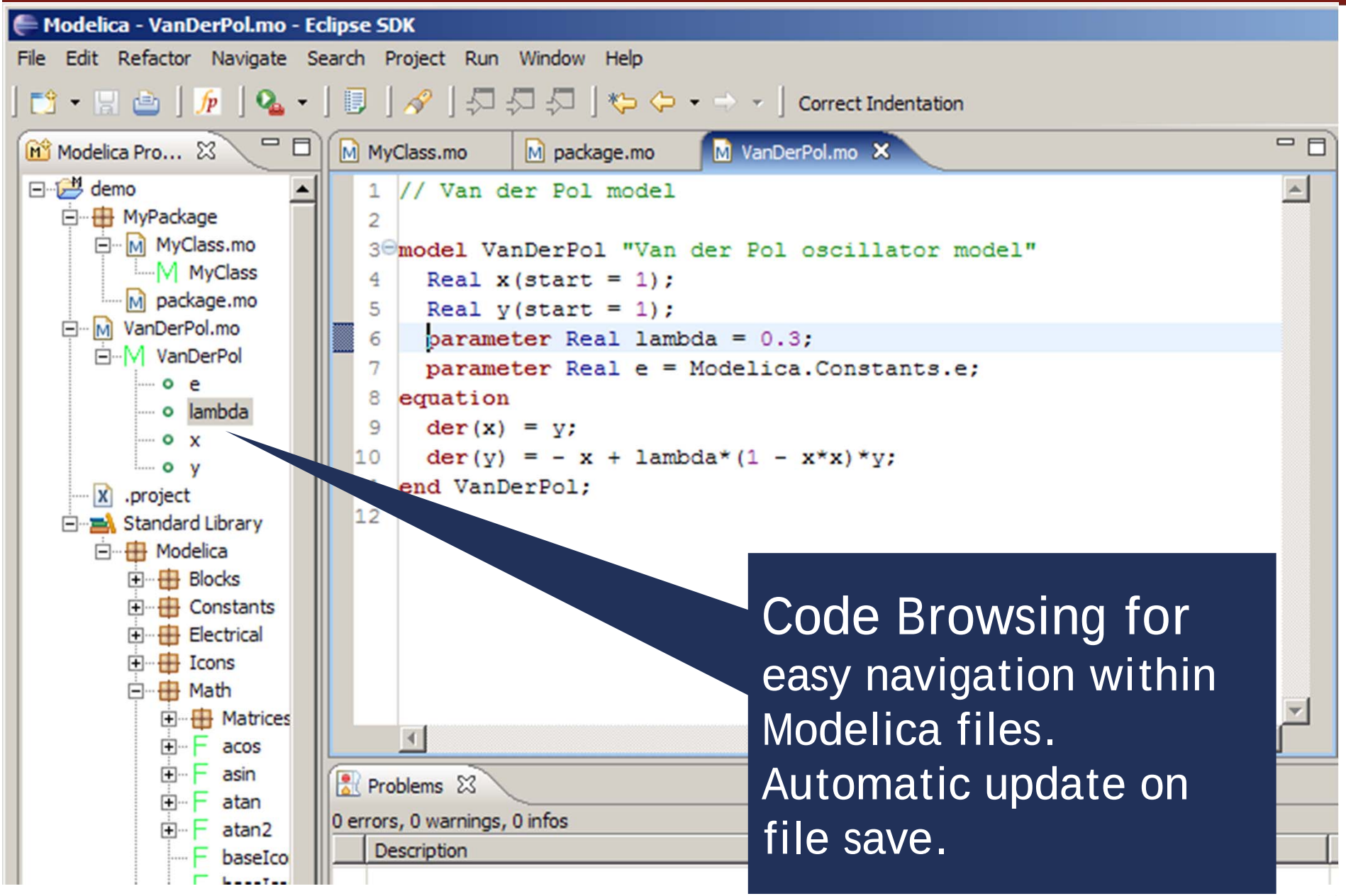
Creation of Modelica packages using wizards

Creating Modelica classes



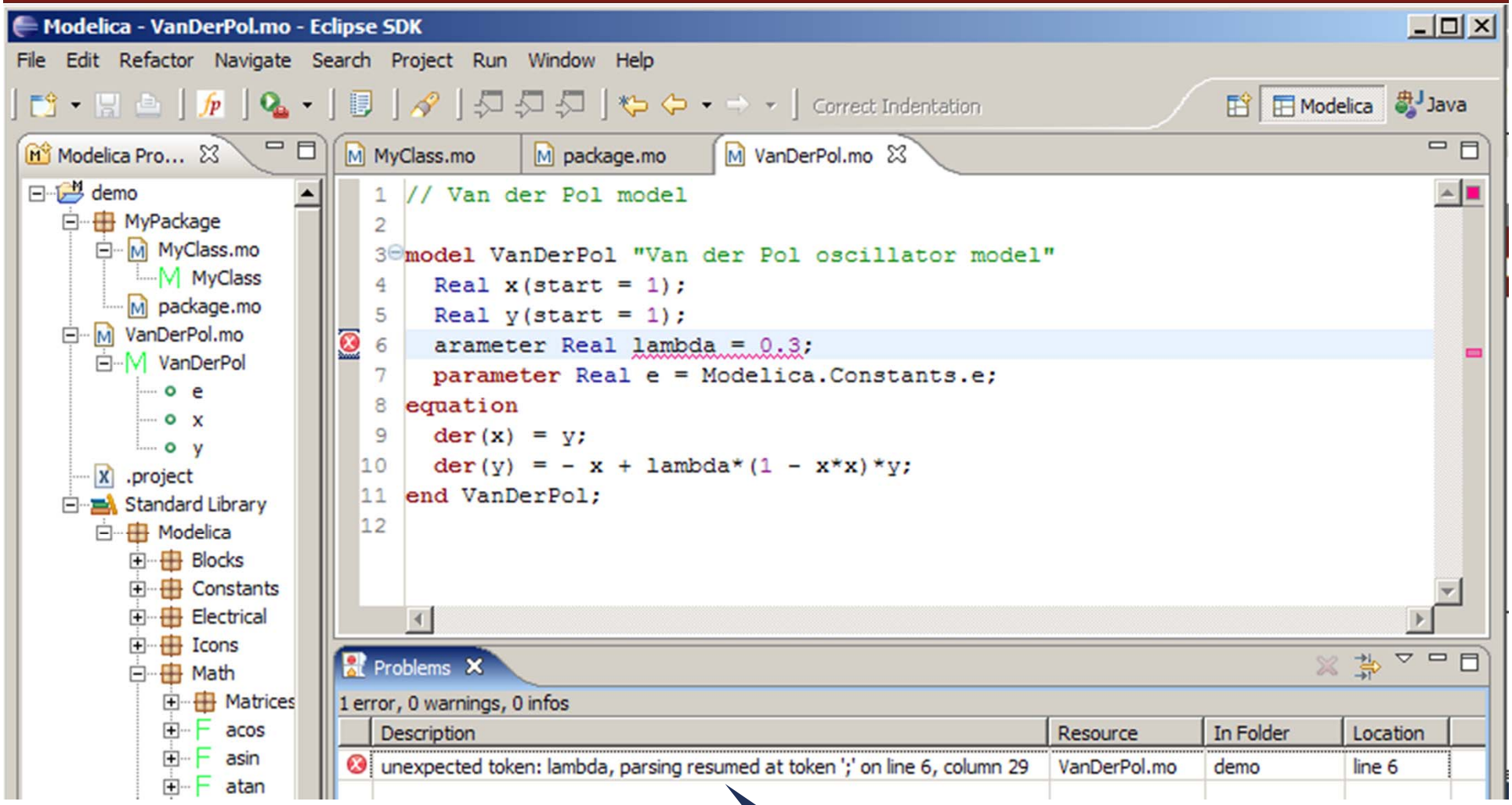
Creation of Modelica classes, models, etc, using wizards

Code browsing



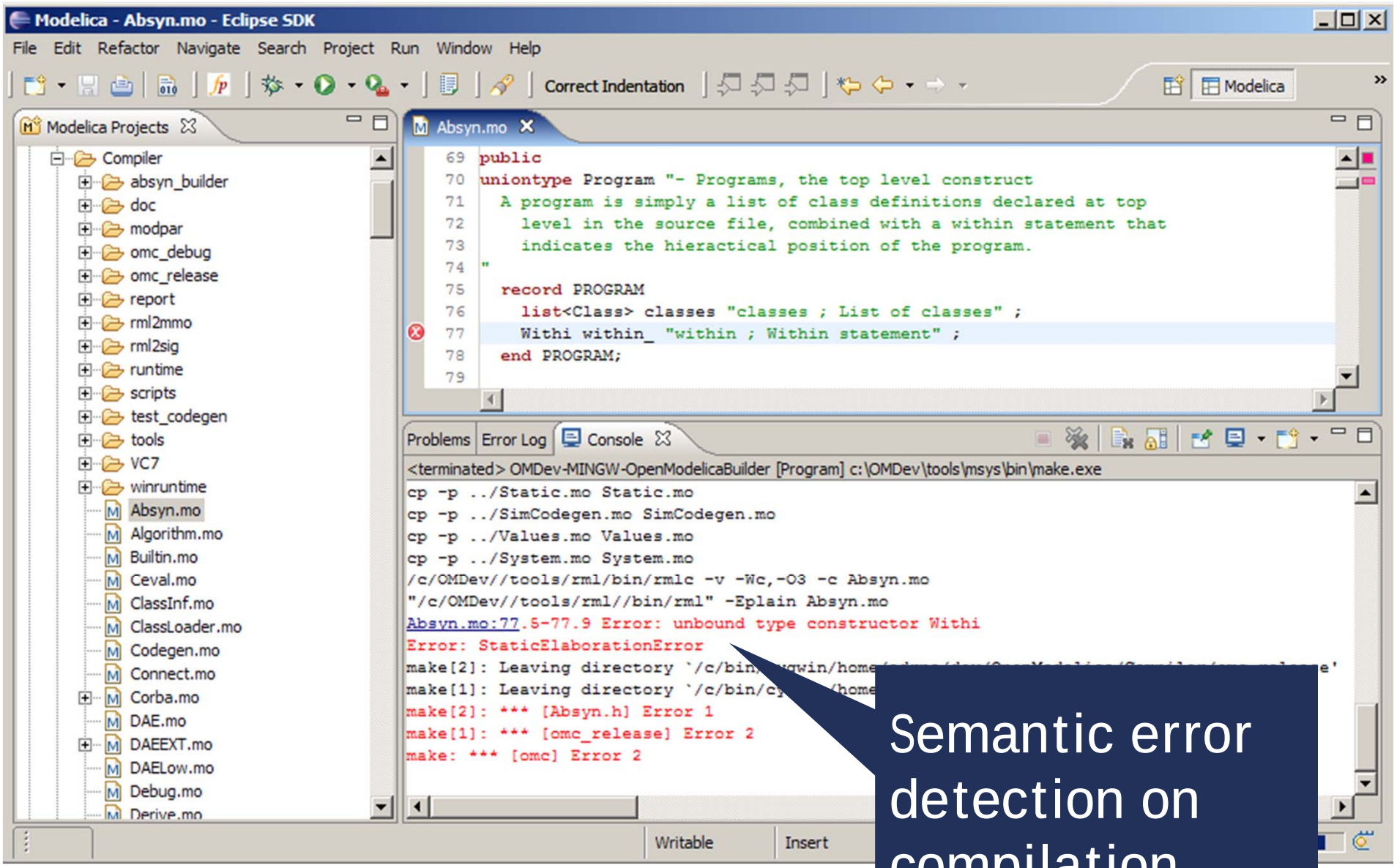
Code Browsing for easy navigation within Modelica files. Automatic update on file save.

Error detection (I)

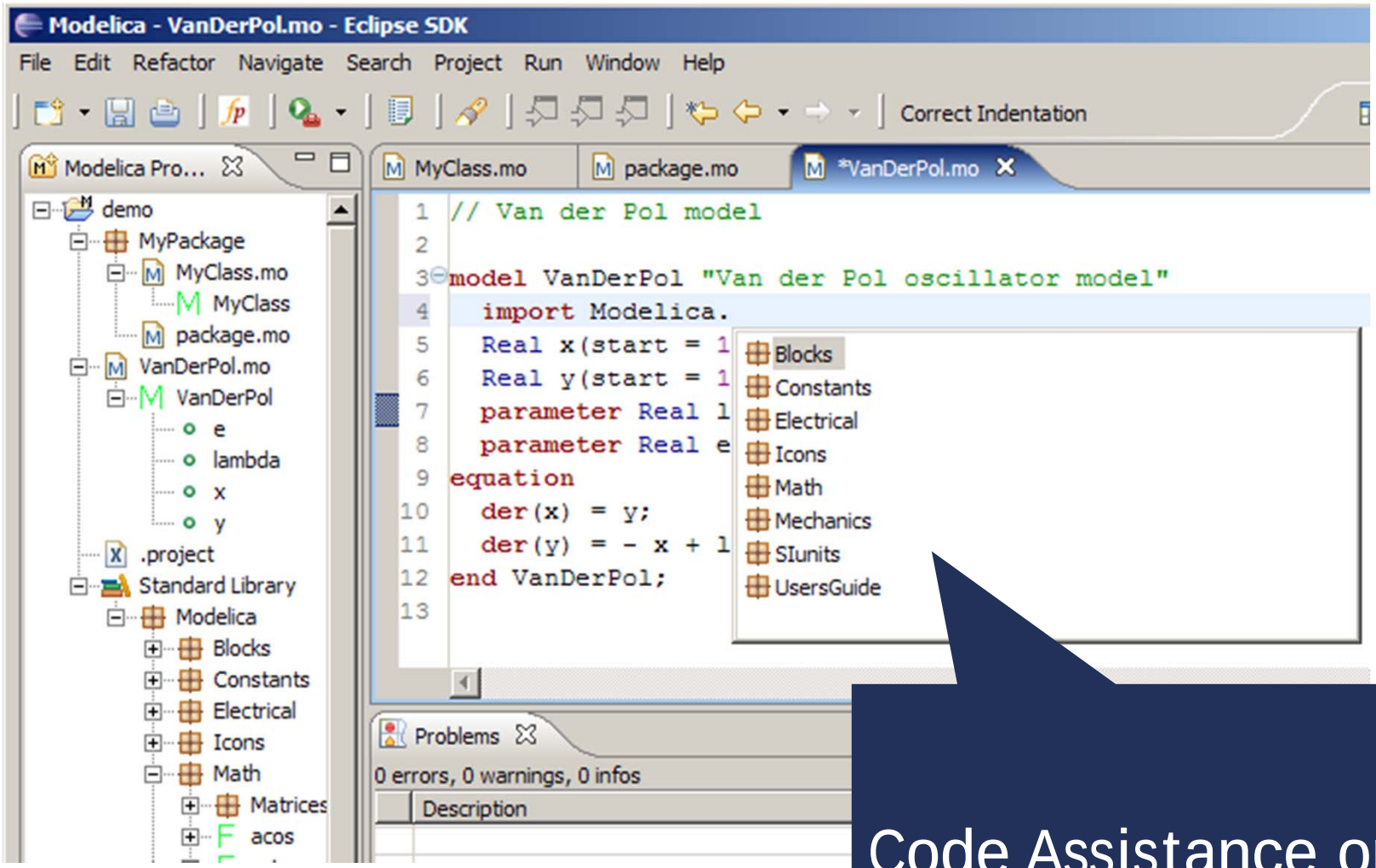


Parse error detection on file save

Error detection (II)

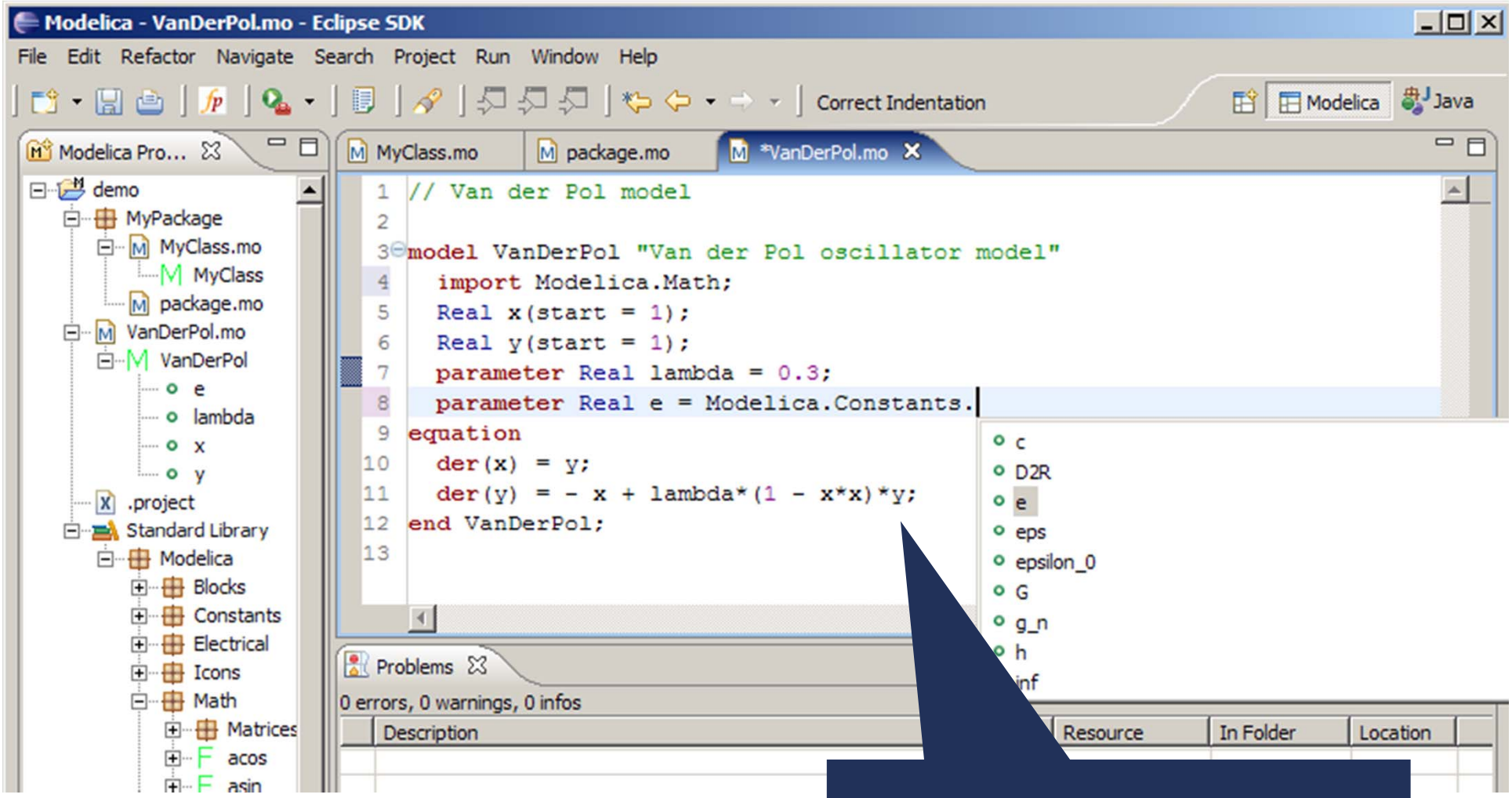


Code assistance (I)



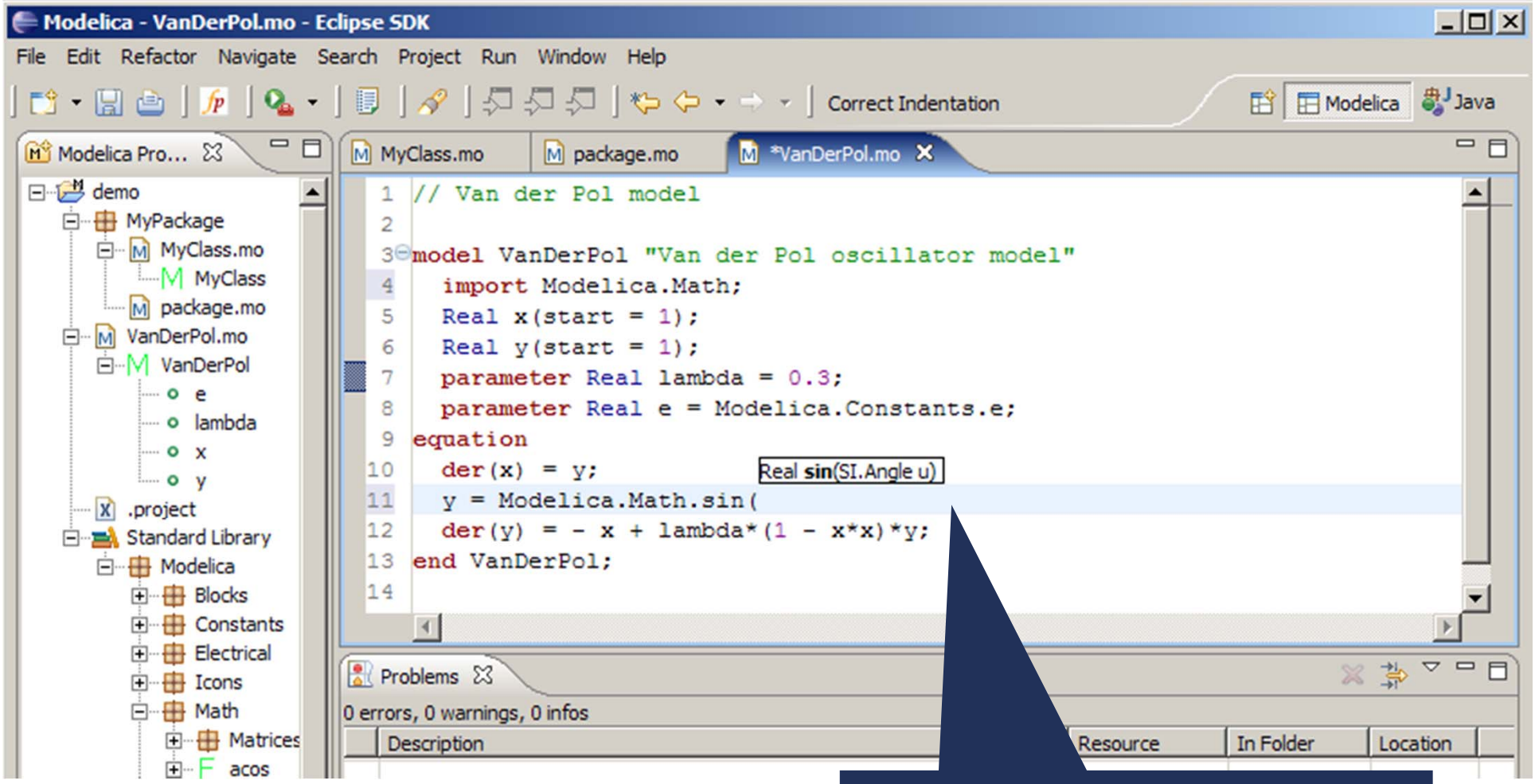
Code Assistance on imports

Code assistance (II)



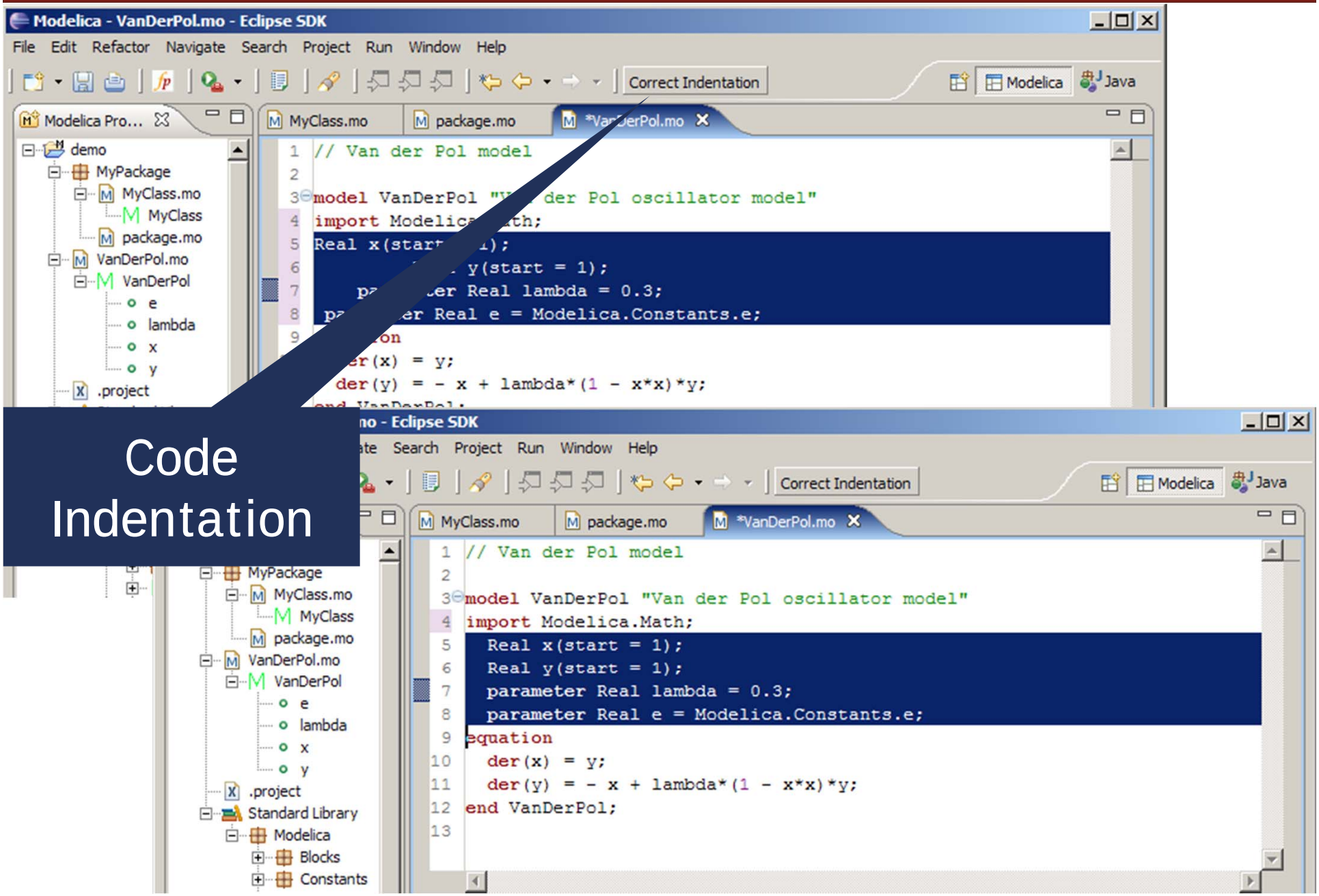
Code Assistance on assignments

Code assistance (III)



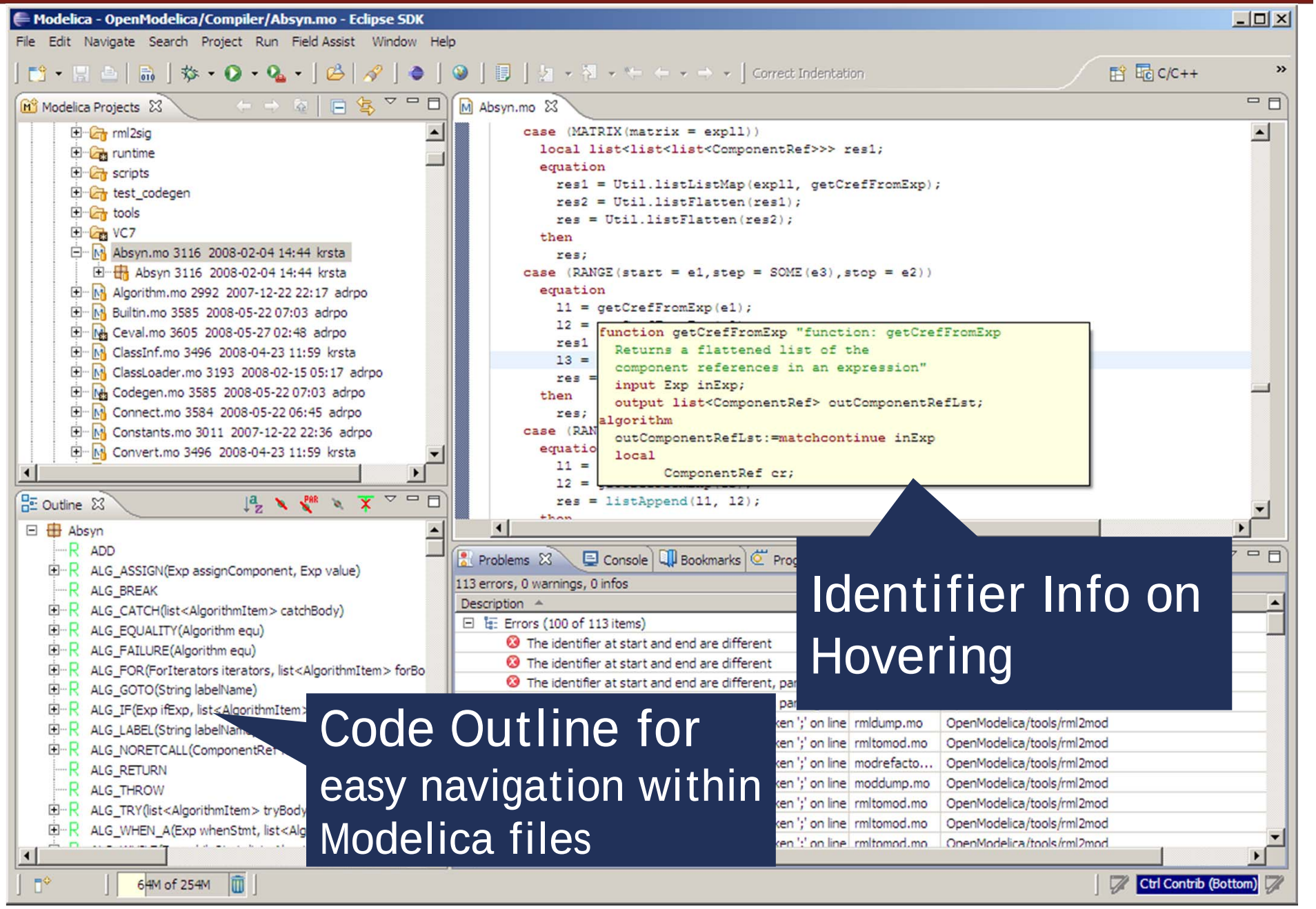
Code Assistance on function calls

Code indentation

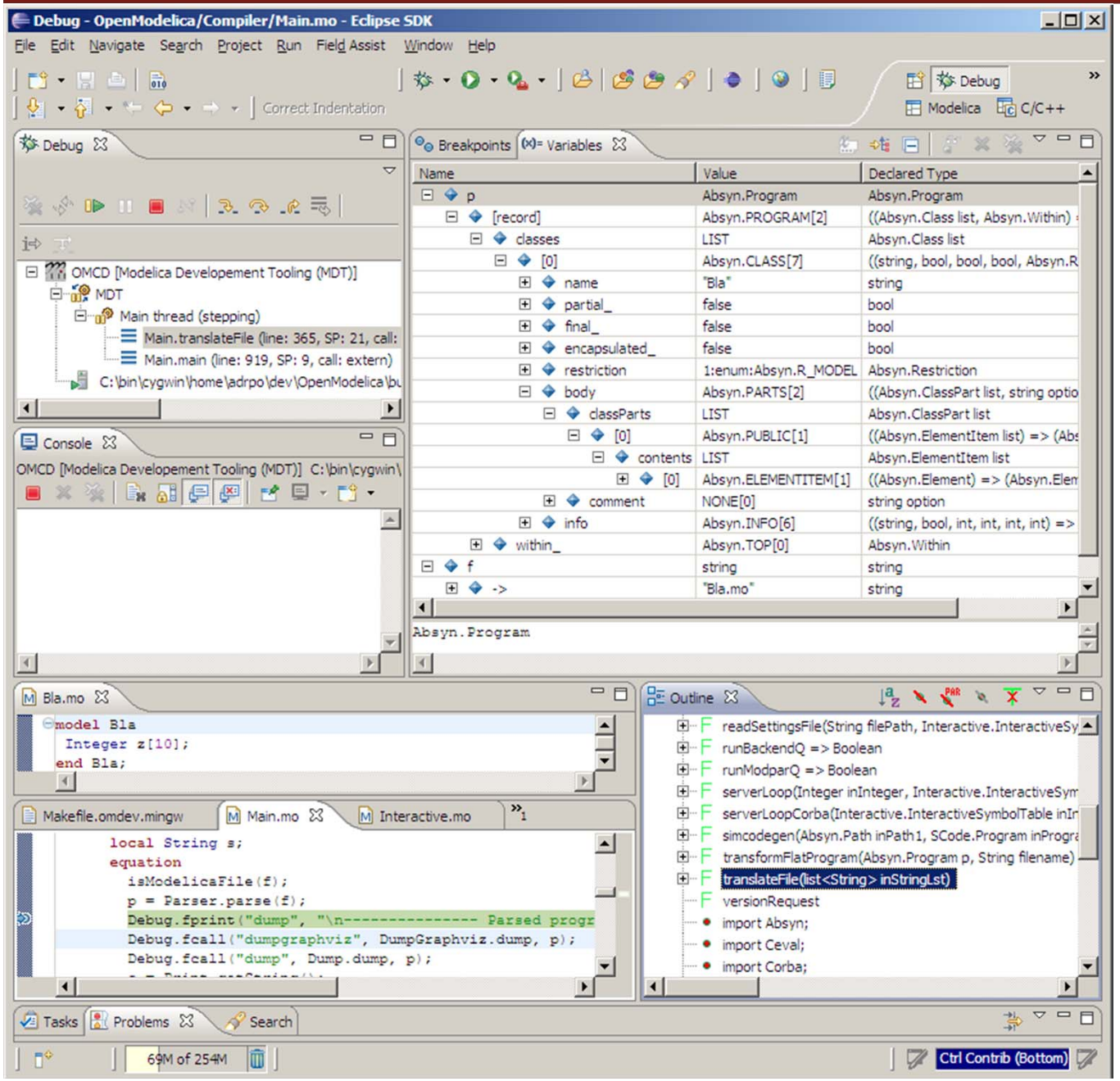


Code Indentation

Code Outline and Hovering Info



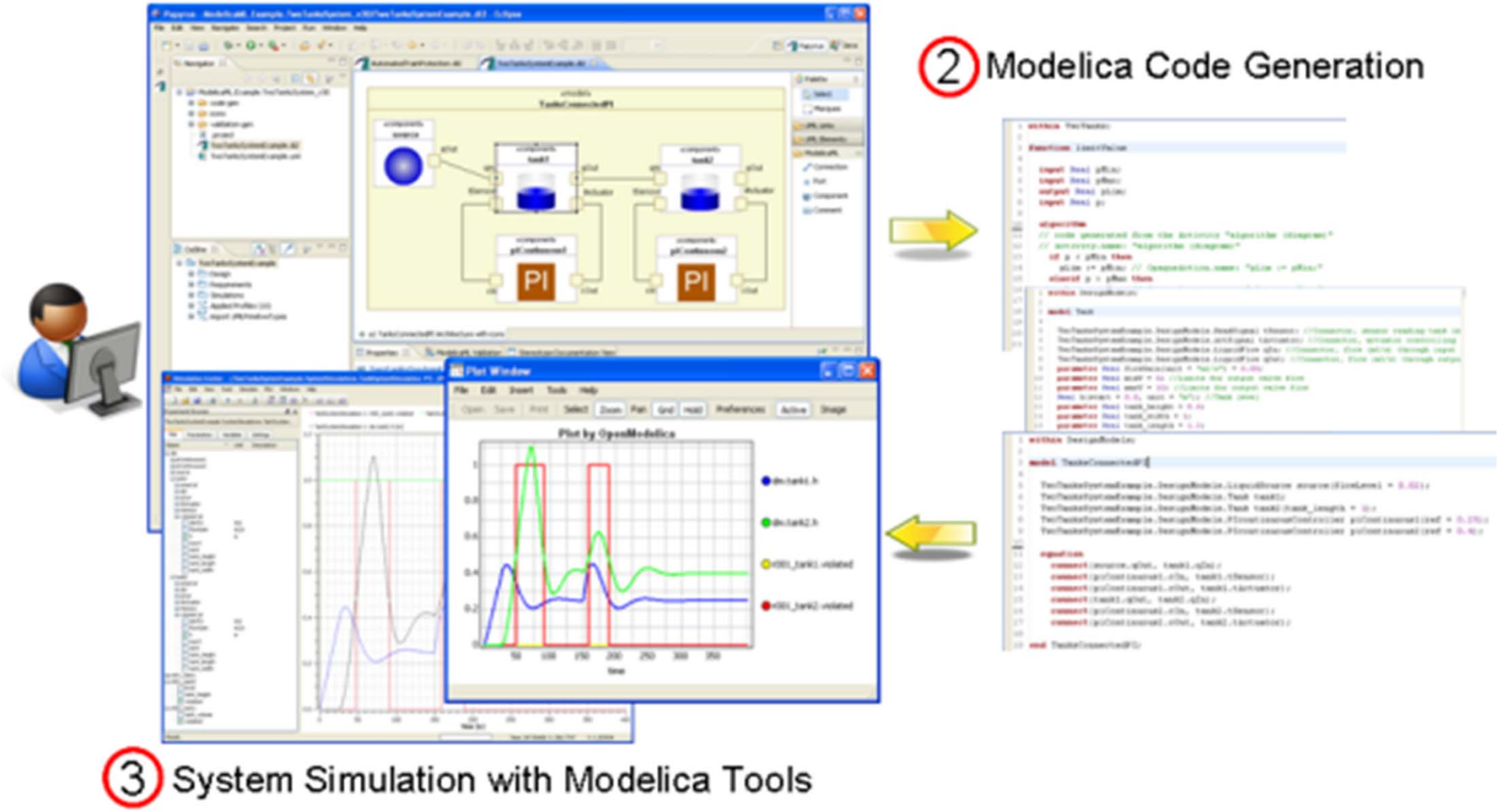
Eclipse Debugging Environment



- Type information for all variables
- Browsing of complex data structures
- Two Debuggers
  - Code instrumentation
  - GDB based

Eclipse environment for ModelicaML

1 System Modeling with ModelicaML



2 Modelica Code Generation

3 System Simulation with Modelica Tools

- Tutorial tomorrow at ModProd 2011!

Outline

- OpenModelica
  - What is OpenModelica?
  - The past and present
- OpenModelica Technical Overview
  - OMC, OMShell, OMNotebook
- OpenModelica Development Environment
  - MetaModelica
  - The Eclipse Environment
- OpenModelica Latest Developments (2011-2012)

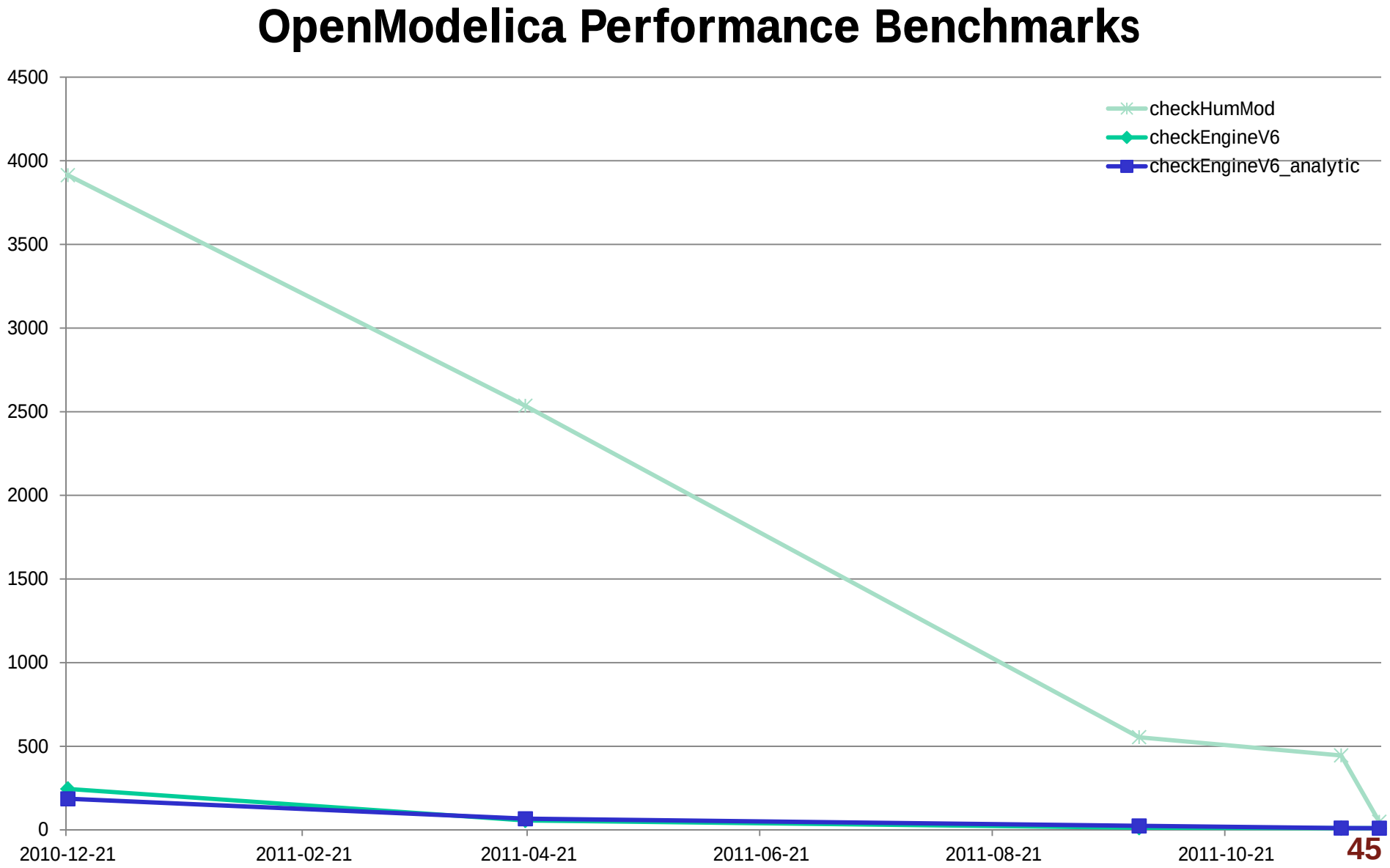
Latest Developments (2011-2012)

2011 – 2012 – Most focus on MSL 3.1 support & performance

- Support for Modelica Standard Library 3.1
- Media now flattens and we can simulate some of the examples (backend work still)
- Fluid is partially supported and new work has started on a new Inst module
- Front-end
  - Performance Enhancements
  - Operator overloading
  - New phases to simplify things (SCode*)
  - New interactive API
- 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
  - MDT GDB debugging based on GDB and the boostrapped compiler
  - OMEdit – improvements
  - Bootstrapping OMC (98% finished) GC speedup remaining
  - 2473 commits in subversion from 2011 to Feb. 7, 2012
  - Bug fixes ~300+ (OSMC)
  - Release 1.7.0, 1.8.0, 1.8.1 (Linux, Mac, Windows)
  - Downloads Windows (~31246) , Linux (~10245), Mac (~4543)

Latest Developments (2011-2012)

2011 – 2012 – Most focus on MSL 3.1 support & performance



Latest Developments (2011-2012)

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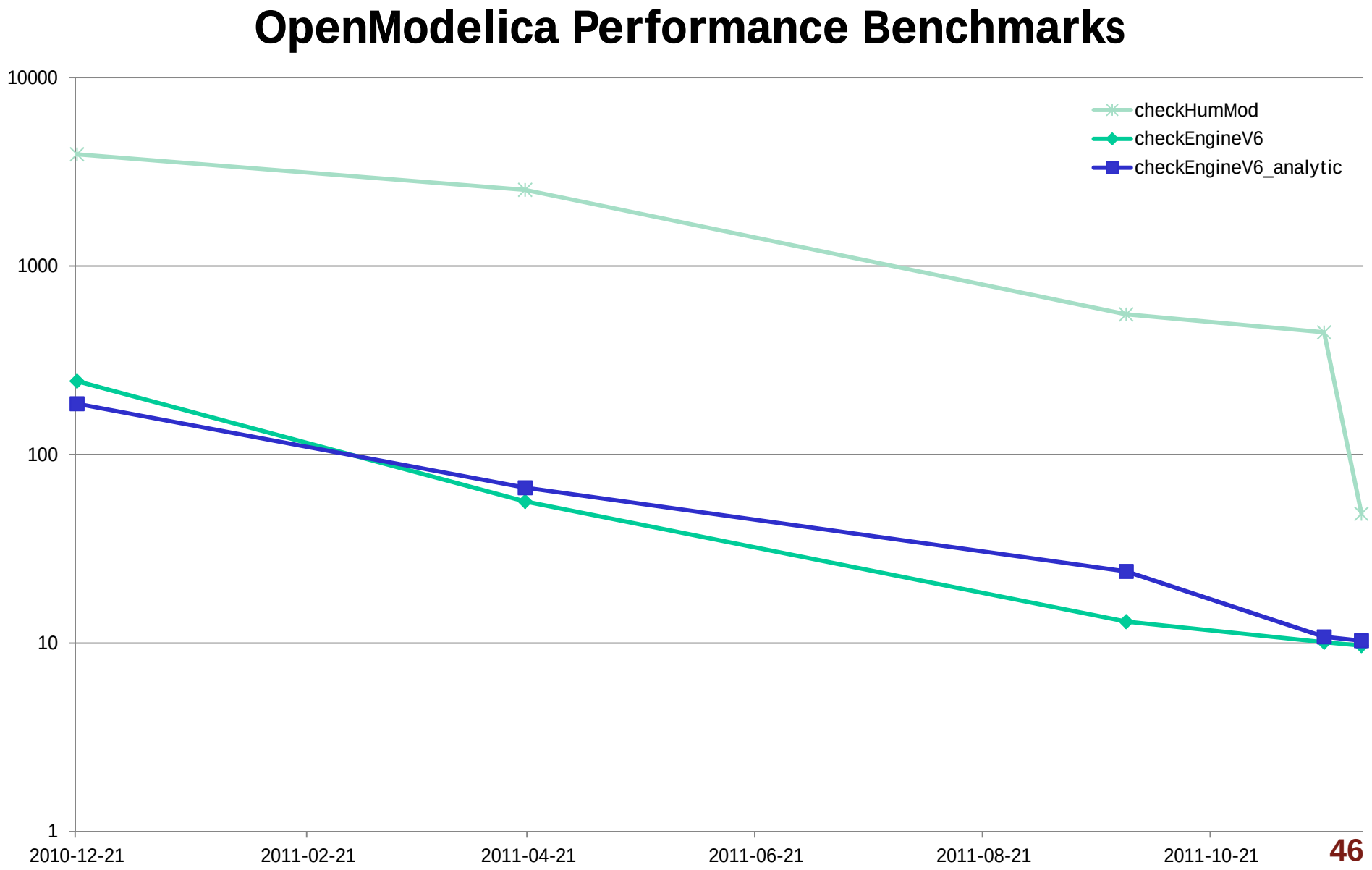

Latest Developments (2011-2012)

legend: faster / slower / out of memory

Performance measurements for OpenModelica

Adrian.Pop@liu.se

Tests done on an HP Elitebook 8440p, Core-I7 (M620) @ 2.67Gz 8GB RAM, SSD, Win 7 64bit

OpenModelica OMC is compiled with MinGW32 GCC 4.4 with -O3

All numbers are in seconds

https://openmodelica.org/svn/OpenModelica/trunk/doc/performance/benchmarks

OpenModelica				operations			difference				max (MB)	Dymola 7.4
version	date	revision	test	instantiate	check	equations	instantiate		check		mem	check
1.6.0	2010-12-21	7524	HumModOMCTotal	2988	3914	24055	0		0		2355,2	13,95
			RobotR3	10,2	22	4828	0		0			4,68
			EngineV6	34,6	245	12491	0		0			2,6
			EngineV6_analytic	27,5	186	9491	0		0			2,4
version	date	revision	test	instantiate	check	equations	instantiate		check		mem	
1.7.0	2011-04-20	8711	HumModOMCTotal	2391	2535	24055	597	-20%	1379	-35%	675	
			RobotR3	9,1	11,5	4828	1,1	-11%	10,5	-48%		
			EngineV6	25,4	56,4	12491	9,2	-27%	188,6	-77%		
			EngineV6_analytic	25,6	66,7	9491	1,9	-7%	119,3	-64%		
version	date	revision	test	instantiate	check	equations	instantiate		check		mem	
1.8.0	2011-09-28	9944	HumModOMCTotal	550	554	24091	1841	-77%	1981	-78%	274	
			RobotR3	7,1	7,5	4828	2	-22%	4	-35%		
			EngineV6	12	13	12491	13,4	-53%	43,4	-77%		
			EngineV6_analytic	24	24	9491	1,6	-6%	42,7	-64%		
version	date	revision	test	instantiate	check	equations	instantiate		check		mem	
1.8.0	2011-11-20	10556	HumModOMCTotal	437	445	28083	113	-21%	109	-20%	245	more equations due to more correct handling of expandable connectors
	revisions	3032	RobotR3	6,8	7,1	4828	0,3	-4%	0,4	-5%		
			EngineV6	9,5	10,1	12491	2,5	-21%	2,9	-22%		
			EngineV6_analytic	10,2	10,8	9491	13,8	-58%	13,2	-55%		
version	date	revision	test	instantiate	check	equations	instantiate		check		mem	
1.8.0	2011-11-30	10604	HumModOMCTotal	46,5	48,5	28083	390,5	-89%	396,5	-89%	243	
	revisions	48	RobotR3	5,6	6	4828	1,2	-18%	1,1	-15%		
			EngineV6	8,8	9,7	12491	0,7	-7%	0,4	-4%		
			EngineV6_analytic	9,6	10,3	9491	0,6	-6%	0,5	-5%		

Media & Fluid (I)

- The most evil Library is **Media …**
  and its evil father is **Fluid** ☺

- Everything in the Modelica Language Specification is used
  - partial functions in partial packages
  - full packages in partial packages used via the fully qualified path
  - redeclare replaceable model extends x
  - functions using redeclare replaceable function extends used to set constants in partial packages
  - redeclared components that have no replaceable
  - replaceable and redeclare base classes
  - constants with no bindings that *have* to be used in instantiation
  - constant records with components that have no binding
  - large depth of replaceable chains
  - package extension via dot notation on the way to types
- … and then some more that is not even specified

Media & Fluid (II)

Action plan to support Media & Fluid

- Simplify flattening (instantiation) by preprocessing phases
  - Remove imports (100%)
  - Apply redeclare and modifiers (100%)
  - Perform dependency analysis (100%)
  - Handle record constants (100%)
  - Instantiate in phases and do type checking after (30%)
- Back-end issues
  - Complex equation support (30%)
  - Other code generation issues
  - Initialization
- Any other unknown issues
- *Hopefully full Media & Fluid flattening in 2012*

OMC Bootstrapping Status

- The bootstrapped OpenModelica
  - Works and can run the full testsuite
  - Supports very fast debugging via GDB
  - Fully supports Modelica and several new MetaModelica constructs that will make compiler development much easier and modular
  - Comparable in speed with the MMC based one
  - Code generation is much more user friendly (readable)

- Work in progress
  - First Garbage Collector (GC) drafts combining mark-and-sweep and generational are working (but not fast enough)
  - Work is on the way to speedup the GC to be able to switch to bootstrapped compilation

Thank You!
Questions?

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, adrpo

OpenModelica Project

http://www.OpenModelica.org

Funny Facts

- adrpo is most productive Wednesdays at 9 o'clock!
- at least 7-8 times more productive ☺
- can I take holidays in the other days?