Technical Overview of OpenModelica and its Development Environment

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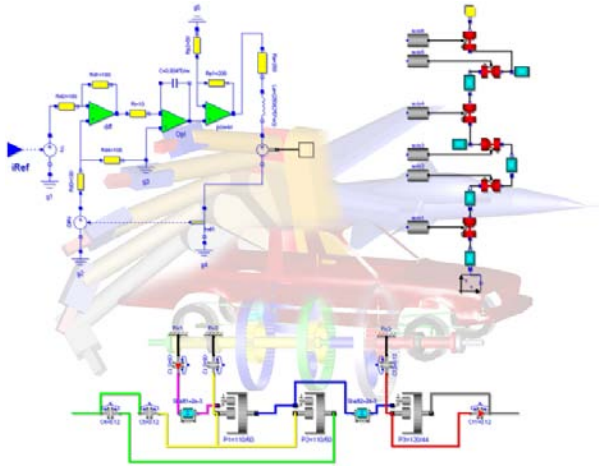
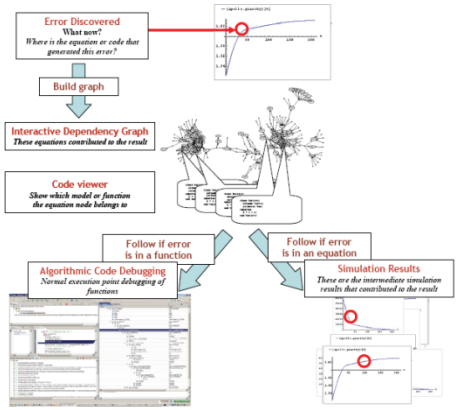
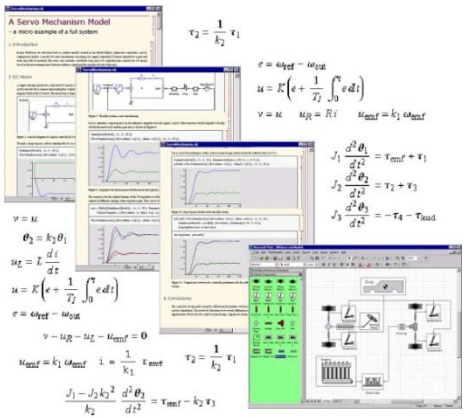
www.OpenModelica.org







OPEN SOURCE MODELICA CONSORTIUM

OpenModelica

MODELICA

pelab

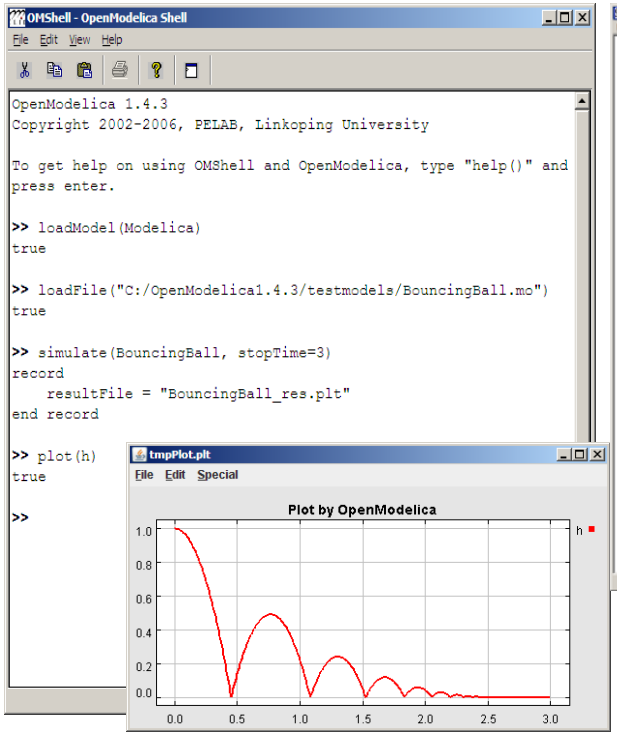
LINKÖPINGS UNIVERSITET

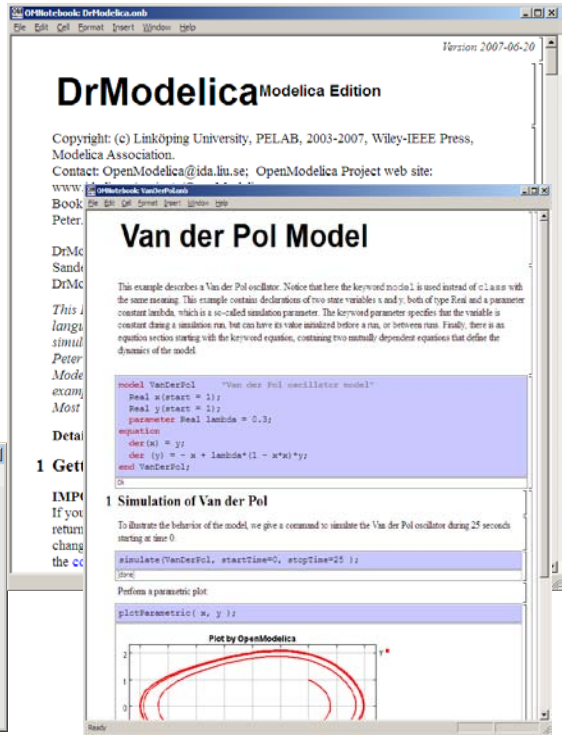
Outline

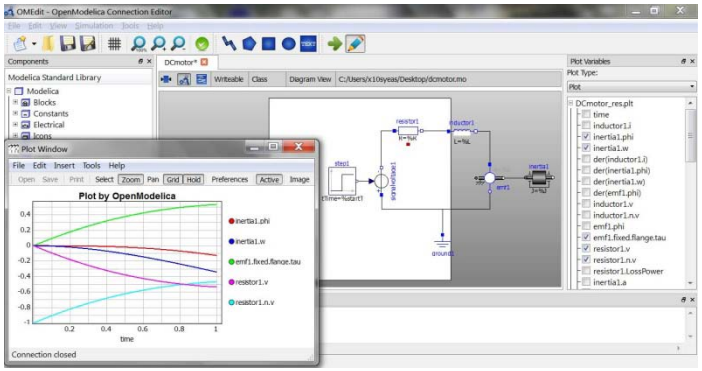
- OpenModelica
  - What is OpenModelica?
  - The past and present
- OpenModelica Technical Overview
  - OMC, OMShell, OMNotebook,
  - OMEdit, ModelicaML, SimForge
- OpenModelica Development Environment
  - MetaModelica (RML/OMC)
  - The Eclipse Environment (MDT)
- OpenModelica Latest Developments (2010-2011)

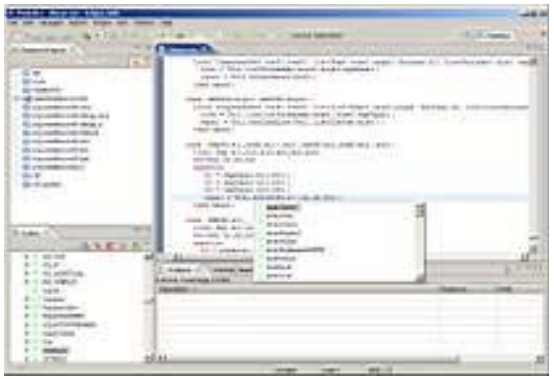
What is OpenModelica? (I)

- Advanced Interactive Modelica compiler (OMC)
  - Supports MLS v. 3.1 (without Media & Fluid)
- Basic environments for creating models
  - OMShell – an interactive command handler
  - OMNotebook – a literate programming notebook
  - OMEdit – Open Modelica Connection Editor (New)
  - MDT – an advanced textual environment in Eclipse



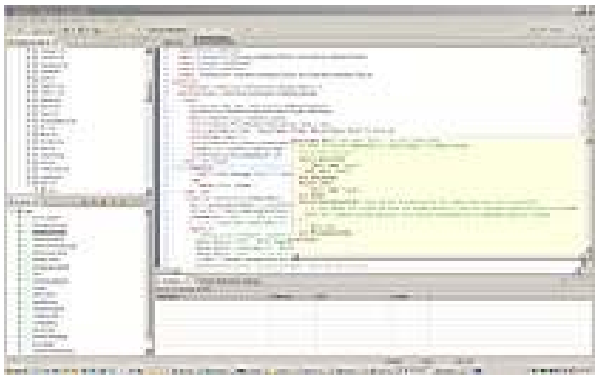


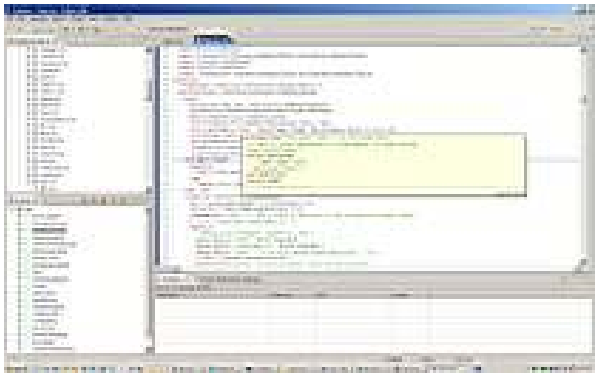


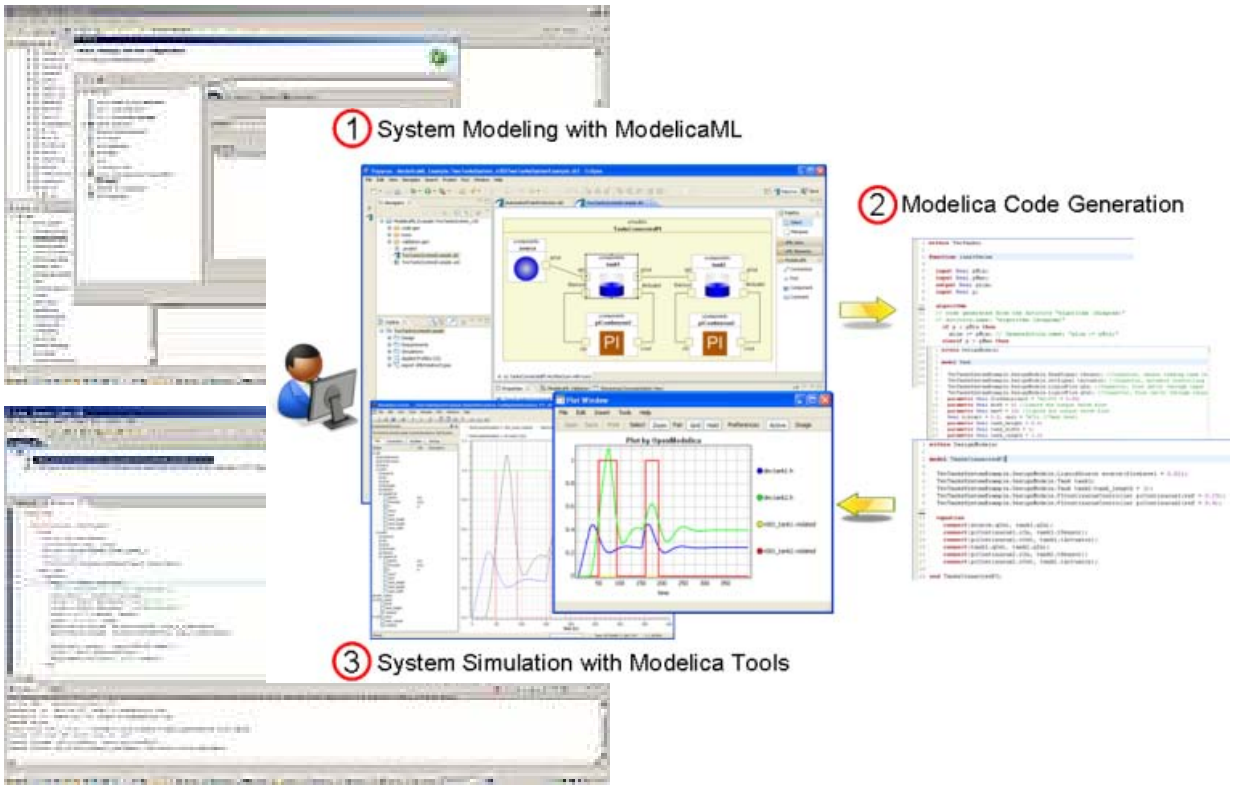


What Is OpenModelica? (II)

- 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 8 OpenModelica Development Courses (INRIA, PELAB)
- **ModelicaML UML/SysML integration (New)**

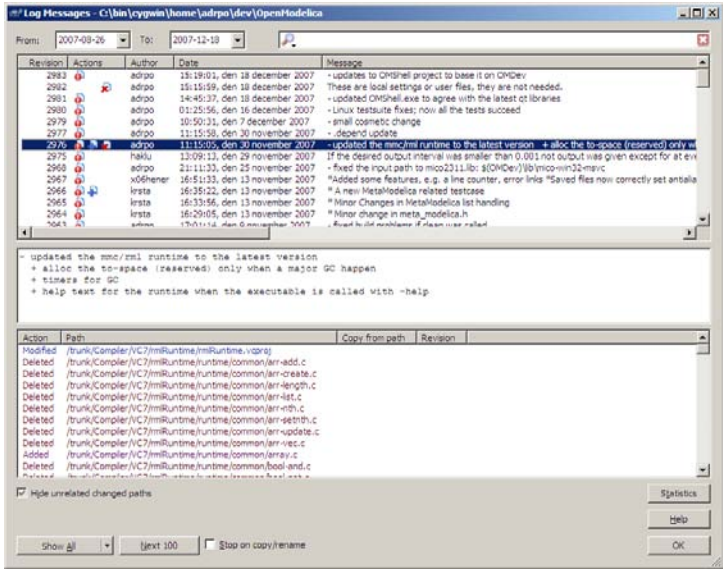


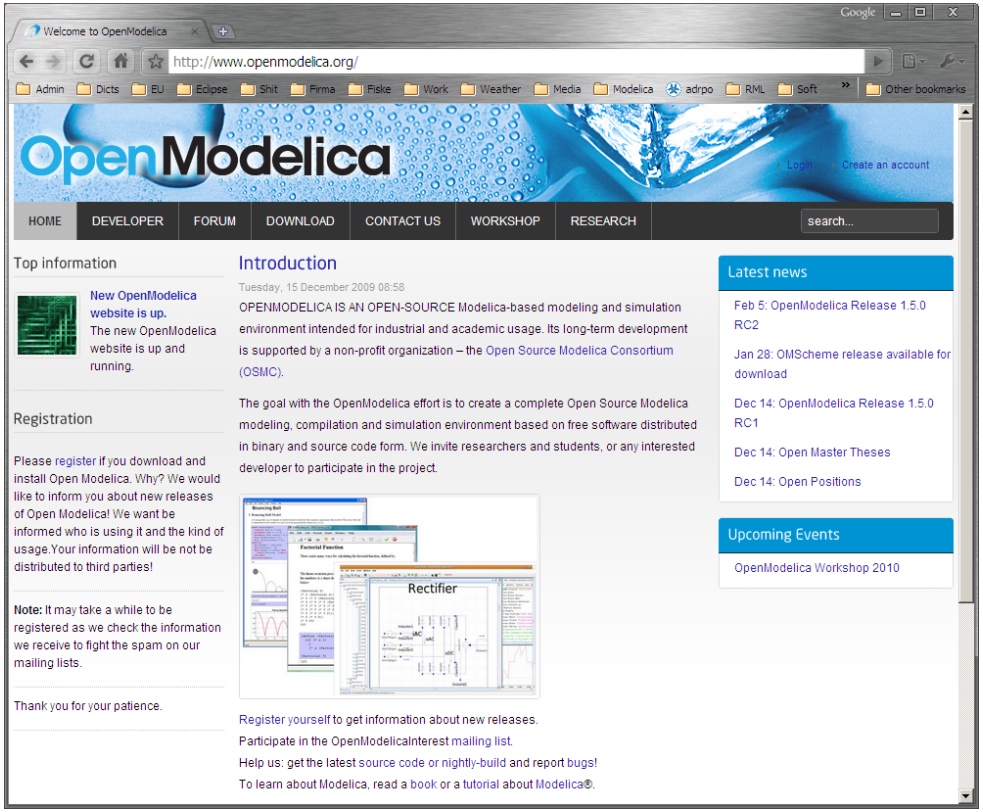


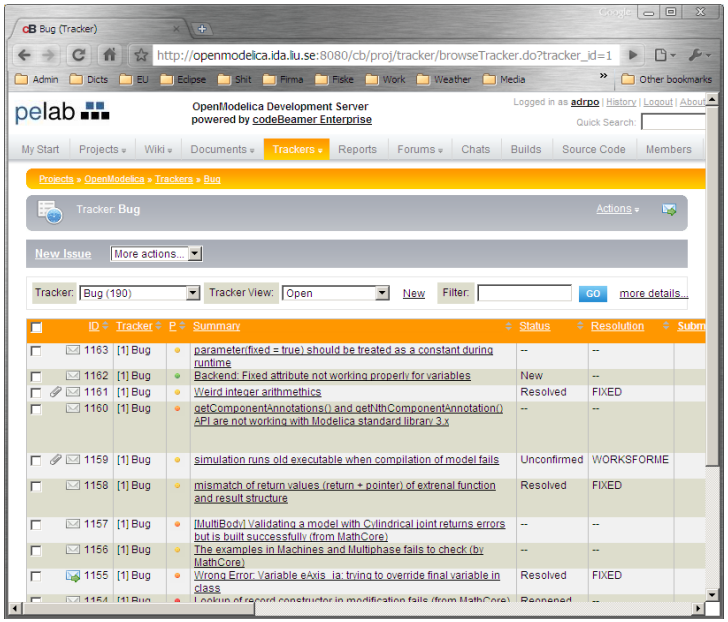


What is OpenModelica? (III)

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







What is OpenModelica? (IV)

- An incubator platform for research
  - 4 PhDs since 2004 (Debugging, Parallelization, PDEs Extensions)
  - 18 Master's theses since 2004
  - Both the students and the project benefit
- Master theses at PELAB 2006-2011
  - 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 Cuda parallel simulation
  - OMEdit – Modelica Connection Editor
- 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

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

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
- Much more other things I don't remember

OpenModelica Roadmap – Past

2009

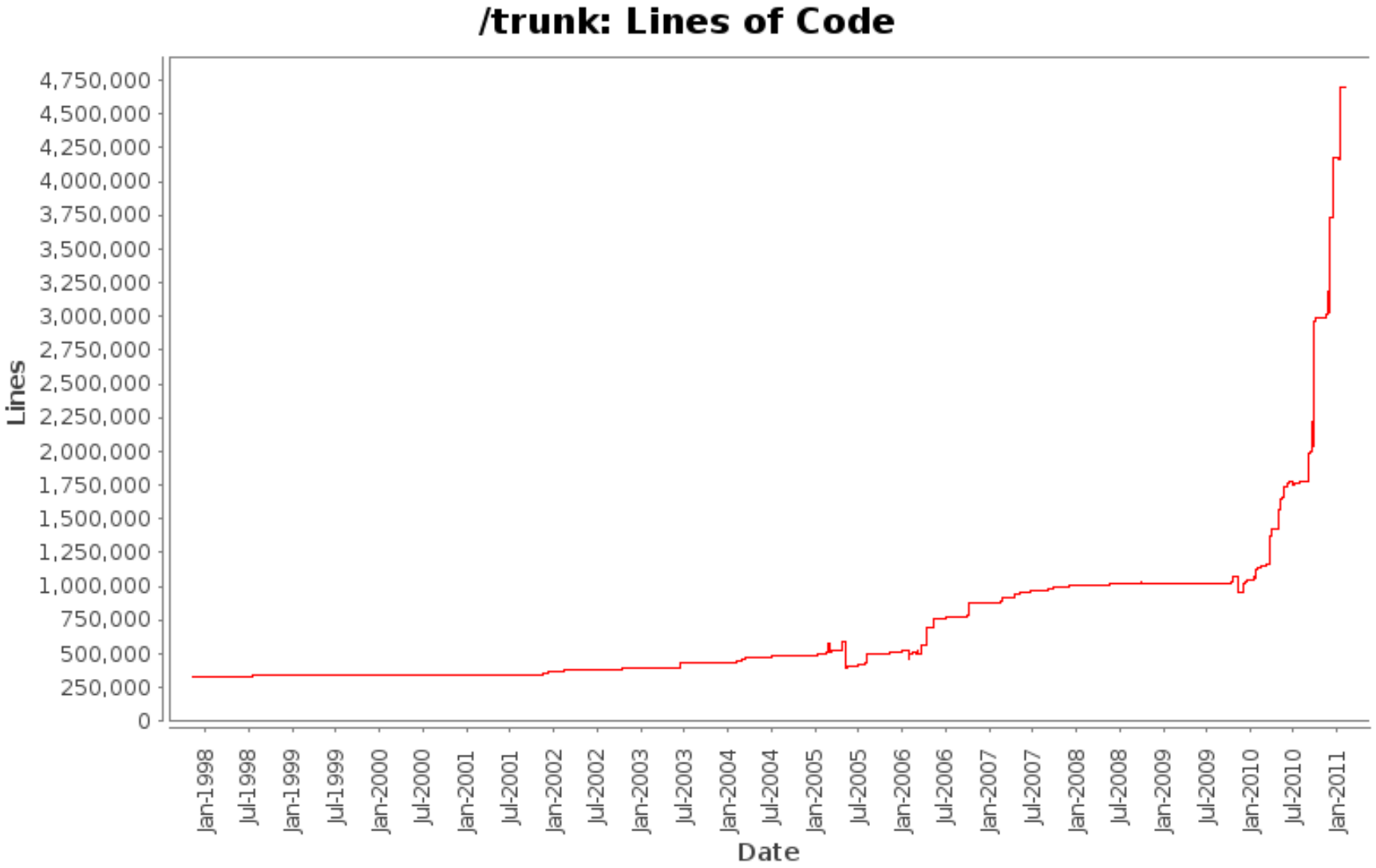
- Work mainly happened in OSMC (partially on a non-public branch)
- Front-end
  - Refactoring (OSMC)
  - Enumerations (OSMC)
  - Java Interface and Booststrapping (Martin Sjölund)
  - MultiBody flattening (OSMC)
  - Constraint connection graph breaking (VTT + OSMC)
  - Support for Modelica 3.x and 3.x 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 Booststrapping (Martin Sjölund)
  - Additional Solvers + Events (Willi Braun, FH-Bielefeld)
- General
  - New MDT based on Xtext (Antanas Pavlov, SysMO and BMW)
  - 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 & Present

2010 – 2011

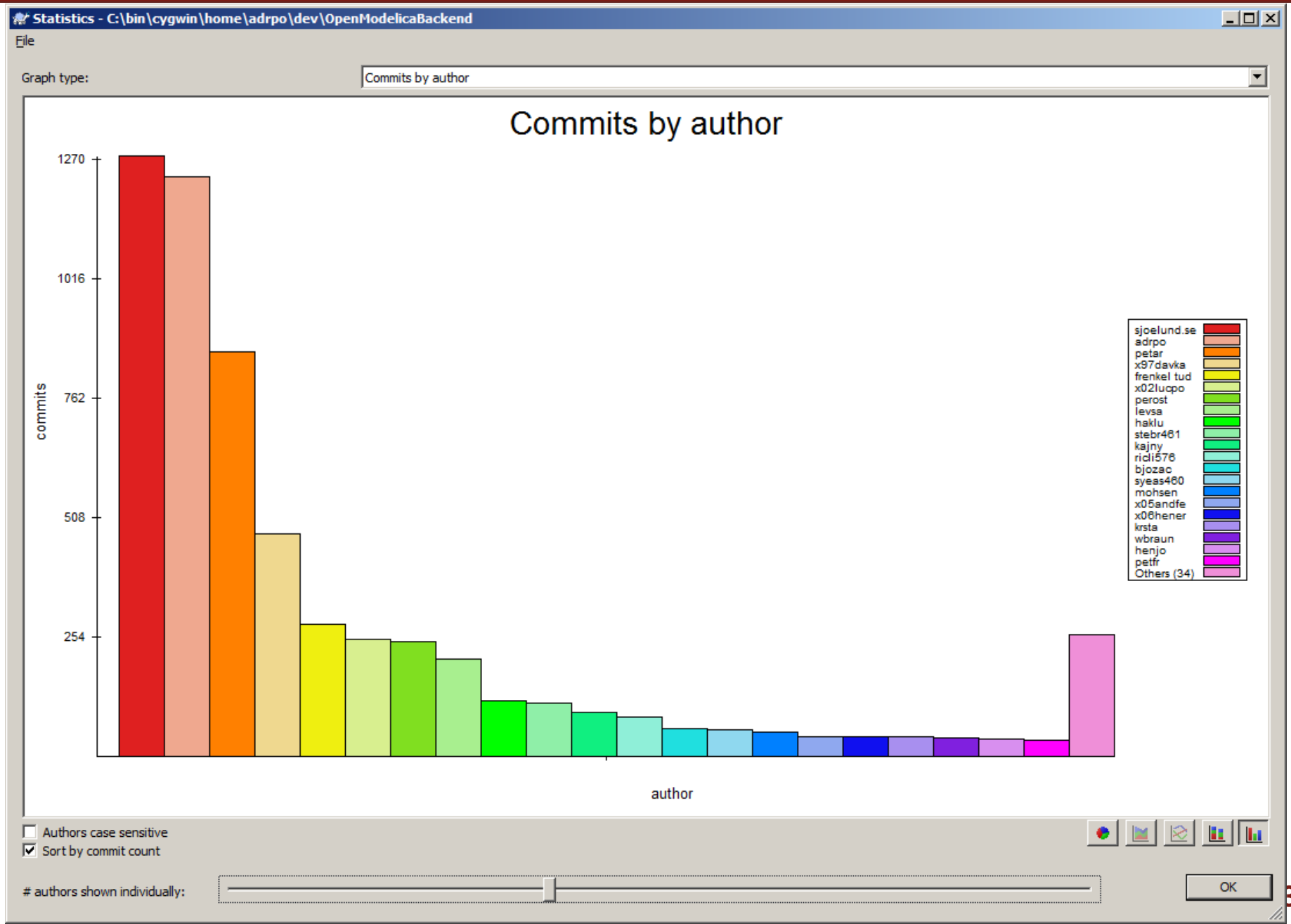
- Support for Modelica Standard Library 3.1 (Media & Fluid in works)
- Front-end
  - MultiBody flattening (OSMC)
  - Support for Modelica 3.x and 3.x annotations (OSMC)
  - Performance Enhancements
  - Stream connectors
  - Media & Fluid work is on the way
- Back-end
  - Back-end redesign (Jens, Willi,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

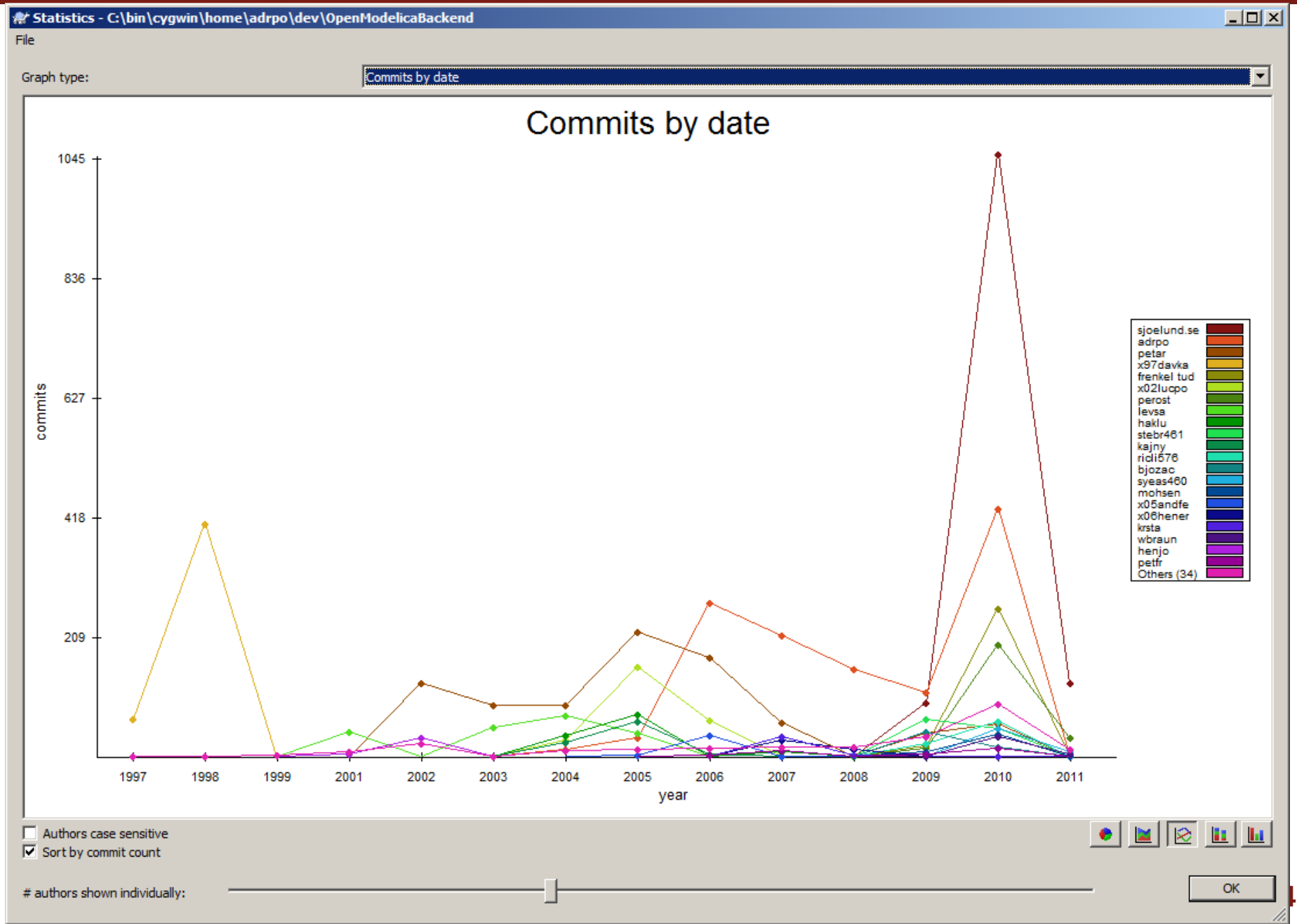


- Mature code base (http://build.openmodelica.org/omc/statsvn_trunk/)
- ~ 4000K lines of code and tests, steady increase

OpenModelica Statistics (II)



OpenModelica Statistics (III)



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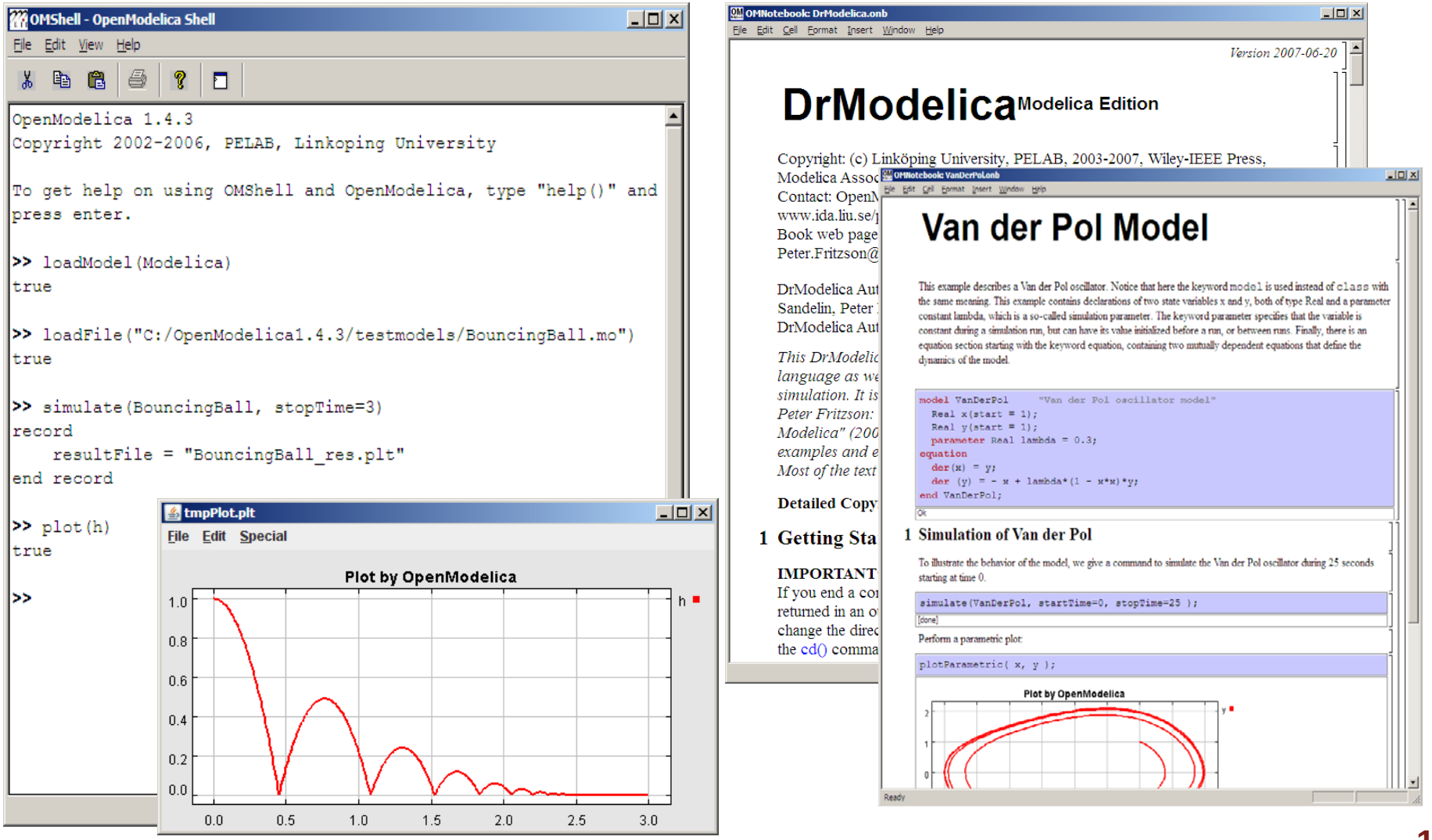
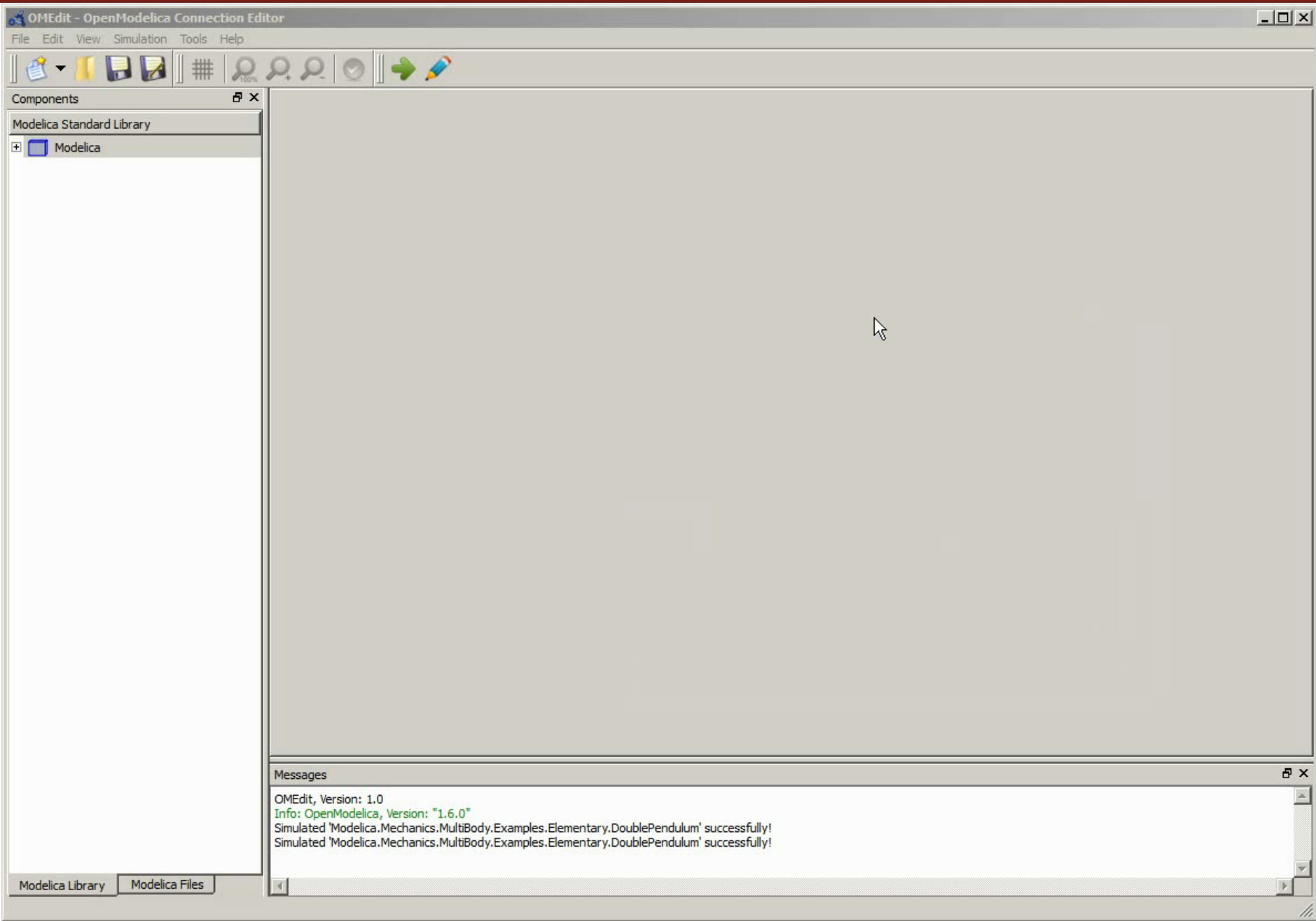
OMShell & OMNotebook

- Demo?

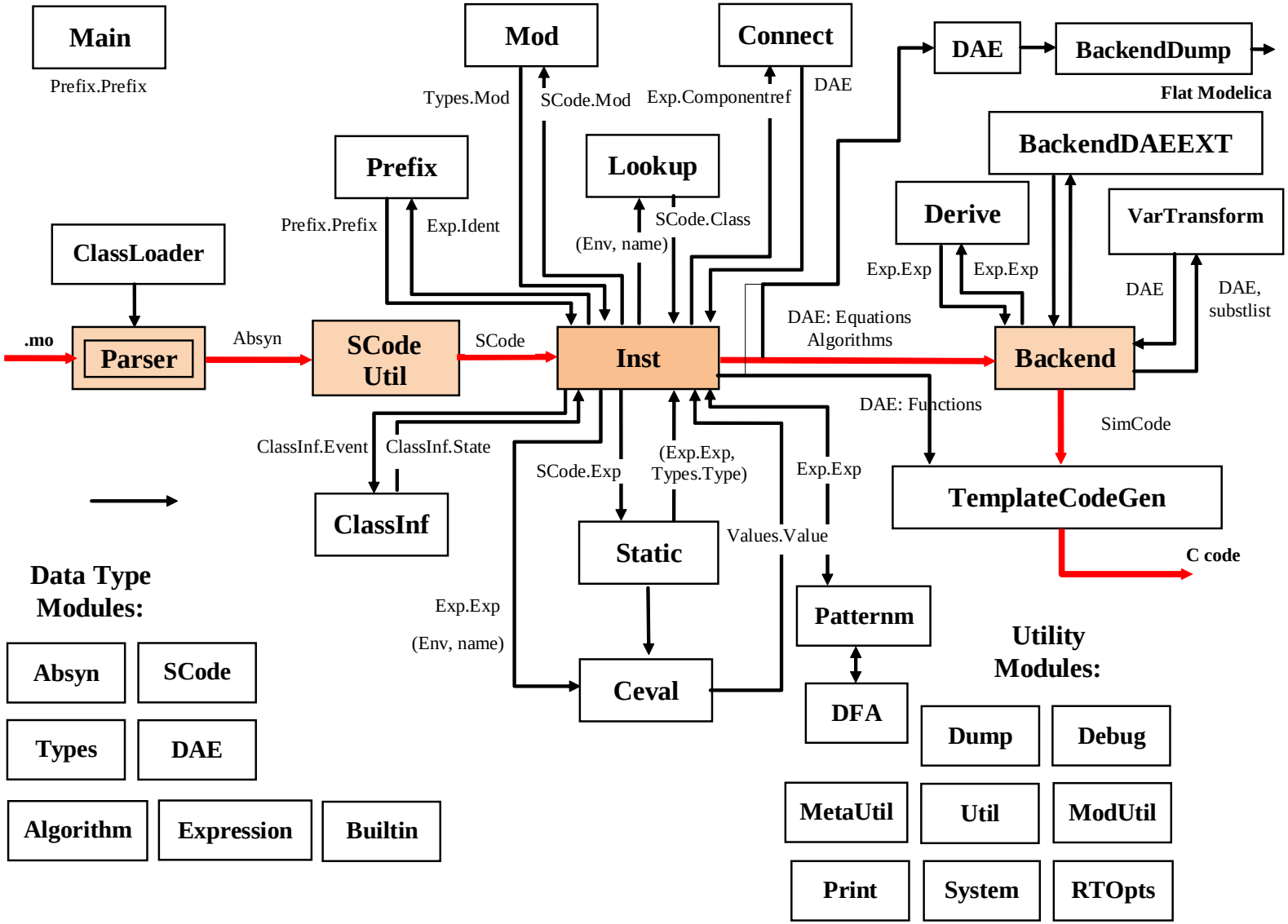


OMEdit - Demo? Maybe a movie!



The OMC Compiler

- Implemented mainly in MetaModelica and C/C++
- The compiler has 114 packages (in my local working copy)



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

Two libraries:

- libc_runtime.a
  - Runtime used by the generated functions in the model
  - Linked with the model
- libsim.a
  - Runtime used for simulations, it contains solver implementations and a main function for the simulation

Simulation Runtime Main

Executable Model

OMC Simulation Runtime Library

```
DATA *globalData: simulation_runtime.h
simParams:start,stop,stepSize,
          outputSteps,tolerance, method

  main: simulation_runtime.cpp
```

```
globalData = initializeDataStruc(FLAGS);
setLocalData(globalData);
read_input(globalData, simParams);
switch (method)
 “dassl”: dassl_main(simParams);
 “euler”: euler_main(simParams);
deInitializeDataStruct(DATA, FLAGS);
```

```
dassl_main: solver_dasrt.cpp
```

```
euler_main: solver_euler.cpp
```

```
read_input: simulation_input.cpp
```

OMC Generated Code

```
DATA *localData
```

initializeDataStruc

setLocalData

deInitializeDataStruc

Simulation Runtime Solver

OMC Simulation Runtime Library

DATA *globalData: simulation_runtime.h
simParams: start,stop,stepSize,outputSteps,tolerance, method
dassl_main: solver_dasrt.cpp

```
// set the solver parameters and calculate step from
simParams
initializeEventData(); initializeResult(numpoints,
globalData);
bound_parameters(); initial_function();
storeExtrapolationData();
initialize(init_method);
function_updateDependents();
CheckForInitialEvents(globalData->timeValue);
StartEventIteration(globalData->timeValue);
// calculate initial derivatives
functionODE();
// calculate initial output values
functionDAE_output(); functionDAE_output2();
// take a tiny step
tout = globalData->timeValue + epsilon;
function_updateDependents(); saveall(); emit();
calcEnabledZeroCrossings();
// call the solver for that tiny step
DDASTR(functionDAE_res, function_zeroCrossing, jroot);
checkForInitialZeroCrossings(jroot);
// check if we can continue the simulation
functionDAE_res(globalData); functionDAE_output();
// calculate the next step
tout = newTime(tout, step, stop);
// enter solver loop
```

```
storeExtrapolationData: simulation_runtime.cpp
initializeResult: simulation_result.cpp
emit: simulation_result.cpp
initializeEventData: simulation_events.cpp
CheckForInitialEvents: simulation_events.cpp
StartEventIteration: simulation_events.cpp
saveall: simulation_events.cpp
initialize: simulation_init.cpp
```

OMC Generated Code

DATA *localData

```
initializeDataStruc
setLocalData
deInitializeDataStruc
```

```
bound_parameters
initial_function
functionODE
functionDAE_output
functionDAE_output2
function_updateDependent
s
functionDAE_res
function_zeroCrossing
```

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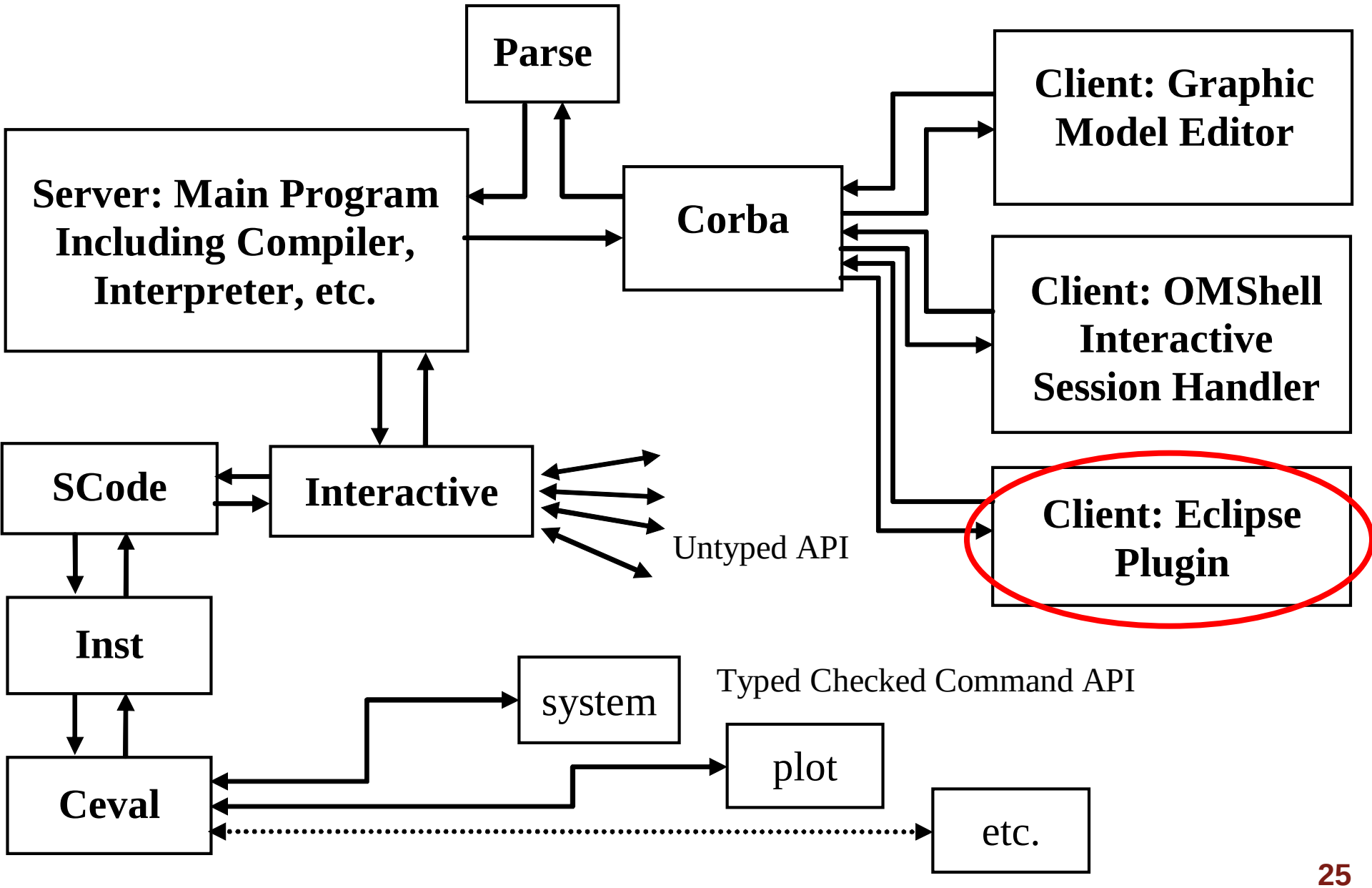
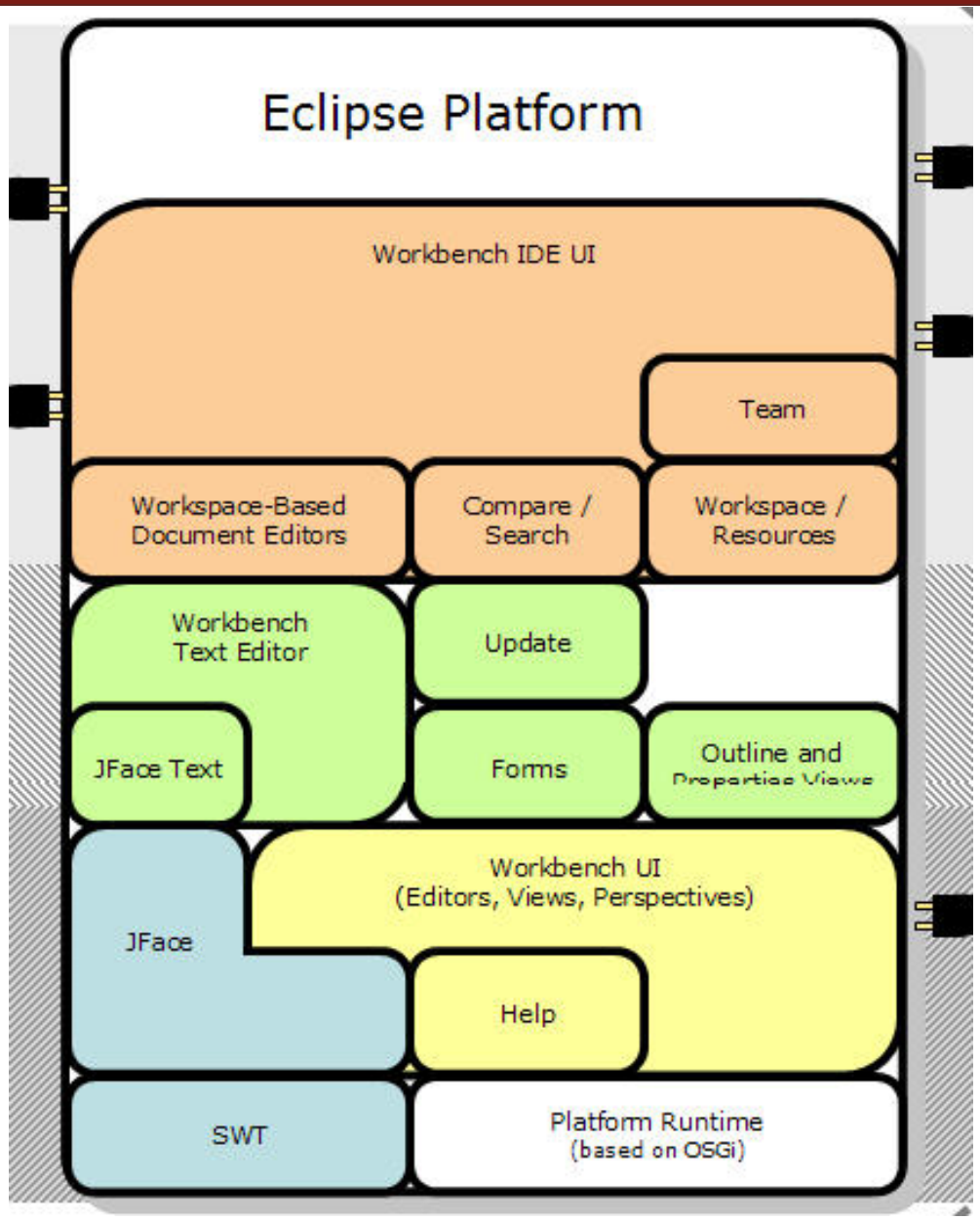
- OMC
  - Implemented mainly in MetaModelica and C/C++
- Modelica
  - classes, models, records, functions, packages
  - behavior is defined by equations or/and functions
  - equations
    - differential algebraic equations and conditional equations
- MetaModelica extensions
  - local equations
  - pattern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

OpenModelica Context



The MDT Eclipse Environment (I)



Modelica Browser

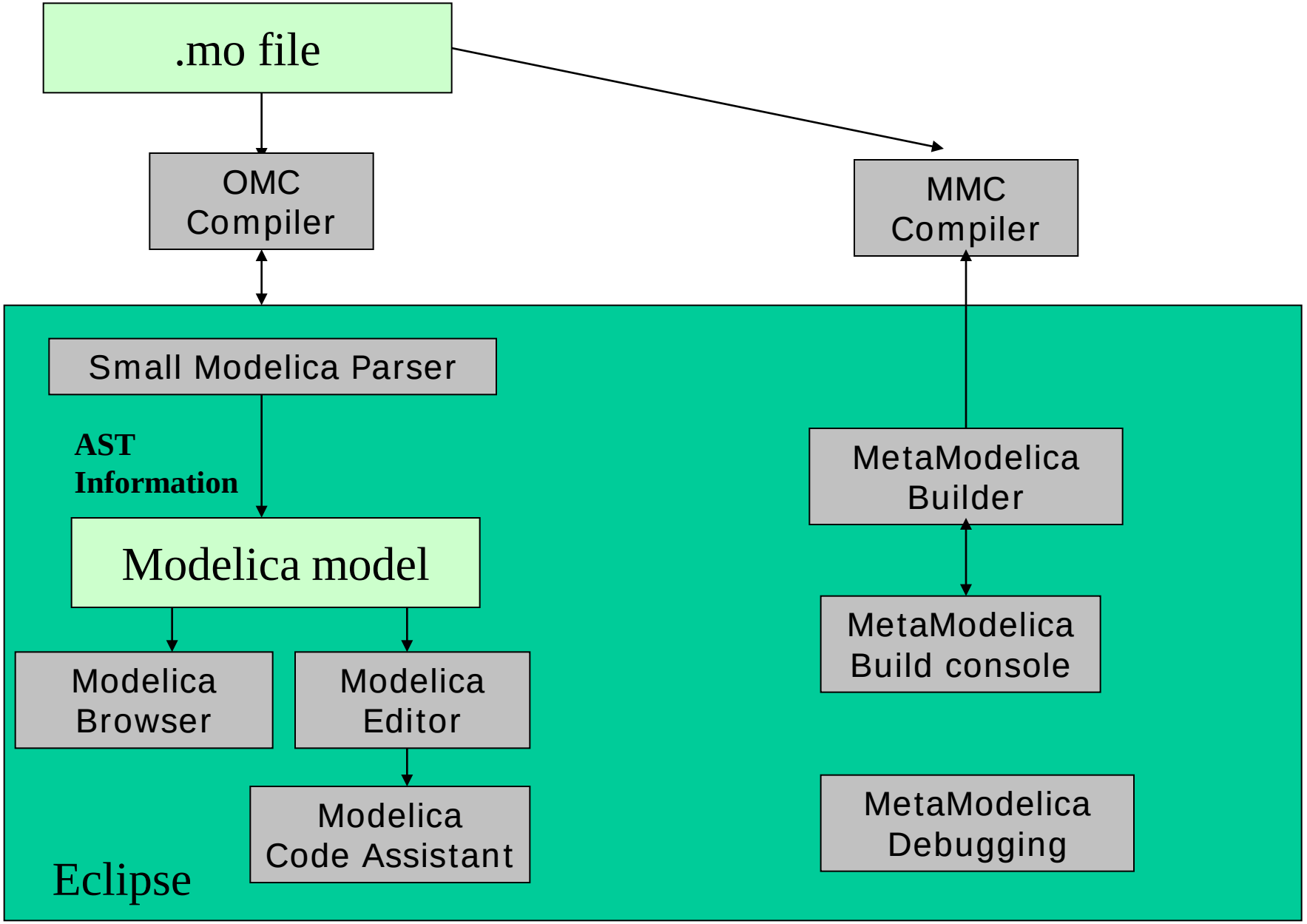
Modelica Editor

Modelica Code Assistant

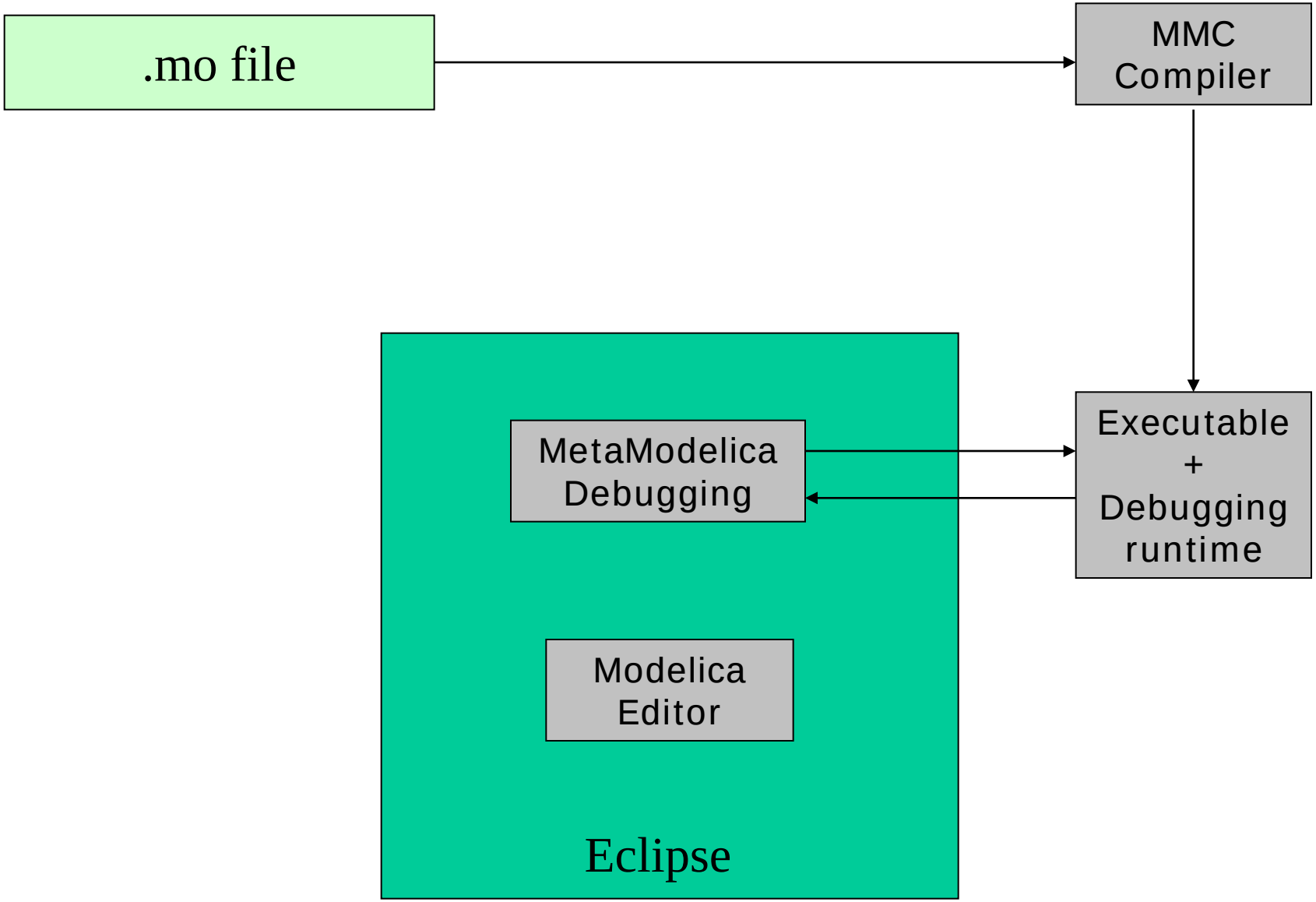
MetaModelica Debugging

Modelica Perspective

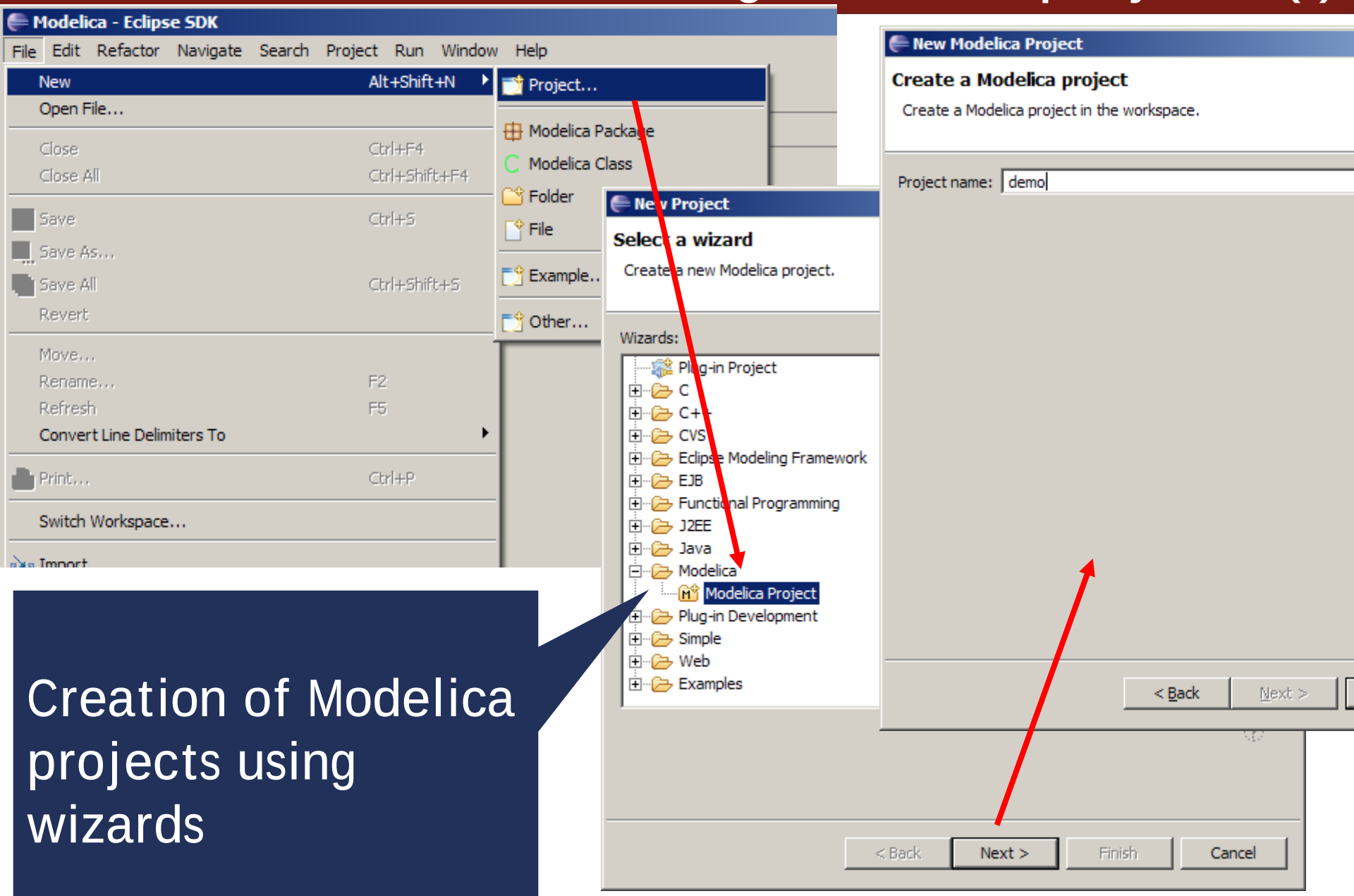
The MDT Eclipse Environment (II)



The MDT Eclipse Environment (III)

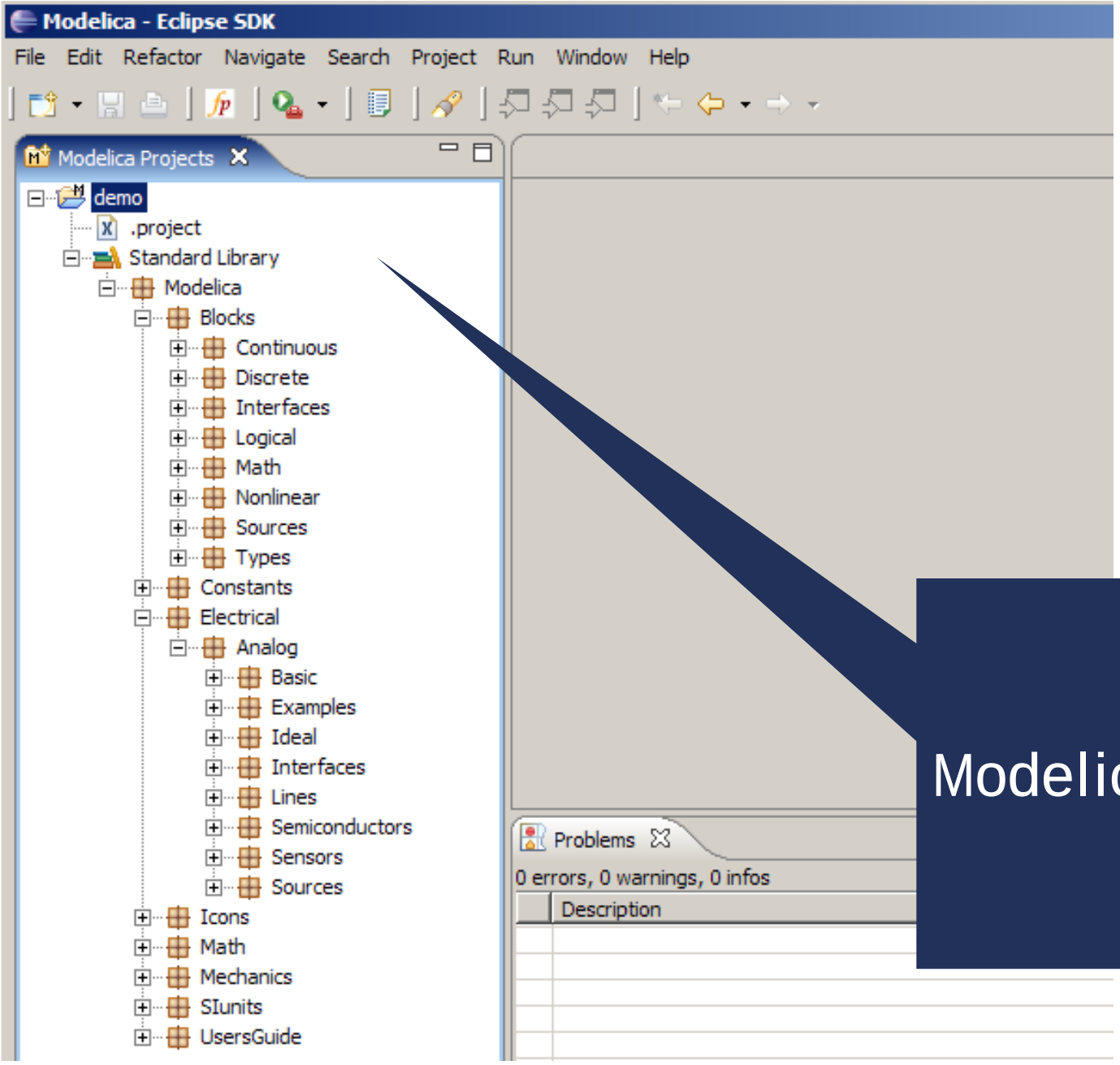


Creating Modelica projects (I)



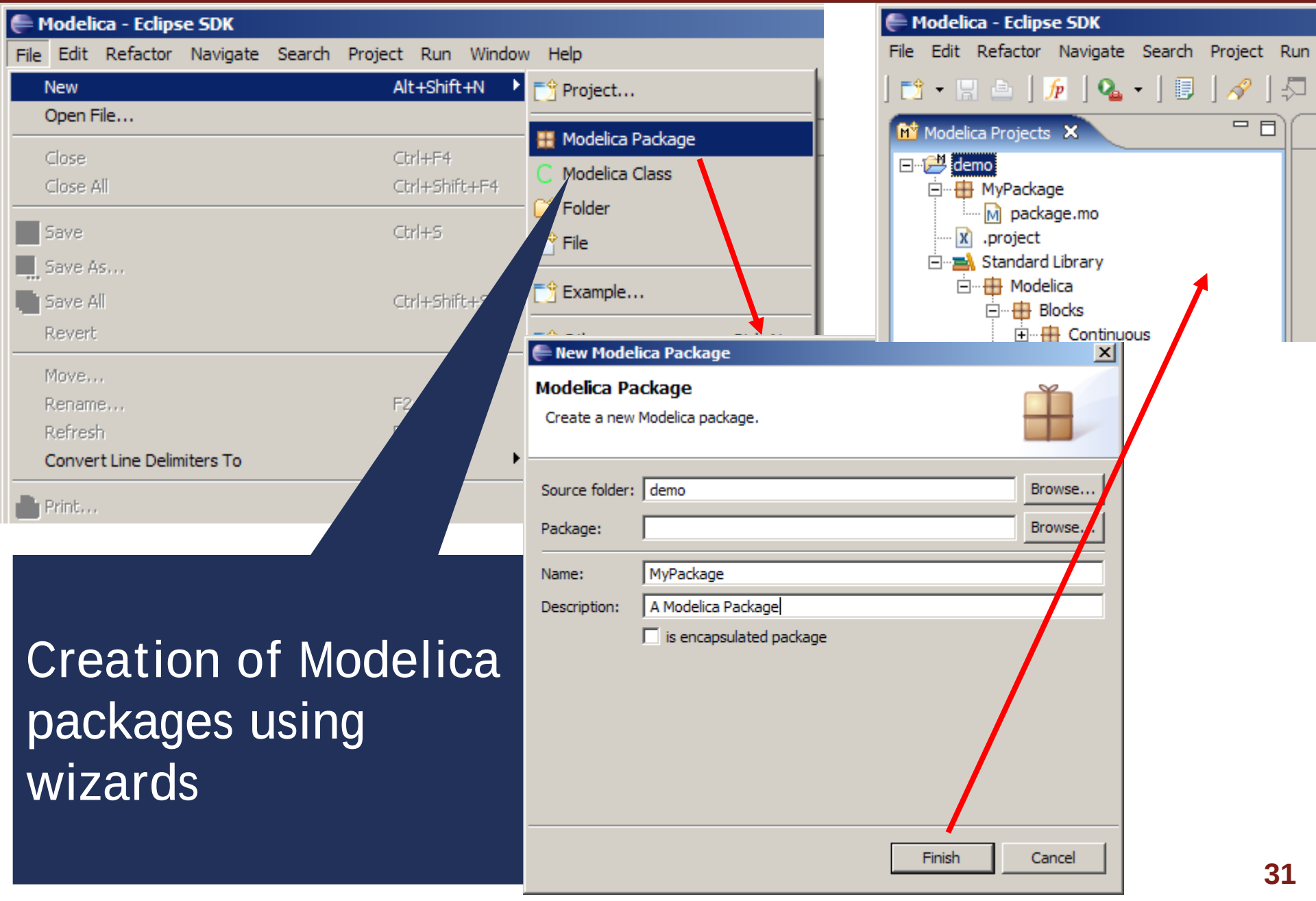
Creation of Modelica projects using wizards

Creating Modelica projects (II)



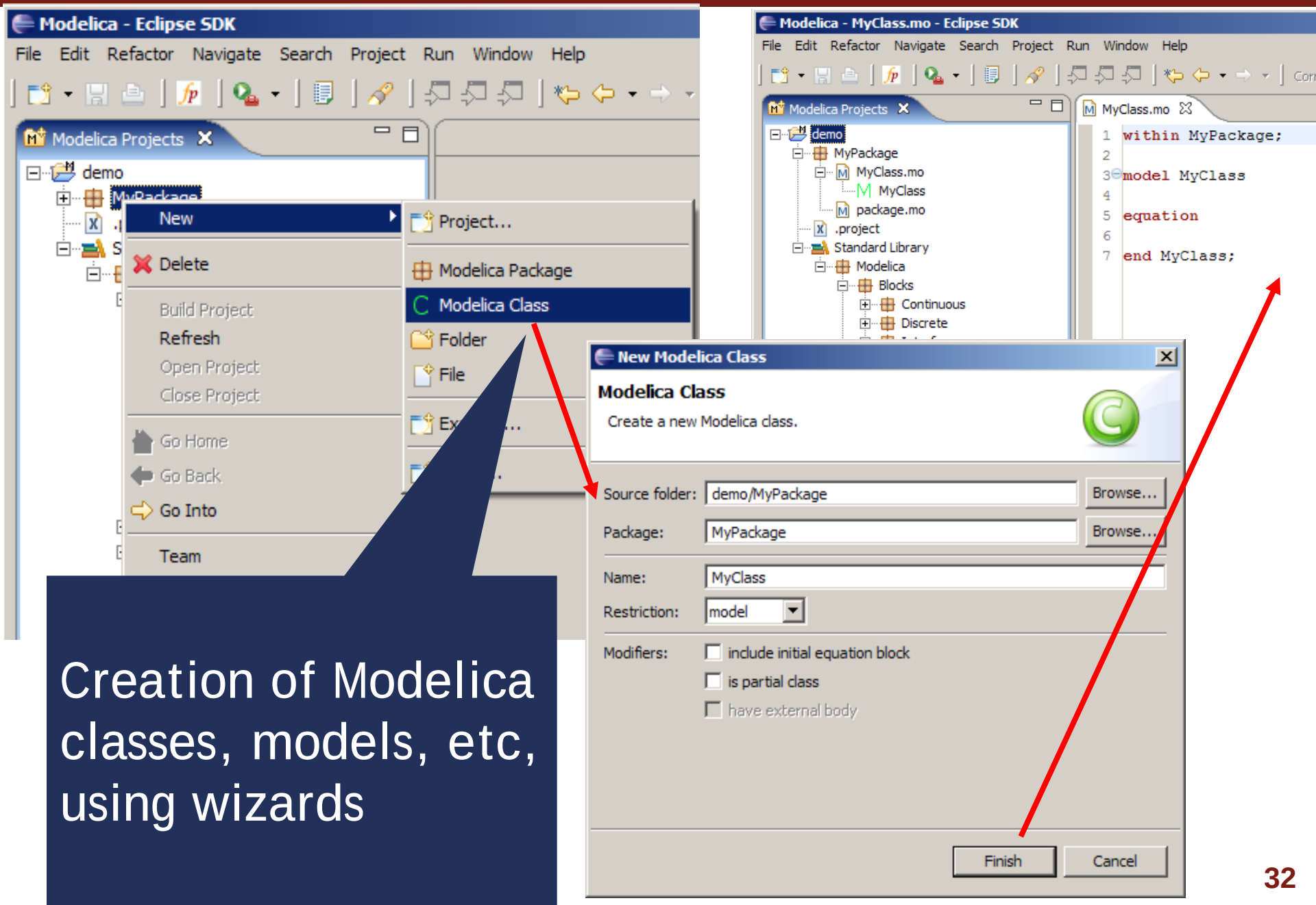
Modelica project

Creating Modelica packages



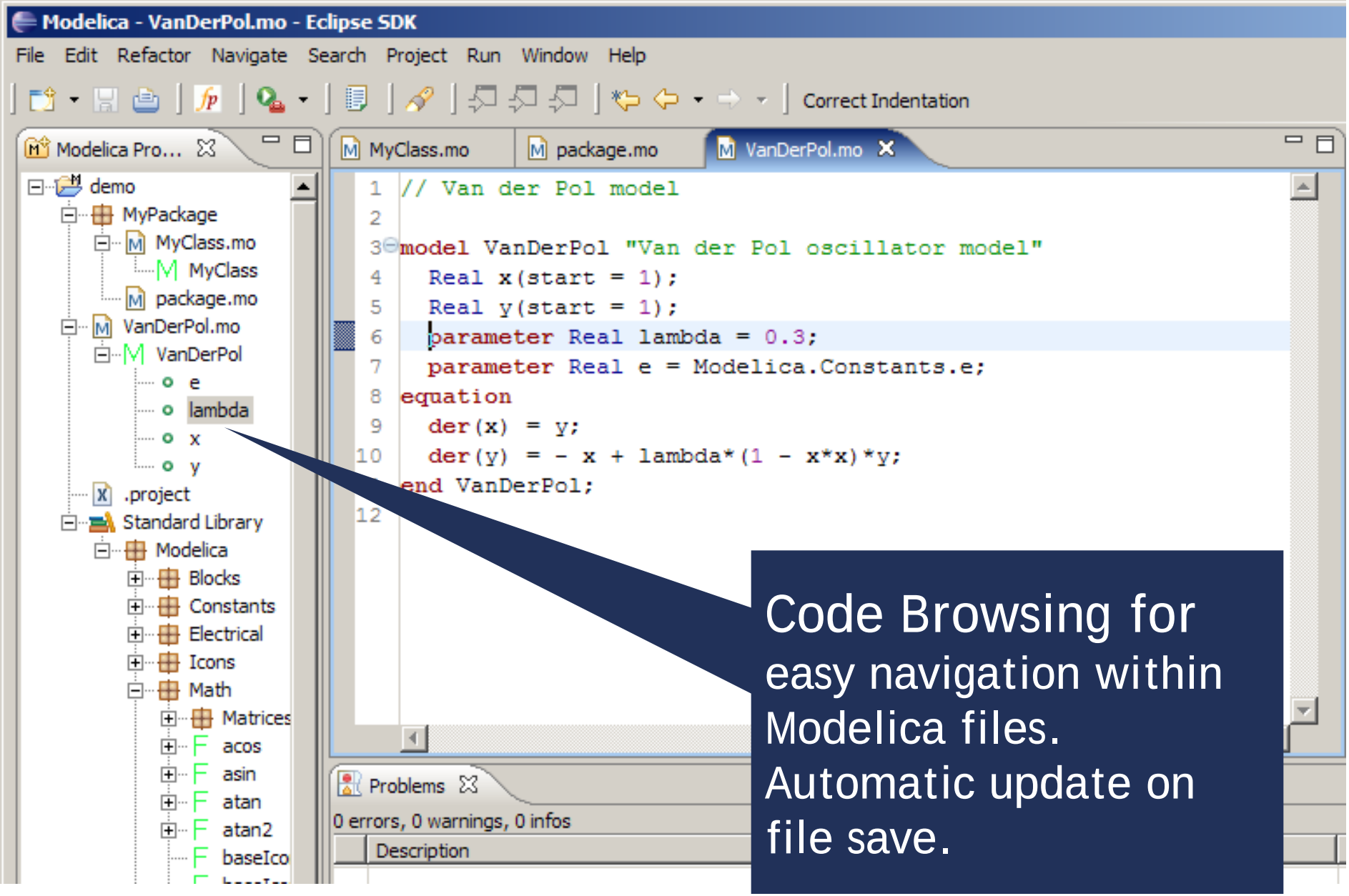
Creation of Modelica packages using wizards

Creating Modelica classes



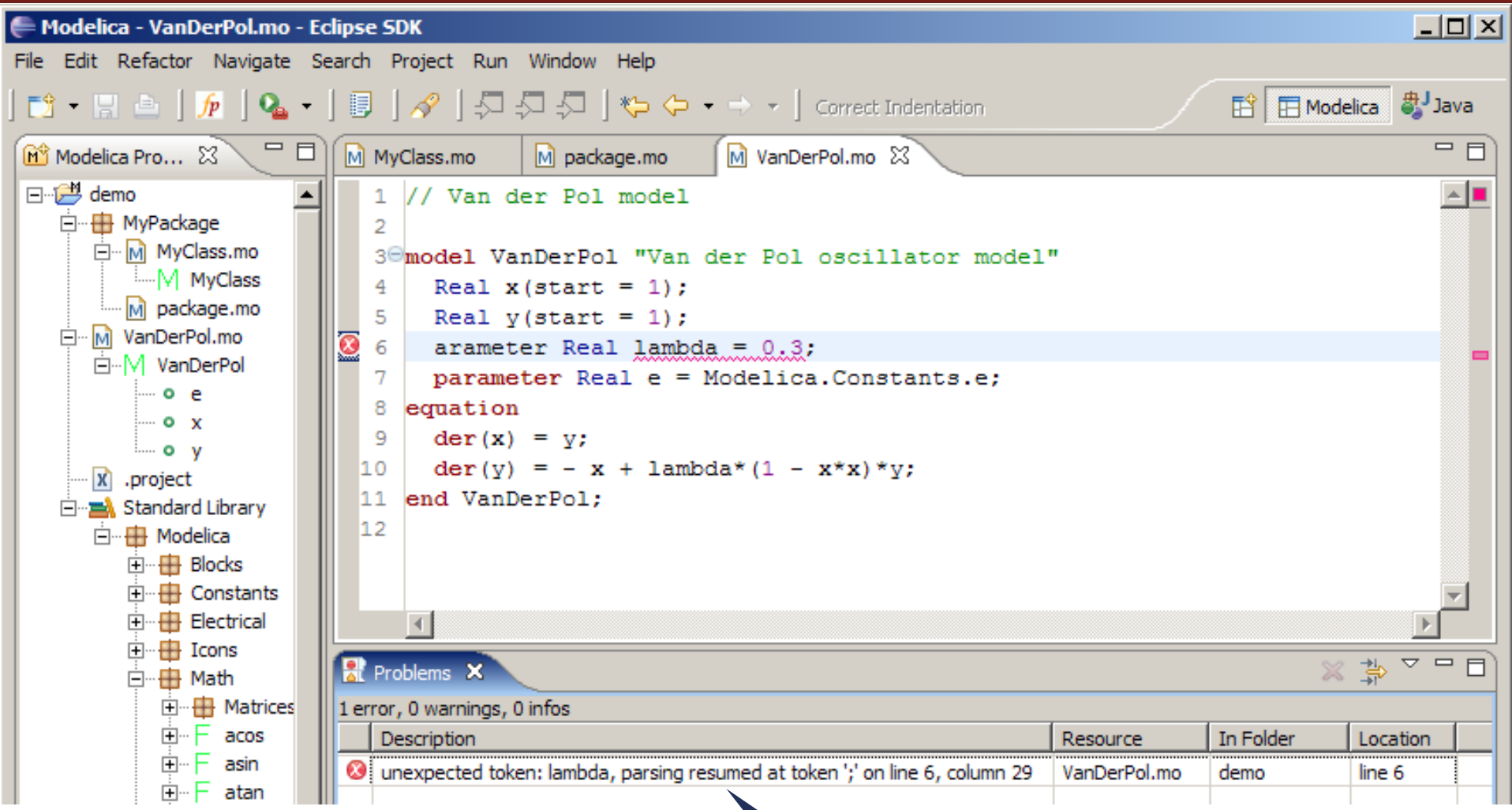
Creation of Modelica classes, models, etc, using wizards

Code browsing



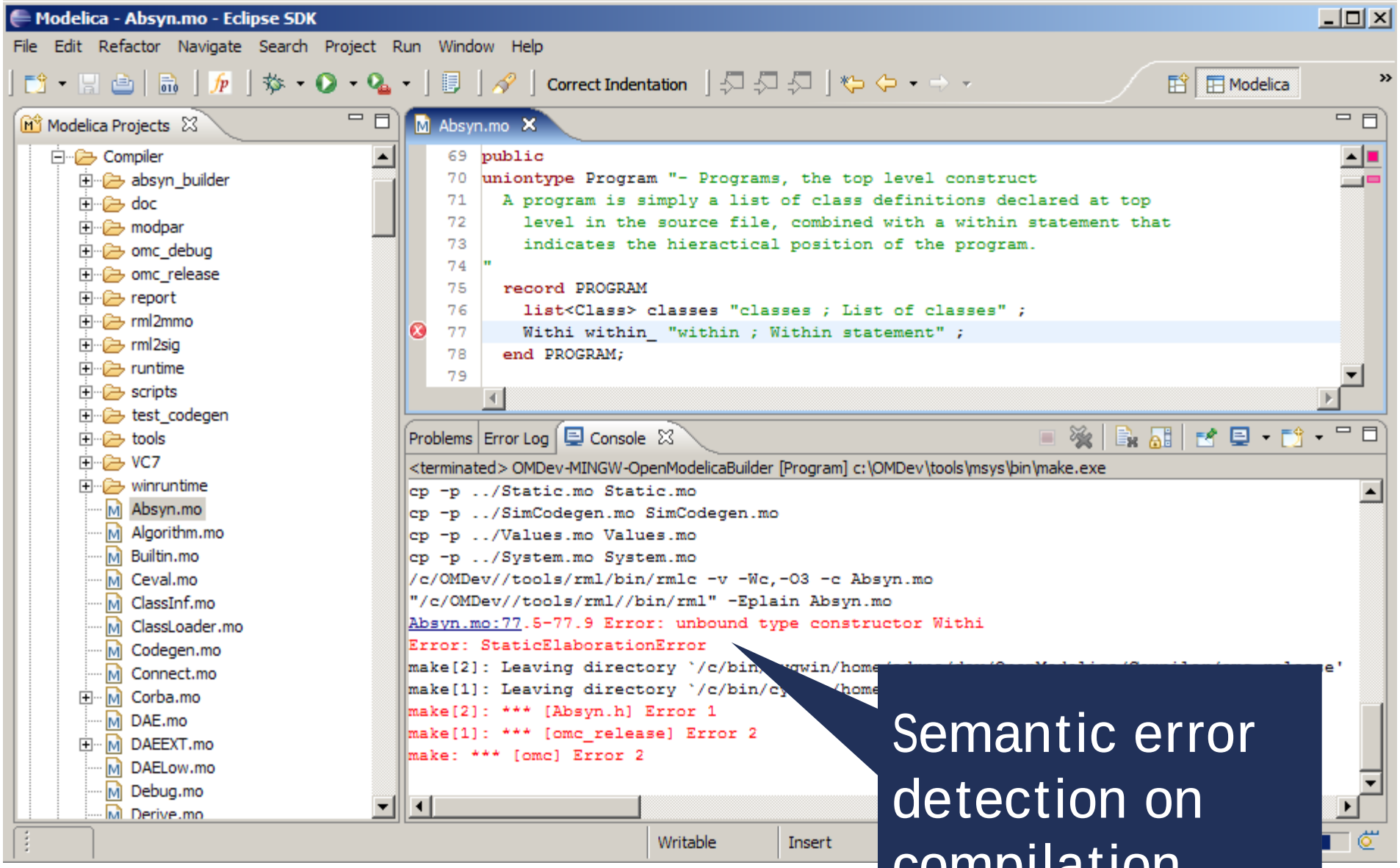
Code Browsing for easy navigation within Modelica files. Automatic update on file save.

Error detection (I)



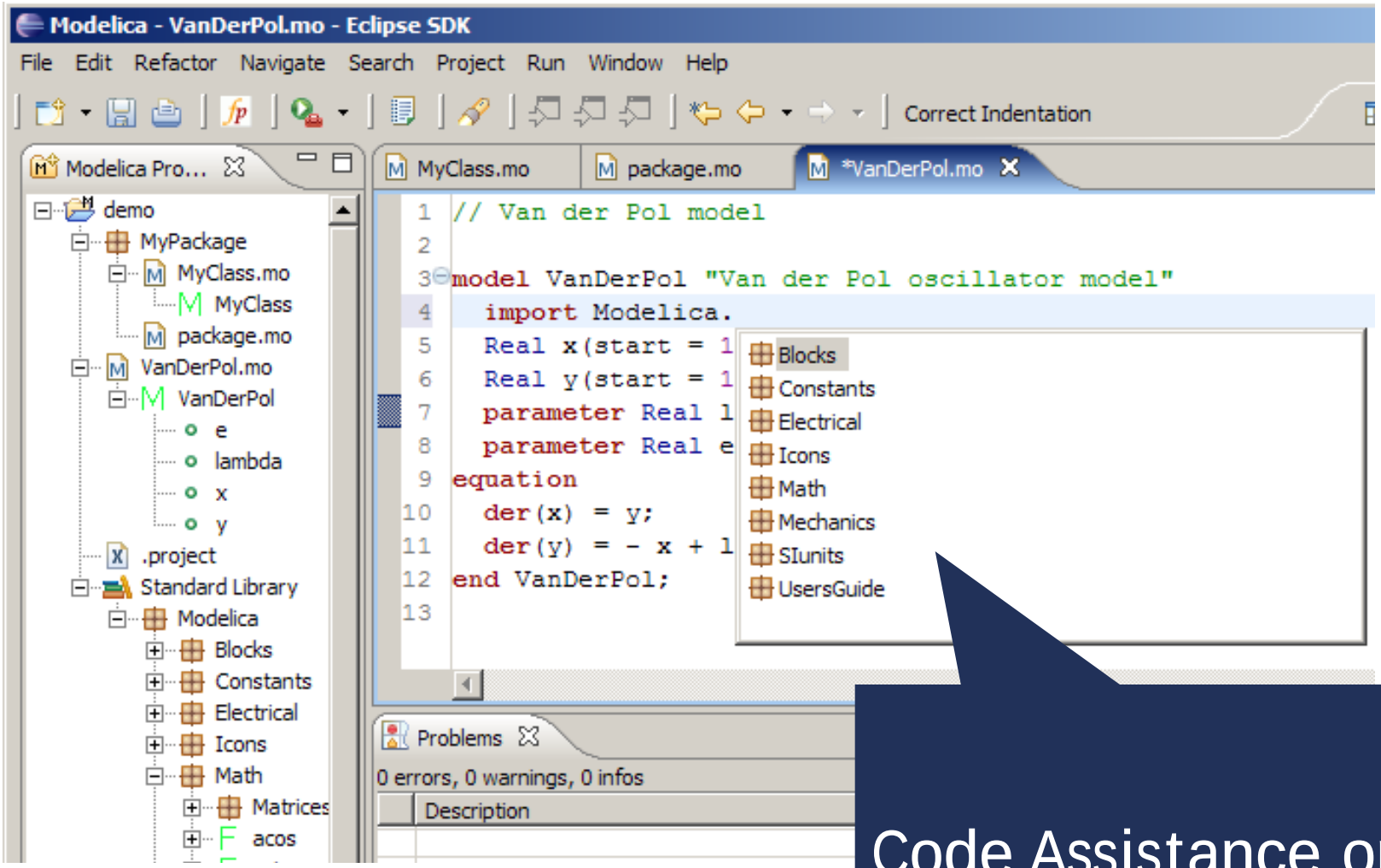
Parse error detection on file save

Error detection (II)



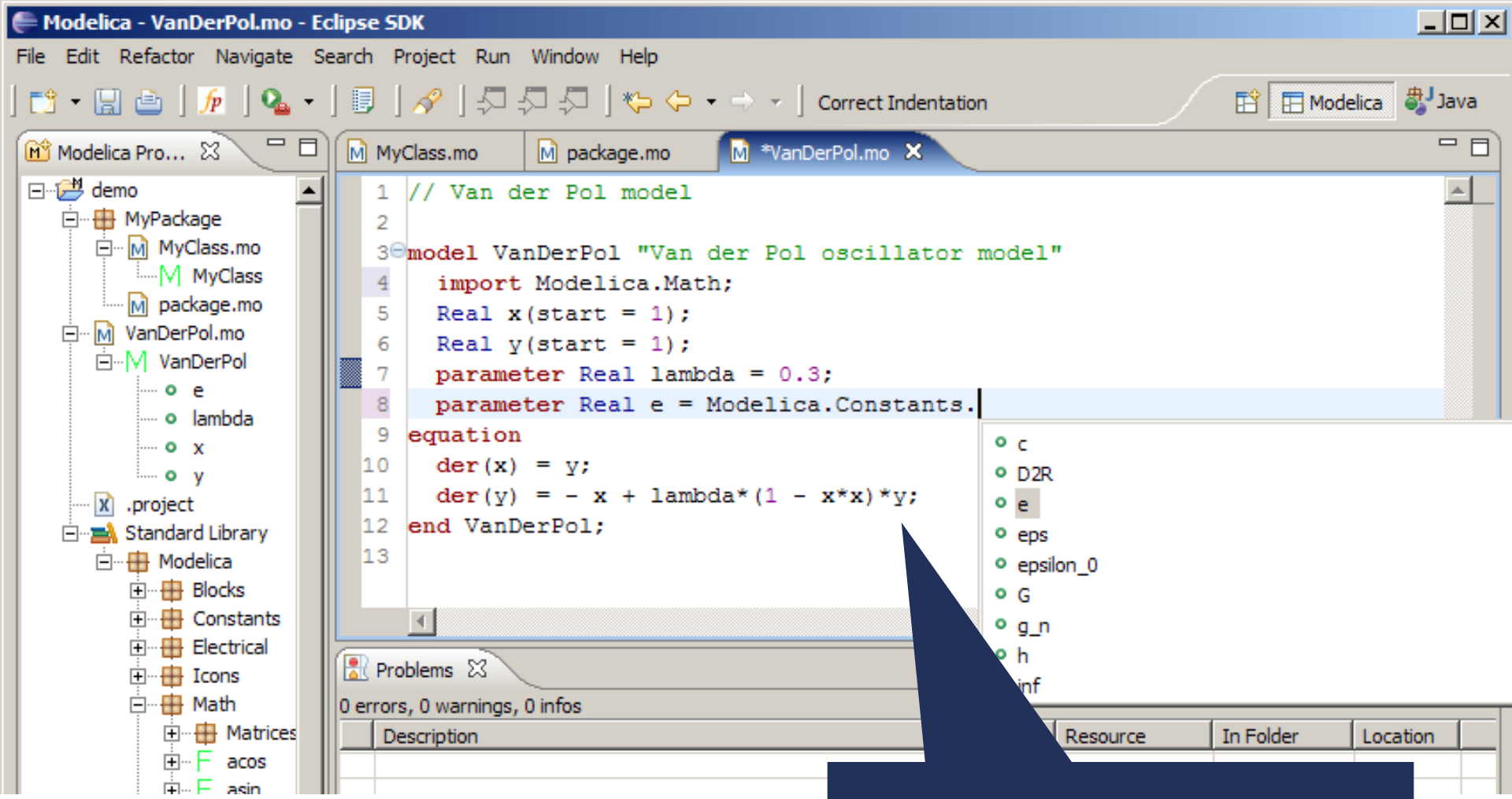
Semantic error detection on compilation

Code assistance (I)



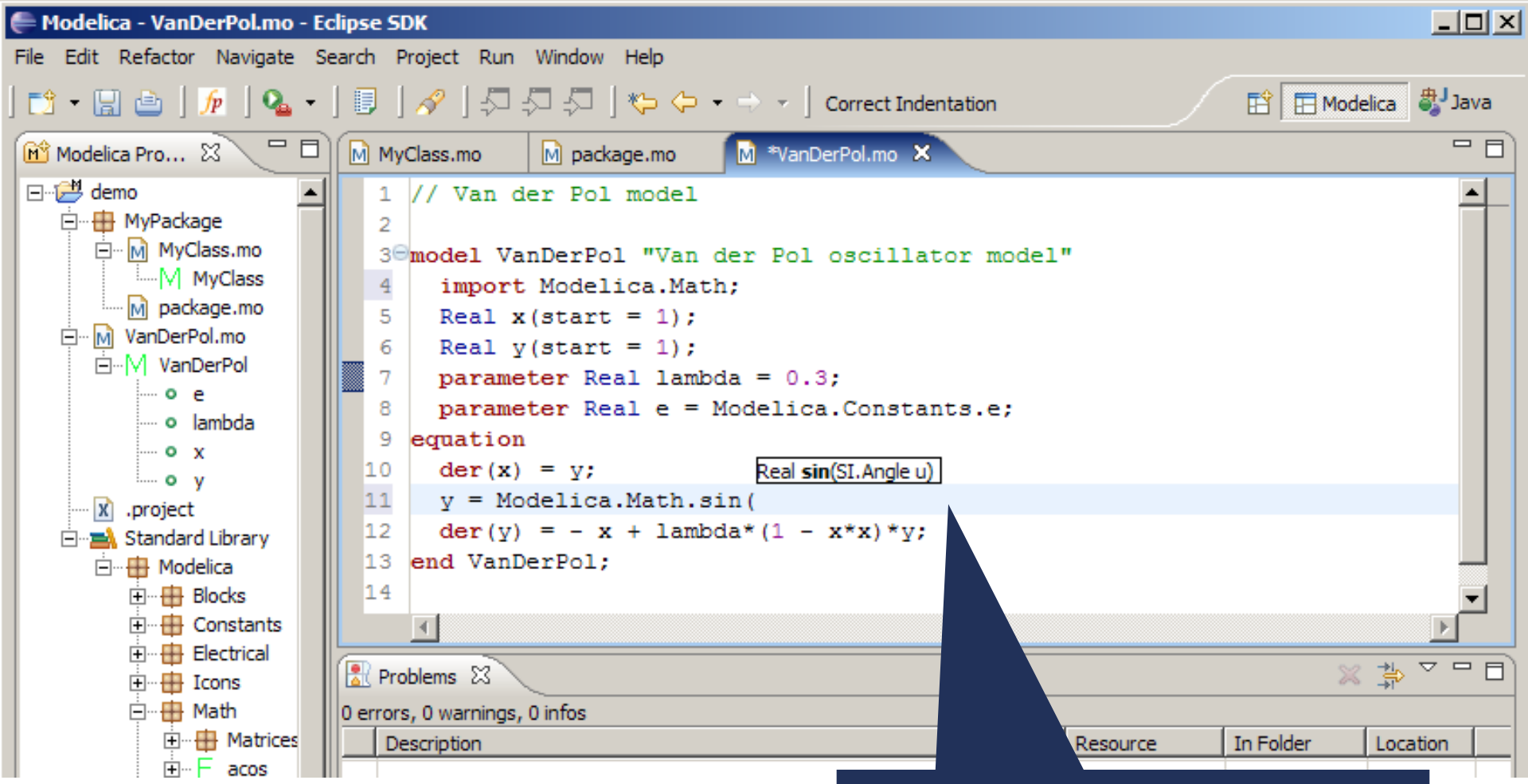
Code Assistance on imports

Code assistance (II)



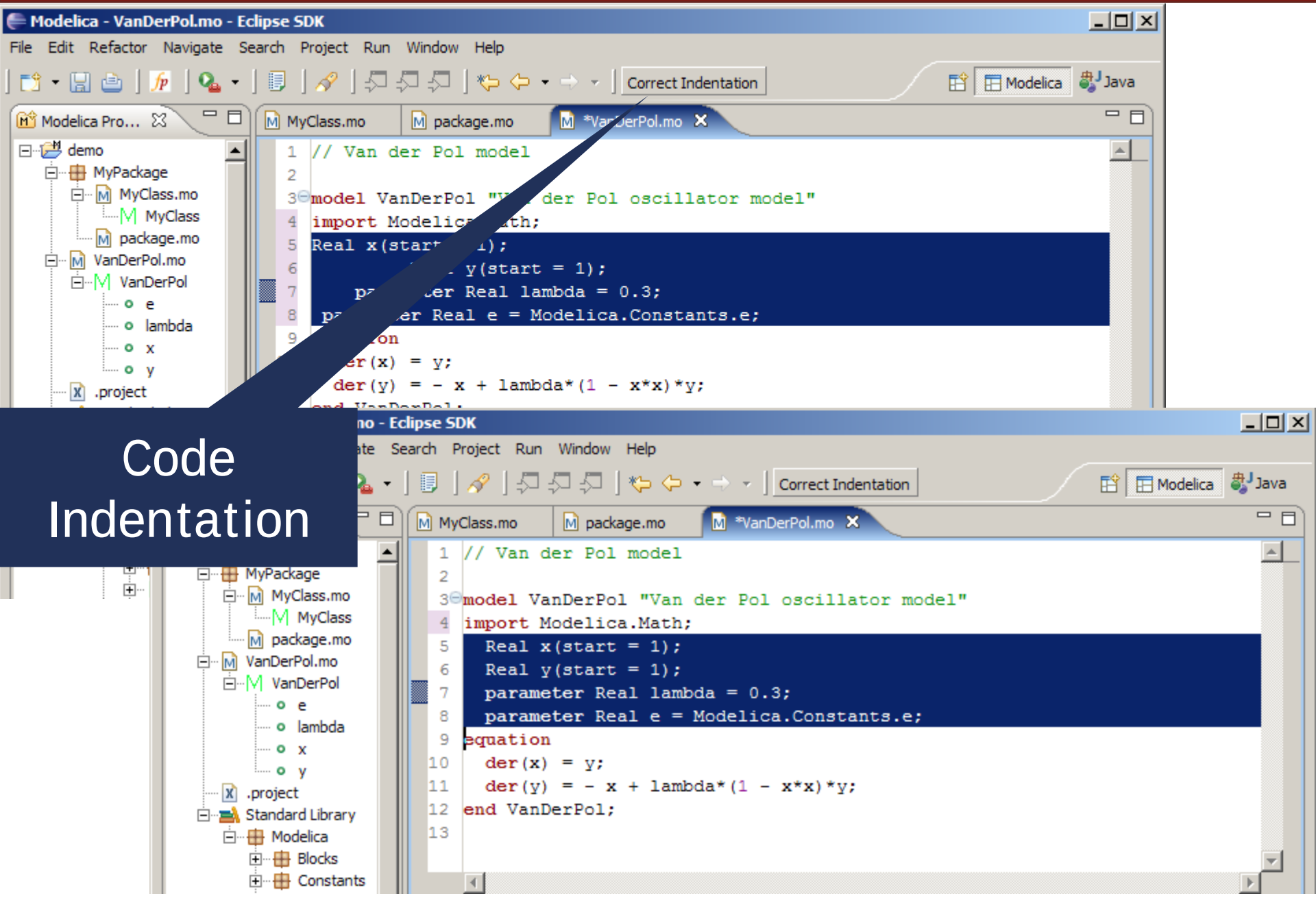
Code Assistance on assignments

Code assistance (III)



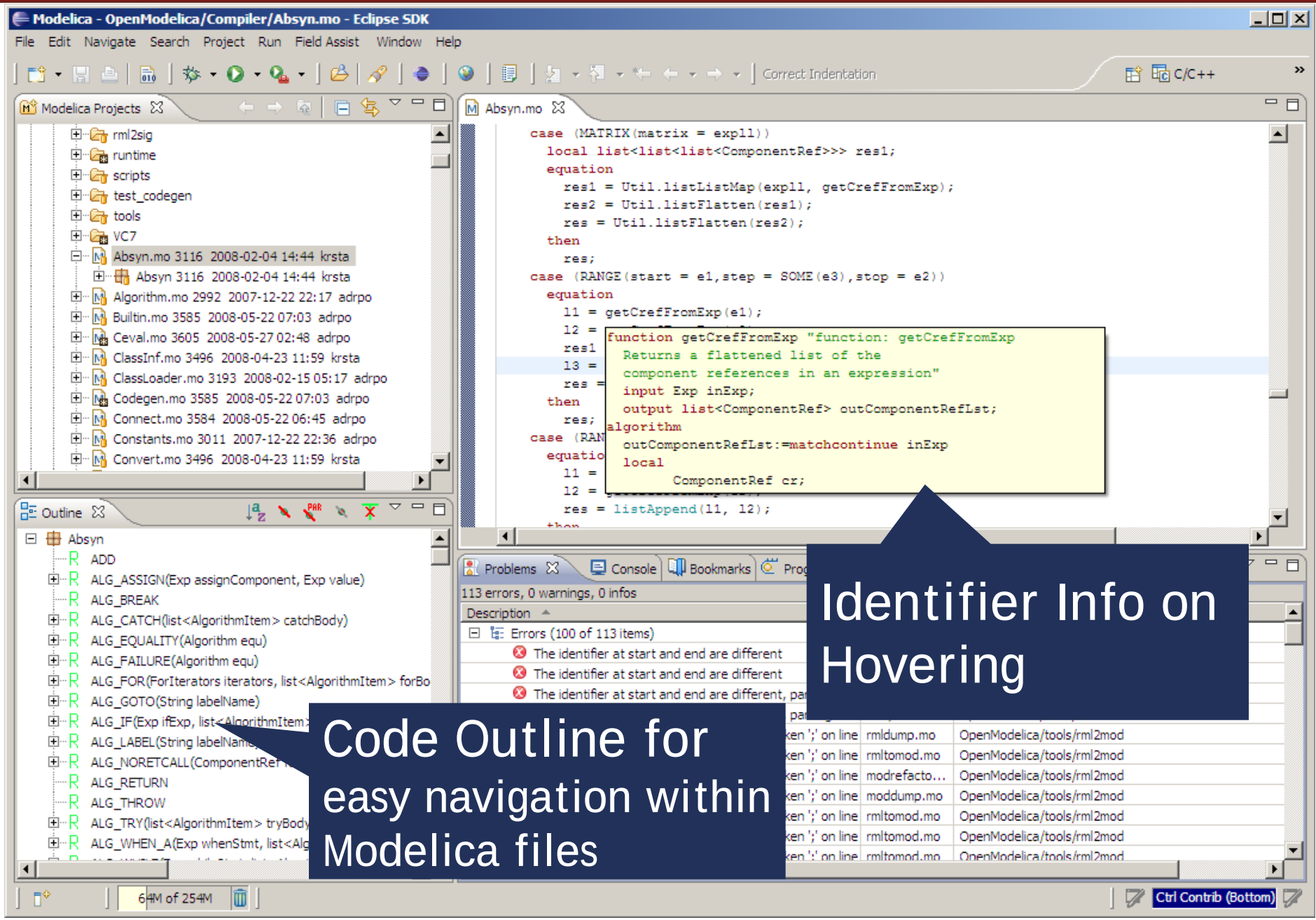
Code Assistance on function calls

Code indentation

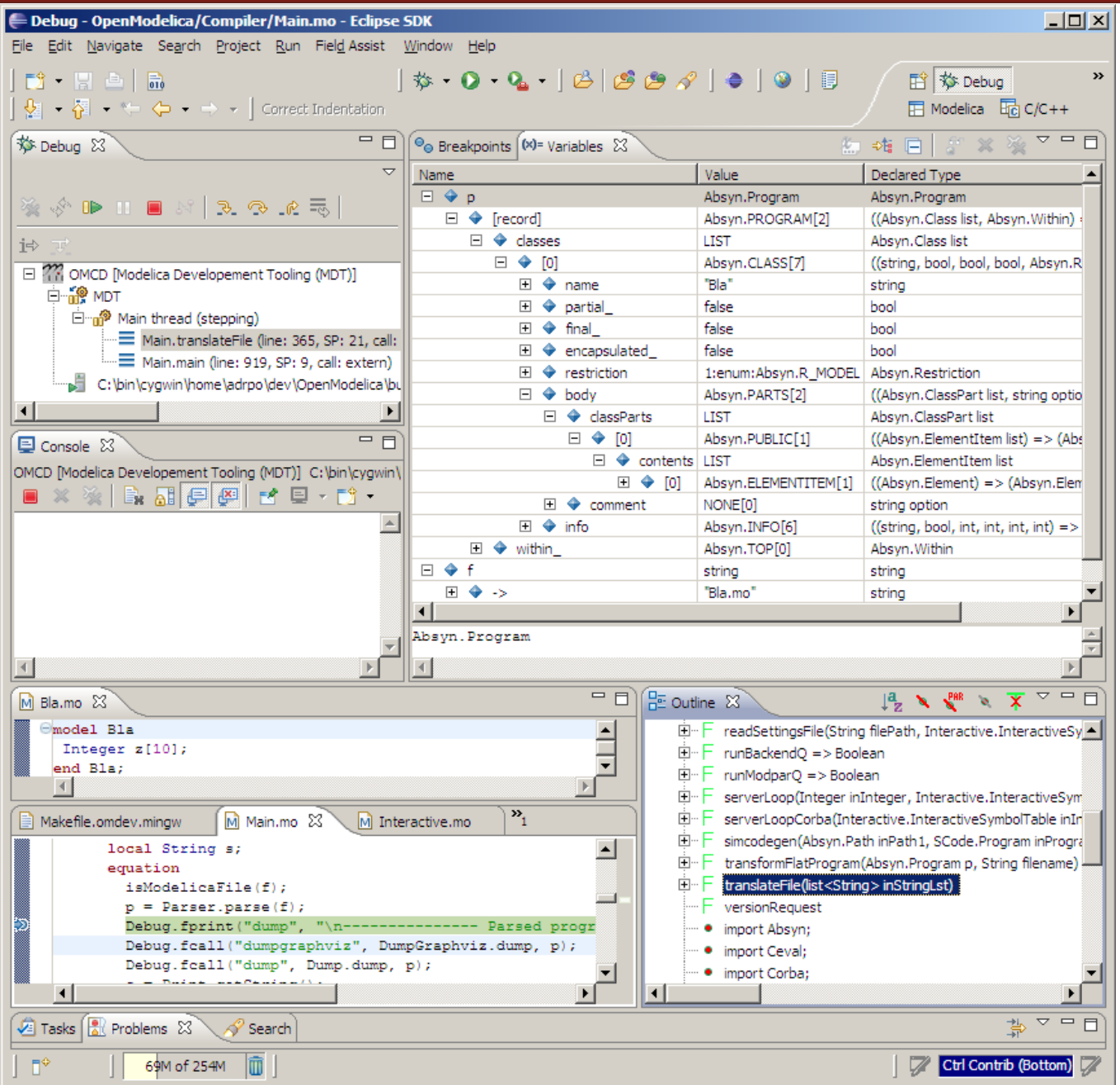


Code Indentation

Code Outline and Hovering Info

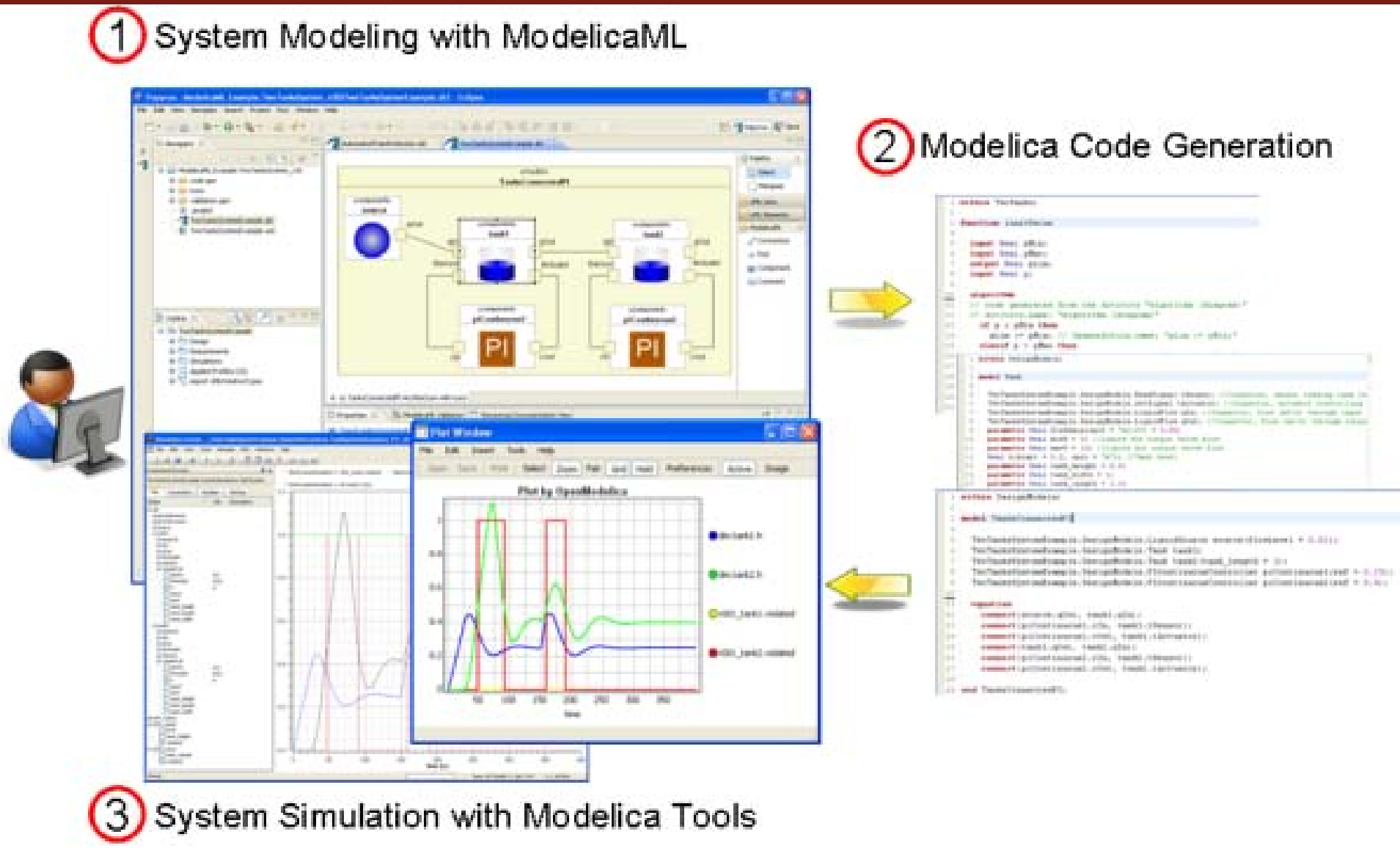


Eclipse Debugging Environment



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

Eclipse environment for ModelicaML



- 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 (2010-2011)

Latest Developments (2010-2011)

2010 – 2011 – Most focus on MSL 3.1 support & some performance

- 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)
  - 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)
- Much More things I don't remember

Media & Fluid (I)

- The most evil Modelica Standard Library: Media

- 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 redelclare replaceable function extends used to set constants in partial packages.

- … and then some more unspecified things
  - https://trac.modelica.org/Modelica/ticket/488
    Unspecified function in Modelica.Fluid (should pose no issue)
  - https://trac.modelica.org/Modelica/ticket/482
    Illegal lookup in Modelica.Media (fixed by Hubertus in a branch)

Action plan to support Media & Fluid

- Simplify flattening (instantiation) by preprocessing phases
  - Remove imports (100%)
  - Remove extends (95%)
  - Remove redeclare (1%)
  - Perform dependency analysis (0%)
- Handle record constants (10%)
- Any other unknown issues
- *Hopefully Media & Fluid flattening will start working for Modelica Conference 2011 (March 20)*

OMC Bootstrapping

- *Next presentation by Martin Sjölund*

Thank You!
Questions?

OpenModelica Project
http://www.OpenModelica.org