

Principles of Object-Oriented Modeling and Simulation of Dynamic Systems with Modelica

Course plan

Lectures

32 hours

Recommended for

Ph.D. students or practitioners in computer science or systems engineering.

The course was last given.

The course was last given 2011, and as shorter tutorials more recently.

Goals

The course has the following goals:

- Being easily accessible for people who do not previously have a background in modeling, simulation.
- Introducing the concepts of physical modeling, object-oriented modeling and component-based modeling and simulation.
- Providing a not too formal reference on the Modelica language.
- Demonstrating modeling examples from a wide range of application areas.
- Providing an understanding of the compilation techniques used for equation-based languages as well as an understanding of the of the mathematical aspects of dynamic systems.
- Introduction to meta-programming with Modelica, used for model transformation and model compilation.
- Introduction to parallel programming on multi-core architectures with the ParModelica extension.

Prerequisites

Some elementary knowledge in programming languages

Contents

Object-Oriented modeling is a fast-growing area of modeling and simulation that provides a structured, computer-supported way of doing mathematical and equation-based modeling. Modelica is today the most promising modeling and simulation language in that it effectively unifies and generalizes previous object-oriented modeling languages and provides a sound basis for the basic concepts.

The course presents an object-oriented component-based approach to computer supported mathematical modeling and simulation through the powerful Modelica language and its associated technology. Modelica can be viewed as an almost universal approach to high level computational modeling and simulation, by being able to represent a range of application areas and providing general notation as well as powerful abstractions and efficient implementations.

The course gives an introduction to the Modelica language to people who are familiar with basic programming concepts. It gives a basic introduction to the concepts of modeling and

simulation, as well as the basics of object-oriented component-based modeling for the novice, and an overview of modeling and simulation in a number of application areas.

Organization

Lectures and hands-on exercises usually organized in 6 full days of teaching simplify attendance by external students.

Literature

Fritzson Peter. (2003). Principles of Object-Oriented Modeling and Simulation - with Modelica 2.1. IEEE Press and John Wiley, 2004.

Relevant papers will be distributed during the course as needed.

Lecturers

Peter Fritzson, Professor, Ph.D. Course leader and examiner.
Olena Rogovchenko, Ph.D. Assistant course leader and lecturer
Martin Sjölund, M.Sc. Assistant instructor for MetaModelica (and ParModelica) part.
Mahder Gebremedhin, M.Sc. Assistant instructor for the ParModelica part.

PELAB - Programming Environment Laboratory
Dept. of Computer and Information Science,
Linköping University, Sweden

Examiner

Peter Fritzson

Examination

Examination will be in form of 24 hour homework. It will include theoretical questions and practical model design.

Credit

7 hp

Comments

Course webpage

<http://www.ida.liu.se/~petfr/ModelicaCourseDescriptionPlanAndReadingInstruction.pdf>

Schedule and Reading Instructions

Modelica Course at Linköping University

September 2012

Peter Fritzson
Olena Rogovchenko
Martin Sjölund

Schedule

Day1: Monday, Sept 10, 9.15-17.00 (hint: Spend evening reading the course book)

Day2: Tuesday, Sept 11, 9.15-17.00 (hint: Spend evening reading the course book)

Day3: Wednesday, Sept 12, 10.15-17.00

Reserve Thursday, Sept 13, 9.15-17

Day4: Friday, Sept 14, 9.15-17 (Designing a Modelica library)

Day5: Monday, Sept 17, 9.15-17 (MetaModelica)

Reserve: Tuesday, Sept 18, 9.15-17

Approximately 28 hours including hands-on exercises.

Day1: Modelica

Lecture: Introduction to Modeling and Simulation with Modelica and OpenModelica

- OpenModelica OMNotebook usage

Introduction to textual modeling

Demo+Exercise: OMNotebook and DrModelica

Demo+short exercise: Graphic modeling with OMEdit

Lecture+Exercises: classes and inheritance

Exercise01-classes-simple-textual.onb

Lecture+Exercises: Component connectors and connections, graphical modeling

Exercise02-graphical-modeling.onb

Day2: Modelica

Lecture:Equations

Exercise03-classes-textual-circuit.onb

Lecture: Algorithms and functions

Exercise04-equations-algorithms-functions.onb

Lecture: Modelica Packages

Lecture: Modelica Libraries

Day3: Modelica

Lecture: Hybrid Systems

Exercise05-hybrid-discreteevent.onb

Lecture:Simple biological models

Exercise06-pop-dynamics-and-model-design.onb

Lecture:Model Design

Exercise06-pop-dynamics-and-model-design.onb

Lecture: Romeo and Julia

Day4: Modelica

Lecture+Exercises: Building a simple Modelica library.

A whole day will be devoted to designing and building a simple modelica library from scratch, primarily using the graphical user interface.

Day5: MetaModelica

Lecture+Exercises:

- Introduction to the OpenModelica Eclipse plugin
- Simple simulation exercise using the Eclipse plugin.

Lecture+Exercises:

Introduction to MetaModelica

- Functional programming in MetaModelica
- Model transformations and symbolic programming
- Simple model transformation exercise in MetaModelica.

Lectures:

Introduction to the OpenModelica compiler

- Structure, information about modules, etc
- The model manipulation and information retrieval API.
- Corba connection to OMC

Advanced OpenModelica compiler development topics

- How to adapt code generator to specific needs,
- How to access the flat Modelica intermediate form,
- Programming AST transformations in the compiler
- How to add simple functionality to the compiler

Day6: ParModelica – Not included in the course 2012

Lecture+Exercises:

- Introduction to MultiCore architectures
- Introduction to the ParModelica extension to Modelica for parallel programming.
- Practical exercises

Reading Instructions

The following are reading instructions for the course book Principles of Object Oriented Modeling and Simulation with Modelica 2.1.

You need to read this well enough to be able to sign a paper where you promise that you have read all the included at a level to understand approximately 95% of the included material.

There will be some sampled oral examinations to check this.

Included in the course:

Chapter 1, whole chapter.

Chapter 2, whole chapter.

Chapter 3: Sec 3.1 - 3.13.1, 3.13.3 - 3.14.7

Chapter 4, whole chapter.

Chapter 5: 5.1 - 5.4.0; 5.4.3 - 5.7.2; 5.8

Chapter 6: 6.1 - 6.8.0;

Chapter 7: 7.1 - 7.2.2

Chapter 8: 8.1 - 8.4.1.3

Chapter 9: 9.1 - 9.3.2.6

Chapter 10: whole chapter.

Chapter 11: not included.

Chapter 12: whole chapter.

Chapter 13: 13.1 - 13.2.5.5; 13.2.5.7 - 13.2.6.5; 13.3.0 - 13.3.4; 13.4.1; 13.5

Chapter 15: 15.1.0; 15.4.1; 15.5; 15.6.0-15.6.2; 15.7; 15.10.2-15.10.3

Chapter 17: 17.1.0, 17.1.4, 17.1.5, 17.1.6,

Chapter 18.1, 18.2.0, 18.2.1, 18.2.1.1

The following are reading instructions for included parts of the “Modelica Meta-Programming and Symbolic Transformations - MetaModelica programming guide”:

Chapter 1: whole chapter.

Chapter 2: Sec 2.0, 2.1, 2.2

Chapter 3: Sec 3.0, 3.1.5, 3.3

(We will have selected exercises, partly from the Appendix of the MetaModelica programming guide)

ParModelica paper and exercises. (Not included in 2012 course)