ISyE 4xxx/ME 4803 section M – Fall 2010
Model Based Systems Engineering

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Class meetings: M-W 4:30-6:00, IC 219

Text:
- *A Practical Guide to SysML (Revised Printing): The Systems Modeling Language*, by Sanford Friedenthal, Alan Moore, and Rick Steiner. Elsevier, 2009. (ISBN: 978-0123786074)

Prerequisites:
- ISyE 3103 or 3104; or ME 3015; or graduate standing

Course Description and Goals:
Engineering analysis or design of complex systems involves two kinds of modeling. One is the description of the system itself, and one is the description of a computation one would like to perform, in order to better understand or to specify some aspect of the system. This course addresses both. The systems modeling language, OMG SysML™ (www.omgsysml.org), provides the syntax for very expressive models of systems. Because SysML is a formal language, it supports a broad range of integration and interoperation with specific solvers, thus it enables tight integration between description and analysis.

In this course, students will learn to use SysML to describe systems of interest from the AE, ISyE and ME domains, and will learn how to integrate their descriptive models with simulation, optimization, and other analysis models.

Course Grading: Students are responsible for all announcements made in class and for all changes in schedule that are posted on the class website. Grades will be determined by homework assignments, a group project, and readings/class participation. The breakdown of grades will be:

Homework 1: modeling structure with objects	10%
Homework 2: modeling behavior as activities	10%
Homework 3: modeling state-based behavior	10%
Homework 4: modeling parametric relationships	10%
Project proposal:	10%
Final project report:	40%
Readings/Class Participation	10%

Exams: There are no exams in this course.

Course Topics
Part 1: Overview
- Introduction
  - Course Overview
  - Introduction to Object-Oriented thinking and modeling
  - Introduction to MagicDraw
- Overview of a systematic design process supported by the SysML language
  - Requirements and objectives, use cases, functional decomposition, physical architecture, black-box and white-box structure, analysis, evaluation, verification.
  - Modeling elements for requirements, structure, behavior, parametrics, cross-cutting relationships.

Part 2: Modeling
- Modeling System Structure
  - Packages, blocks, ports, flows, value types and properties
  - Generalization, composition
  - Package diagrams
  - Block definition diagrams (BDD)
  - Internal block diagrams (IBD)
- Modeling Flow-Based System Behavior
  - Activities, actions, object flow, parameters, pins
  - Activity diagrams
  - Allocations, swimlanes
- Modeling Message-Based System Behavior
  - Asynchronous and synchronous messages, lifelines, interaction references
  - Sequence diagrams
- Modeling Event-Based System Behavior
  - States, transitions, triggers, guard conditions, actions
  - State-machine diagrams
- Modeling Use-Cases and Requirements
  - Use-cases and relationships (association, include, extend, generalize)
  - Requirements and relationships (derive, refine, satisfy, verify, trace, contain)
- Modeling Systems Parametrically
  - Constraint blocks, constraint properties, parameters, binding connectors
  - Parametric Diagrams
- Modeling Cross-Cutting Relationships
  - Allocate, refine, verify, testcase
  - Comments, rationale

Part 3: Systems Engineering
- Modeling in Support of a Systematic Design Process
  - Steps in a design process
  - Modeling the system domain and enterprise
  - Collaborative modeling
- System Architectures: Decomposing Systems with SysML
  - Functional decomposition using call behavior actions
  - Logical decomposition
  - Physical decomposition using BDD and IBD
  - SysML and CAD
- Analyzing Systems with SysML
  - Design-analysis integration
  - SysML and Excel
  - SysML and Mathematica
  - SysML and Simulink
- Creating Reusable Models

- o Stereotypes and profiles
- o Model libraries
- Advanced topics
  - o Federated models
  - o Model transformations
  - o Factory models in SysML

Course Schedule

Week	Topic	Text	Homework
8/23	Course overview; Intro to object oriented thinking/modeling; MagicDraw software	Ch 1, 2	
8/30	Object-oriented modeling with blocks in SysML Overview of systematic design	Ch 3, 4	HW1: 9/3
9/6	IBD, ports, flows, packages (9/6 Labor Day)	Ch 5, 6	
9/13	Activity diagrams, allocations;	Ch 8	HW2: 9/17
9/20	State diagrams	Ch 10	
9/27	Sequence diagrams Cross-cutting relationships	Ch 9, 13	HW3: 10/1
10/4	Parametric diagrams Use cases, requirements diagrams, test cases	Ch 7, 11, 12	
10/11	The System Engineering Process Modeling the domain and the enterprise	Ch 15, Notes	HW4: 10/15
10/18	Holiday (Fall recess); catch up lecture		
10/25	Functional architecture Logical architecture	Ch 16, Notes	Project Proposal: 10/25
11/1	Physical architecture; black-box, white-box SysML and CAD	Ch 16, Notes	
11/8	System analysis using parametrics Parametrics and Mathematica, Excel, Simulink, ModelCenter	Ch 7, 17 Notes	
11/15	Discussions: model organization, supporting collaboration Reusable models: stereotypes, profiles, model libraries	Notes Ch 14	
11/22	Projects; Thanksgiving break		
11/29	Advanced topics		
12/6	Project presentations		Presentation: 12/6
12/13	Final exam week – NO FINAL; finish project report.		Final Report: 12/13

Project: During the second half of the semester, the students will work on a final project. In these projects, the students will follow a systematic systems engineering process to design and model a system of their choice.

The projects will be performed in small groups (3-4 students) consisting of both ISyE and ME students. The size and scope of the contribution is expected to be proportional to the group size. Through collaboration between ISyE and ME students, the projects are expected to address the systems engineering problem from a variety of perspectives, such as economic, manufacturing, supply chain, dynamic behavior, or human interaction perspectives. The goal of the projects

There is some flexibility in the topic of the final project. For instance, graduate students with prior experience in systems design, could take on a more advanced topic possibly related to their research:
- Study the use of SysML for collaboration among multiple stakeholders.
- Study the use of SysML for capturing and reusing domain specific knowledge.
- Explore the application of graph transformations to SysML models for automating repetitive tasks.
Students may propose other topics as well.

Software: To create SysML model MagicDraw by No Magic Inc. is used. The software will be provided for free to all the students enrolled in the course.

Collaboration Policy: For the homework assignments, each student is expected to hand in his/her own individual work. No copying from other students, from the internet, or from any other source is allowed. However, students are allowed and encouraged to discuss the assignments with each other. Discussing the assignments with your peers will help you to develop a deeper understanding of the material. For the final project, students may work in small groups. Each group is expected to turn in only one report. If you have questions about this collaboration policy, do not hesitate to ask your instructors.

Honor Code: The Georgia Tech Honor Code will be strictly enforced in this class. It is each student's responsibility to understand and abide by the Honor Code as it applies to each class activity.

The honor code addresses more than just test taking—it addresses what is expected for all submitted work. In particular, if you use any source—book, magazine, webpage, prior course handouts, old student reports, etc—in preparing an assignment, you are obligated to cite the source. Failure to do so is a violation of the honor code and will result, at a minimum, in a zero grade for the assignment.

In regard to exams, all work is to be done on an individual basis. You may not discuss or exchange information on exam questions or answers with others either in or outside of this class. Asking anyone other than the instructor to interpret an exam question, its response, or the material covered in the question is a violation of the Honor Code. Changing your answer on graded exams is also disallowed. You may form study groups in which to prepare prior to exams or classroom discussion. Failure to adhere to any of these requirements constitutes a violation of the Honor Code; other situations are also at the discretion of the instructor.
    To protect the honest majority, any cheating on any exam, big or small, will be penalized by an "F" in the course and the student will be referred to the Dean of Student Affairs for disciplinary action.

    If there is any question as to whether an activity is or is not permissible (in this class) under the Honor Code, consult the instructor prior to undertaking the activity. The Georgia Tech Honor Code is available at http://www.deanofstudents.gatech.edu/Honor/.

Relation to other courses at Georgia Tech

ISyE 3103 Supply Chain Modeling: Logistics
ISyE 3104 Supply Chain Modeling: Manufacturing and Warehousing
These two courses introduce ISyE students to the important domain of material flow systems, and the methods and tools for modeling, analyzing and designing these complex, tightly coupled systems. In Model-Based Systems Engineering, students will acquire knowledge and tools to both create formal descriptive models of these systems, and integrate these formal systems models with typical optimization, simulation, and financial models.

ISyE 4106 Senior Design
Model Based Systems Engineering will provide students with distinct and valuable skills and tools that support the kinds of modeling and analysis that is expected to be part of successful senior design projects.

ME 2110: Creative Decisions and Design
For Mechanical Engineering students, ME 2110 is a first introduction to the design process. Modeling and evaluation is not the main focus of ME 2110, and it is introduced only informally. In Model-Based Systems Engineering, the design process is revisited more formally and the students will learn how to support this process with models that represent the system from a broad array of perspectives.

ME 3015: System Dynamics and Controls
The focus in ME 3015 is on modeling the dynamic behavior of systems, and the control of these systems. The modeling perspectives in Model-Based Systems Engineering complement the methods and tools presented in Systems Dynamics and Controls.

ME 4182: Capstone Design
Model-Based Systems Engineering will provide students with a solid foundation for capstone design. It bridges the gap between ME 2110 and capstone design. Students who have taken Model-Based Systems Engineering will have a deeper understanding of the system design process and will master more formal methods and tools to support this process.