SEMA 6201 System Modeling and Analysis

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Abstract

The course "SEMA 6201" System Modeling and Analysis is a 5 day course. The first two days address the CAFCR model that serves as a framework for systems architecting and design. Core to the CAFCR model is the use of multiple viewpoints and multiple visualizations. The last three days of the course address quantification, modeling and analysis.

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1 Introduction

The first two days of this course are derived from the PhD thesis "CAFCR: A Multi-view Method for Embedded Systems Architecting; Balancing Genericity and Specificity"[2]. Three more days are added to address actual modeling of systems and their contexts and the analysis.

2 Course description

Modeling is one of the core techniques in Systems Engineering to facilitate amongst others communication, discussion, exploration, and validation of system specification and design. Modeling can be applied at all levels, from detailed design simulations to high level context models. In practice we struggle with finding the appropriate models and the appropriate level of abstractions. Quite often designers keep on extending and detailing their models. But is the additional effort worthwhile? Is the extended, more complex model better than the previous simpler model? Can we trust the outcome of our models? Should we integrate all aspects in one integrated model?

Let's look at some real life scenarios:

Scenario: *The complex not trusted model.* The pre-development team has made an extensive model of the system with tens of parameters and possible design options. Unfortunately, designers don't really trust the model, because of its complexity. Since they don't understand what the model does, they don't trust the results. What to do to escape from this cul-de-sac?

Scenario: *Assessing system performance from subsystem models.* For three different subsystems models have been made to explore performance for a few different design choices. The system designers face the challenge to combine the results into an integral system performance assessment. By making a fourth system level model they trigger the communication between the subsystems and facilitate system-wide design discussions.

Scenario: *Overoptimistic performance prediction.* During system integration the design team observes behavior and performance that is completely different than expected from previous system and subsystem models. They discover that several housekeeping tasks of the system have not been modeled and have been underestimated significantly.

Scenario: *Introduction of Model Based or Model Driven engineering.* The development organization has scheduled a transition to model based engineering. The expectations from management are high. Engineering teams are sent to education. Unfortunately, after 2 years of development the team discovers that there are plenty of detailed models, but that system characteristics "emerge", because system level models have not been made.

Target audience: (sub)System engineers, designers, and architects who create, maintain or use models. This course looks especially at multi-disciplinary models.

Prerequisites: at least bachelor in engineering or science and some practical experience in design and engineering.

Course Objectives The objective of the course is to teach system engineers and architects methods and techniques for achieving an effective transformation from requirements and business drivers to technology and product design.

After this course students will be able to:

- understand what is a model, types of models, purpose of models
- understand the need for quantification and understand the limits of quantification
- be able to transform loose facts into an insightful model, to be used as input for requirements discussions and system design and verification
- be able to use scenario analysis as a means to cope with multiple alternative specifications and or designs
- apply problem-driven light-weight simulations and understand their value and purpose in early design decisions
- understand and be able to apply the threads-of-reasoning method as a means to communicate about, and discuss the linkage between, business needs and technological decisions
- be able to analyze dependability qualities, such as reliability, safety and security
- be able to analyze the impact of changes; change and variation cases
- understand the value of rapid prototyping for: requirements, potential design issues, modeling inputs
- be able to manage expectation level of different stakeholders

2.1 Educational objectives

- teach system engineers and system architects how to model and analyze their system under design, and evaluate alternative design options
- teach them to understand the complexity of this task
- provide them with adequate methods, knowledge, techniques, and methods to be applied in their daily job

2.2 Course duration and format

The course takes 5 full days. Participants taking the course for credits have to do a 10 week project afterwards. During the course participants work on real-life cases, preferably from their own domain. Theory and exercises alternate continuously. The models created during the course are limited models, since creating real simulations would take too much time. The exercises provide even more value when multiple participants from the same company participate. We recommend to send a small team to the course, if possible. Course content

During the course we address the following questions:

1. Why do we model? What are the indicators that show that modeling and analysis beyond the level of "business as usual" is needed? What questions do trigger modeling and analysis?

2. What do we model? What kinds of views do we need to consider (4+1, DoDAF, Zachman, CAFCR)? Do we model everything that appears in the relevant views?

3. When do we model? What models are needed at various points in the project life cycle?

4. What is the appropriate type of model? Formulas, visualizations, simulations/emulations (replay of (aspects of) the system), executable models (the model is the system).

5. What is the required accuracy of the model? How do we achieve the desired risk mitigation?

6. What is the appropriate level of abstraction? Model economics: How much details have to be taken into account versus how much effort can we afford?

7. How to calibrate models? Models are based on facts and assumptions. The model outcome depends strongly on these input data. Note again the tension between effort to make and calibrate versus the value in terms of risk mitigation.

8. How to use models? What is the working range, what are restrictions to model validity? What is the credibility of the model?

This course focuses at system level and the multi-disciplinary design. We strongly emphasize the objectives of the modeling effort: Most modeling effort supports the decision process of the project, such as what are feasible requirements and what is the impact of design choices. The modeling effort itself helps the designers to understand their system much better. Since a model is a simplification of reality, we need to calibrate models with the real world by performing measurements.

The course is based on several complementary principles:

- continuous iteration and time-boxing
- gradual refinement from coarse estimates to well-supported results
- visualization of problems and solutions
- quantification of problems and solutions
- complementary representations such as formulas, graphs, tables and diagrams

3 Course program

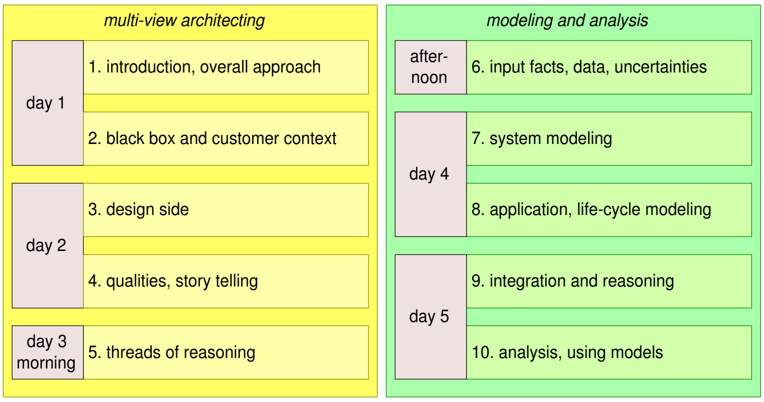

Figure 1: SEMA program

The SEMA course starts with *Multi-View Architecting* based on the CAFCR+ model. Multi-view is the foundation for the later (quantified) *Modeling and Analysis*.

4 Project assignment

The team composition for the assignment is the same as the team composition during the course. The assignment is performed in teams, except for an individual report at the end. Contact the teacher for a more individual assignment, if that is needed for practical reasons such as traveling. The timing steps are indicative and not mandatory.

Send at least twice intermediate results, as presentation, to the teacher. For all emals with the teacher follow the conventions below.

email subject: [SEMA] team<team name><version number>
attachment filename: team<team name><version number>.<ext>

Make sure that you discuss the content of this work every week with a relevant contact person within the company belonging to the assignment.

4.1 Recommended assignment steps

The steps described below are recommended, not mandatory. These steps guide you through on more iteration. This last iteration takes place outside the class room enabling you to collect some “real” data, and to talk with some stakeholders. After this iteration the last steps are to identify what should be done in next iterations, and to process the feedback on this iteration.

week 1 consolidate work of course in 20 slide presentation; e.g. make neat diagrams and power point slides covering the system, usage context and life cycle context; annotated with models, data, rankings et cetera. The presentation should serve as baseline and should help you to explain to others what your system and models are about.

week 2 present to company management; collect facts and figures from the company

week 3 Make two to three models of the "system" Make these models much more detailed than during the course; make an annotated version with quantifications.

week 4 Model the customer context

week 5 Model the Life cycle context, what are sources of change, who is handling change and how.

Week 6 Model one of the relevant system qualities

week 7 Consolidate your work and the conclusions/results in a 20 slide presentation. You might try to make a Thread of reasoning to integrate the insights. The target audience of this presentation is your management. The presentation should be top-down, starting with objective, need or problem statement.

Week 8 Identify required changes in models made so far, due to increased insight; Change one of the models accordingly

week 9 identify next models to be made, measurements to be done, or fact finding to take place. Rank the work to be done, to identify next steps. Update the presentation with feedback from management and future work. Submit the updated presentation as the final team deliverable.

week 10 write a individual report containing the following sections:

- What is the credibility and accuracy level of the models so far and why?

- What is the problem statement that should be addressed by this modeling effort?
- What would you do differently if you would have to do this again?
- How are you going to apply this in practice?

Mail the individual report to the teacher, with subject and filename: [SEMA]report <your name>

Grading is based on the final presentation submitted by the team and based on the individual report.

References

[1] Gerrit Muller. The system architecture homepage. `http://www.gaudisite.nl/index.html`, 1999.

[2] Gerrit Muller. CAFCR: A multi-view method for embedded systems architecting; balancing genericity and specificity. `http://www.gaudisite.nl/ThesisBook.pdf`, 2004.

History
Version: 0, date: 21 September 2009 changed by: Gerrit Muller

- derived from CAFCR and MA course descriptions