SYSEN5400/5410/MAE 5950 – Systems Architecture

Fall 2016, 3 credits
Rhodes 253
Lecture: Mon/Wed 11:40-12:55
Discussion: Fri 9:05-9:55

Instructor:	Daniel Selva, 449 Upson Hall, ds925@cornell.edu, 607-255-6351
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Office Hours:	Daniel Selva Fri 1:30-3:30 or by appointment, Upson 449
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Grading:	Letter

I. Rationale:

Systems Architecture is the study of the high-level or conceptual design of a system, called the architecture. Architectural decisions are the first and most important design decisions of a system. They are made at the beginning of the systems engineering process, when the uncertainty and ambiguity on the system and its context are maximal. The goal of the System Architecture process is to select an architecture that ensures the system's ability to satisfy stakeholder's needs and goals sustainably over the system's lifecycle. The concepts and skills needed to do system architecture are a mix of structured and unstructured tools, methods and principles that span different disciplines including decision analysis, optimization, and statistics, as well as a large body of domain-specific expertise about the system at hand.

II. Course Aims and Outcomes:

Aims

The goal of this course is to provide students with a set of tools, methods, concepts and principles that will help conduct system architecture studies more effectively, while giving them exposure to a number of real system architecture problems from a variety of industries. This is a mixed course, with a theoretical component but emphasis on practical applications of the theory.

Specific Learning Outcomes:

By the end of this course, students will:

- Produce a complete representation of a system architecture using SysML including functional architecture, physical architecture, and mapping of function to form.
- Be familiar with the major architectural frameworks (e.g. DODAF, TOGAF)
- Characterize and prioritize stakeholders and their needs using stakeholder value networks and transform stakeholder needs into a set of goals for the system
- Use formal brainstorming methods and computational tools to synthesize large spaces of concepts and architectures
- Develop functions that assess the relative value of system architectures across all important metrics including performance, cost, schedule, risk, and others.
- Use design of experiments and multi-objective evolutionary algorithms to fully or partially explore the architectural trade space and find a set of "good" architectures
- Use statistics and unsupervised learning to discover the structure of the tradespace

- Use supervised learning algorithms to generate surrogate models of value functions
- Analyze the flexibility, modularity, robustness, and scalability of system architectures
- Critique an architecture, identifying its strengths and weaknesses
- Be exposed to principles of good (and examples of bad) systems architecture by real practitioners from different domains, including aerospace, defense, and biomedical

III. Format and Procedures:

The course has a theoretical component based on lectures, assignments, and a quiz, and a practical component based on a semester-long project (integrated into the assignments) and guest lectures.

Course participation is essential for the success of the course, and therefore it will contribute to the student's grade in the course. In-class questions delivered by online survey software will be used to foster and assess participation.

There will be (roughly) biweekly homework. Each assignment will have the following format: a set of short questions and problems to reinforce tools and methods seen in class, and a set of longer questions or problems based on the project. Some of the questions will require the use of software, namely Artisan Studio for creating SysML diagrams and Matlab (or another programming language of your choice) for everything else.

There will be an individual take home quiz focusing on theoretical content (tools and methods), but no final exam. Instead, a team report summarizing the main findings of the project will be due at the end of the semester.

IV. Course Requirements:

1. Final Project Report and Presentation: Students will work in groups on a semester-long project to apply the concepts learned in class. All students must have a project approved by the course instructors to use as a basis for their homework and final project. Project topics can also be provided by the course instructors to students should they not be able to find an acceptable project on their own. Decisions on project approvals will be announced before the end of the add/drop period and project approval descriptions should be submitted at least one week before that date. A final report will be due at the end of the semester summarizing the main findings in the project. The findings will also be presented to the class in a final presentation.

2. Homework: Homework will be due roughly every 2 weeks (exact due dates are on the schedule). It will consist of an individual theoretical part with relatively short questions and problems on tools and methods, and a group practical part asking to develop a part of the semester-long project relevant to the latest material seen in class. Assignments will be made available in the Blackboard site during class, and will be due at 11:40am Eastern time on the date indicated in the schedule. Students must submit the homework individually (including the project part) via the Assignment feature on the Blackboard site. Homework submitted after the due date and time receives a penalty of 10 points per day. The submission time is based on Blackboard's record, which is linked to the NIST web clock.

3. Take-home Quiz: The take-home quiz is designed to assess the ability of the student to apply the tools and methods seen in class in relatively simple examples. It will consist of questions similar in nature and difficulty to those used in the theoretical parts of the assignments.

4. In-class Questions: In most lectures, a short in-class exercise will be done using the REEF polling tool. Answers will be due at 8am on the day of the next lecture (multiple submissions are allowed).

V. Grading Procedures:

1. Three credit option:

- **(a)** 40% Homework (15% individual questions, 25% project questions)
- **(b)** 25% Final Project Report
- **(c)** 15% Take-home quiz
- **(d)** 10% Final Presentation
- **(e)** 10% Participation

The Final Project will be graded on the basis of the following criteria: a) technical depth; b) use of tools and methods; c) presentation.

Assignments will be given a numerical grade based on a weighted average of the scores for the individual theory questions and for the group project questions.

There will be no extension on homework assignments irrespective of the excuse. Instead, **we will drop the lowest homework assignment grade at the end**. This should provide enough flexibility. Please use these two homework assignments wisely.

All grading appeals must be made to the TA in writing with justification (including references to lecture notes or readings) within one week after graded material is returned. The entire homework will be re-graded, not merely the part in question. So, a regrade by the TA may raise or lower the score.

The participation grade will come from an assessment of overall participation of the student in class, including the percentage of in-class questions answered through the REEF polling tool. **Students are required to purchase a copy of the REEF polling cell phone app ($9.99)**. More information about how to obtain and use this software is available on the Blackboard site.

VI. Academic Integrity

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work.

The student is encouraged to turn to the TAs, professors, and other students for help in understanding the general approach to solving homework assignments. However, after sharing ideas, getting, and/or giving help, each student must work through each assignment completely

and by himself or herself, without the use of any material that originated with any other person (except for team project work).

For team project work, all team members are expected to review all sections of what the team submits because the grade will be shared.

Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

For further information on Cornell's Code of Academic Integrity see:
http://cuinfo.cornell.edu/Academic/AIC.html

VII. Accommodations for students with disabilities
In compliance with the Cornell University policy and equal access laws, I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.

VIII. Inclusivity Statement
We understand that our members represent a rich variety of backgrounds and perspectives. The Systems Engineering program is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- share their unique experiences, values and beliefs
- be open to the views of others
- honor the uniqueness of their colleagues
- appreciate the opportunity that we have to learn from each other in this community
- value each other's opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the Cornell community

IX. Tentative Course Schedule (*May change to accommodate guest presenters & student needs*)
See Schedule on Blackboard.

X. Resources

There is no required textbook for the course. All course materials will be made available in the Blackboard site.

However, some materials including homework questions will be drawn from the following optional recommended textbook, available in the Cornell book store:

- Edward F. Crawley, Bruce G. Cameron, Daniel Selva, "Systems Architecture", Pearson, 2015

Other references on systems architecture are:

- Dennis M. Buede "The Engineering Design of Systems: Models and Methods, 2nd Edition," Wiley, 2009.
- Friedenthal S, Moore A., Steiner R., A Practical Guide to SysML, Morgan Kauffman, 2nd edition, 2012
- Mark W. Maier and Eberhardt Rechtin "The Art of Systems Architecting, 3rd Edition" CRC Press / Taylor & Francis, 2009.
- Charles Dickerson and Dimitri Mavris "Architecture and Principles of Systems Engineering," CRC Press / Taylor & Francis, 2010.
- Ronald E. Giachetti "Design of Enterprise Systems: Theory, Architecture, and Methods," CRC Press / Taylor & Francis, 2010.
- Ulrich, Karl T., Steven D. Eppinger, and Anita Goyal. Product design and development. Vol. 2. New York: McGraw-Hill, 2011.