

ISYE 4113 Advanced Modeling and Analysis of Workflow Systems

Supply chain engineering concentration depth-elective

Credit: 3-0-3

Coordinator: Spyros Reveliotis

Prerequisite(s):

1. **ISYE 3232 Stochastic Manufacturing and Service Systems:** Students are expected to be comfortable with the stochastic/probabilistic models and the basic queueing theory that are covered in that course.
2. Familiarity with some basic concepts and techniques coming from deterministic optimization theory are also expected.

Texts:

1. **G. L. Curry and R. M. Feldman, Manufacturing Systems Modeling and Analysis (2nd ed.), Springer, 2011.** This book functions as a primary base for the course development.
2. Additional supplementary material will be provided through (i) a course website accessed from the instructor's homepage, (ii) CANVAS announcements, and (iii) in-class developments.

Catalog Description:

In-depth modeling and analysis of the workflow dynamics shaping the operation and performance of production and service systems. Application of stochastic modeling in practical problems.

Course Description:

This course will introduce the students to an in-depth modeling and analysis of the workflow dynamics that shape the operation of a broad range of modern applications, ranging from the contemporary production systems to health-care facilities. More specifically, in its primary developments, the course material will be motivated and presented primarily through applications drawn from the high-volume discrete-part manufacturing domain, for specificity and concreteness. But through additional examples, homework and exam problems, it will be further demonstrated how the presented models and methods are also applicable in many other application domains involving a structured workflow, like various logistics and health care operations, and even the broader service industry.

An important attribute of the course is that it does not intend to teach the students only the various models and computational methods that are covered in it, but also the thinking processes and the

broader modeling and analytical methodology that underlie the development of the presented results. Developing these perspectives and the corresponding skills is important for an effective application of the course material, and even the adaptation and extension of this material in order to address various nuances and intricacies in those applications that will be encountered by the students in their professional life. The ongoing advent of Generative Artificial Intelligence (AI) and the proliferation of the various Large Language Models (LLMs) render this more profound understanding of the presented models and methods even more imperative, as the students eventually will be called to navigate and effectively exploit all the corresponding information and capability that is provided by these platforms.

Topical Outline

1. Introduction (~4 lectures): Course Objectives, Context, and Outline. Here are some more specific topics that are covered in this introductory part:
 - The Manufacturing System as a Transformation Process, Operations Management, and the role of Corporate Strategy.
 - A brief introduction to layout theory.
 - Contemporary high-volume (discrete-part) manufacturing systems, and their modeling as stochastic systems.
 - A taxonomy of the considered manufacturing systems based on their workflow management: Synchronous vs. Asynchronous, and Push vs. Pull and CONWIP models.
 - Course overview.
2. Design of Synchronous Manufacturing Systems / Assembly Line Balancing (~2 lectures).
3. A review of some key results from Markovian Queueing Theory, and their use in the modeling and the analysis of some simple workflows (~4 lectures).
4. Stability characterization and Mean Value Analysis (MVA) of the M/G/1, G/G/1 and G/G/m queues (~1 lecture).
5. Modeling, Analysis and Design of Push-Controlled Manufacturing Systems as a series of G/G/m queues (~2 lectures).
6. Modeling of the operational outages of the system servers, and of some other operational features of the considered facilities (~3 lectures).
7. The role of batching in modern production systems, and queueing-theoretic modeling of some batched operations (~2 lectures).
8. Extension of the aforementioned theory to the modeling of workflows that evolve over more complex network structures (~4 lectures).
9. Modeling and analysis of some pull-controlled manufacturing systems as closed queueing networks (~3 lectures).
10. Introduction to some more complex queueing dynamics like priority and/or (combinatorial) scheduling theory (~3 lectures).

Course Learning Outcomes:

At the end of this course, the students will be able to:

1. Understand and appreciate the necessity and the significance of using queueing theoretic-modeling and analysis for the systematic study of the sequential workflows that support the operations of the target application environments.
2. Use effectively the fundamental concepts, terminology, results and methods of the employed queueing theory in the context of the considered applications.
3. Appreciate the role and the significance of a pertinent modeling abstraction as an effective tool for structuring design, analysis and control problems in various application domains, while controlling the conceptual / representational, analytical and computational complexity of these tasks.
4. Understand the effective / proper use of the presented models (as defined by their structure and their embedded assumptions), their potency, but also their limitations.
5. Understand the complementarity of the presented models and theory with discrete-event simulation.
6. Experience the potential of the current LLM platforms in the course domain.
7. Strengthen their ability to adapt the prototypical developments presented in class, through their composition, adaptation and extension, in order to address additional workflows arising in “real-world” settings.

The Mapping from the Course Outcomes to ABET Student Learning Outcomes

The table below shows the relationship between course outcomes and ABET student learning outcomes. The table has 8 columns. The first column lists the course learning outcomes listed above. The next 7 columns list the abbreviated ABET Student Learning Outcomes. The entry of H in a row with specific course learning outcome and column with specific ABET Student Learning Outcomes indicate the importance of attain this outcome is high and will be assessed.

Course outcome \ Program Outcomes	1. identify, formulate solve engg prob by engg, sci &	2. produce solutions consider public health, safety, welfare, global, cultural, social, environ & economic	3 communicate with a range of audience	4 recognize ethical & professional responsibilities, make informed judgement consider resolutions in global, economic, environ and societal context.	5. effective on a team provide leadership, collaborative and inclusive envirn, plan tasks & meet objectives	6. develop and conduct experiment, analyze and interpret data & use engineering judgement to draw conclusions.	7. acquire and apply new knowledge using appropriate learning strategies
1.	H						
2.	H		H				
3.	H						
4.	H						
5.							
6.							H
7.							H

Assessment of the course outcomes

Course outcomes will be assessed based on the in-class interactions, and the student ability to address the various questions and problems posed in the course assignments and exams.