Discrete Event Systems

Automata and Queueing Systems

2021/22

About the instructor

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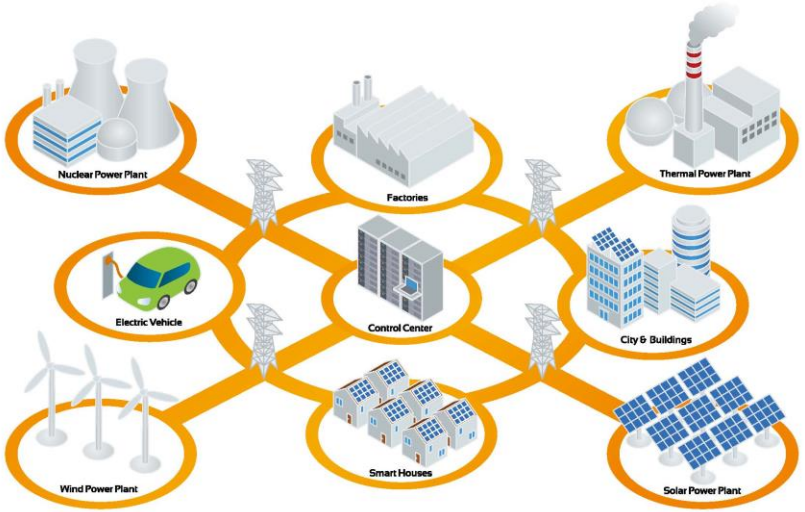
Research interests:

- Robust control
- System identification
- Smart grids



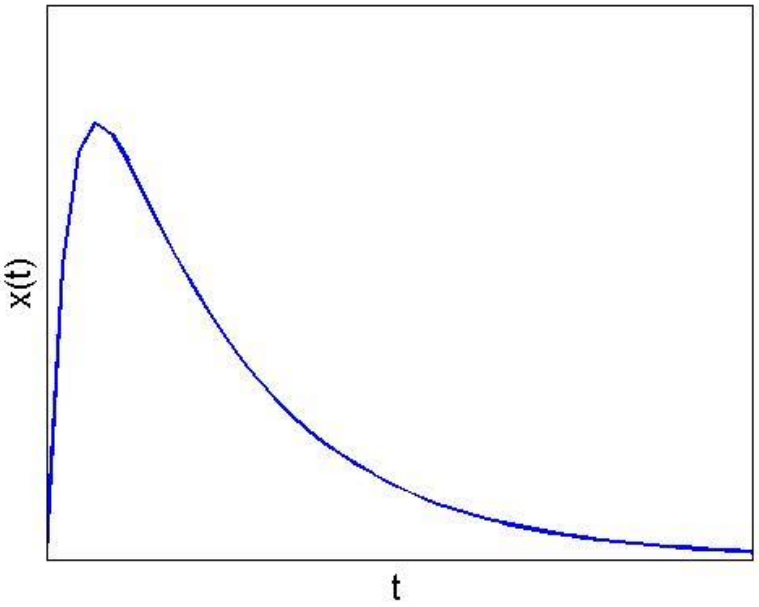
Find the differences… (1/2)

Suspension system

Queueing system

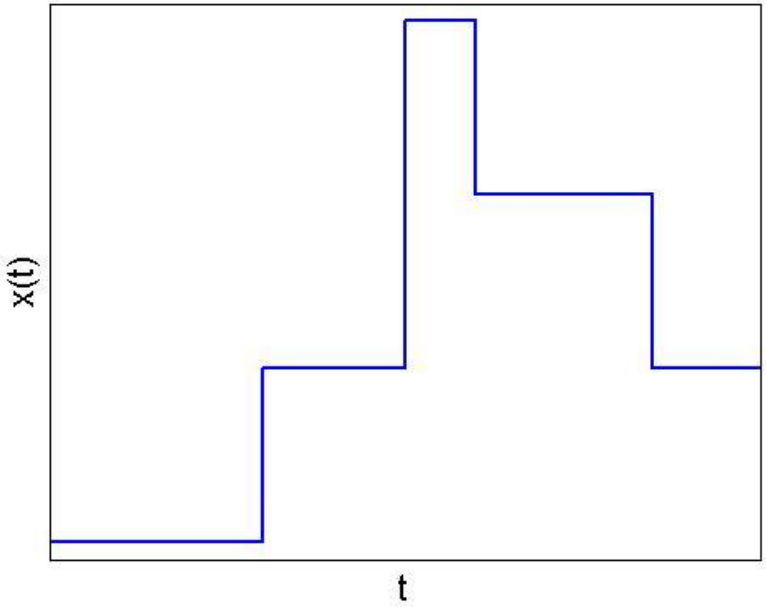
Find the differences… (2/2)

x: suspension displacement



"time-driven" dynamics

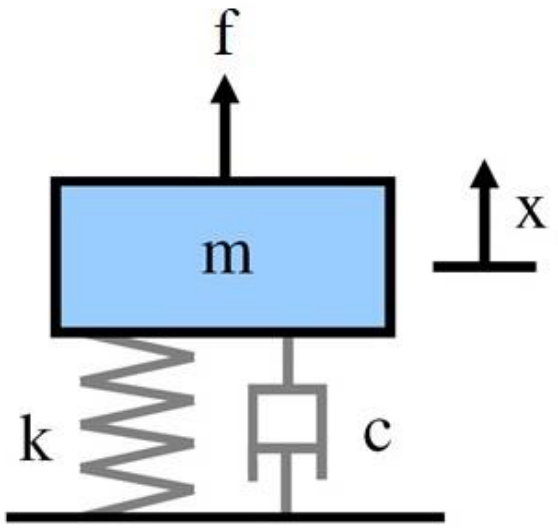
x: # of customers in the queue



"event-driven" dynamics

Mathematical models (1/2)

Suspension system: modelled as a *mass-spring-damper system*



$$m\ddot{x} + c\dot{x} + kx = f$$

linear time-invariant differential equation

x: mass displacement

f: applied force

Mathematical models (2/2)

- **Time-driven** dynamics are described by differential equations
- How can we model **event-driven** dynamics?

Objectives of the course

Modelling, analysis and simulation of **Discrete Event Systems (DES)**

Main contents:

- modelling
- probability
- programming (Matlab)

Which types of models will be considered?

- Logical and timed models (**automata**)
- Markov chains

Main application: **queueing theory**

Examples of discrete event systems (1/3)

- a *manufacturing plant* with machines, workers, conveyor belts, buffers, etc.
- a *bank* with different types of customers and services (desks, ATMs, etc.)
- an *airport* with passengers in different states (check-in, security control, gate, boarding, etc.)
- a *computer system* with resources and processes needing access to resources
- a *road system* with cars, roads, crosses, traffic lights, etc.
- a *fast-food restaurant* with a staff and different types of customers

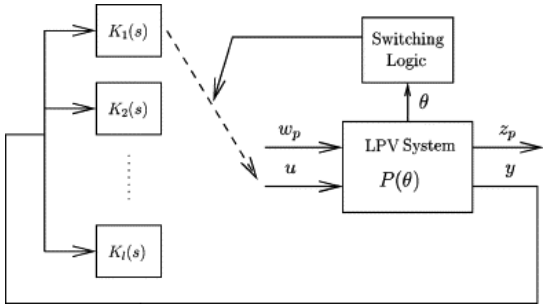
Examples of discrete event systems (2/3)

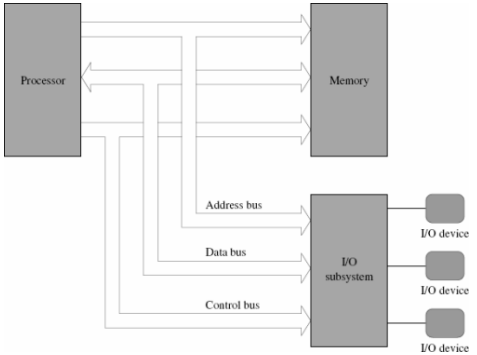
- a *switching control system* where it is possible to switch between different controllers
- an *electronic component* subject to deterioration and failures
- etc.

Examples of discrete event systems (3/3)

Summarizing, discrete event systems can be found in:

- control systems
- manufacturing systems
- computer systems
- information networks
- transportation networks
- communication networks
- etc.



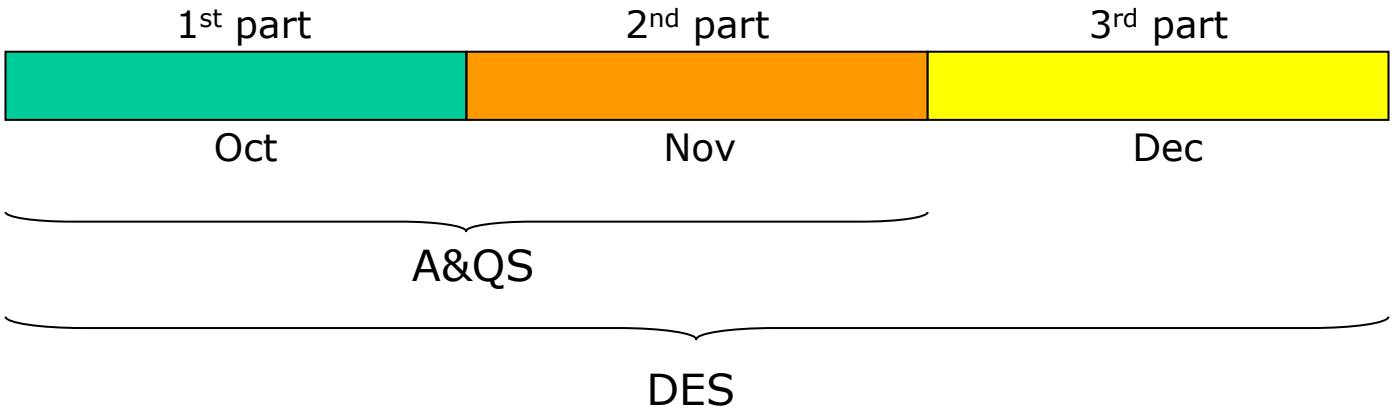


About the course

- **Automata and Queueing Systems- A&QS** (6 CFU)
  - MSc Artificial Intelligence and Automation Engineering - *Intelligent Systems* (A2-IS) – 1st year
  - MSc Engineering Management (EM) - 1st year
- **Discrete Event Systems - DES** (9 CFU)
  - MSc Artificial Intelligence and Automation Engineering - *Robotics and Automation* (A2-RA) – 1st year

Course organization

- A&QS is a "subset" of DES



  - 1st part + 2nd part: A&QS
  - 1st part + 2nd part + 3rd part: DES

Course schedule

Teaching period:

- From October 6, 2021 to January 19, 2022

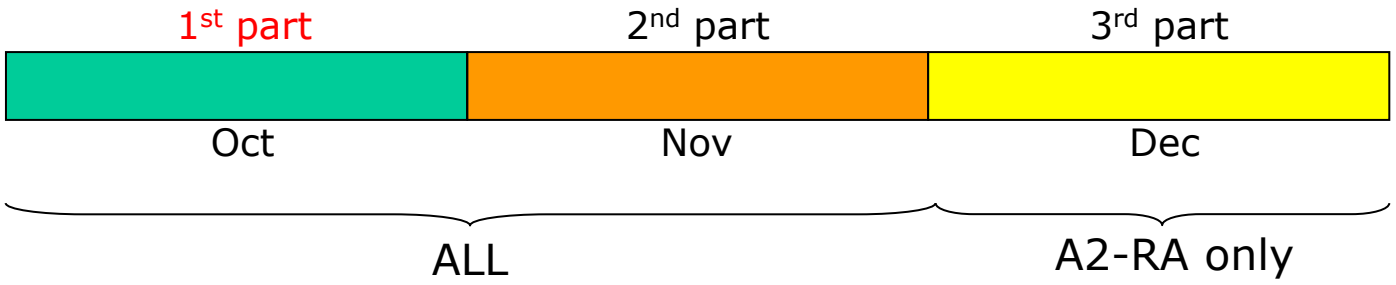
Timetable:

- Monday – from 5:30 PM to 7:30 PM (room C/D/F)
- Tuesday – from 8:30 AM to 10:00 AM (room C/D/F)
- Wednesday – from 2:00 PM to 4:00 PM (room 145)

Distribution:

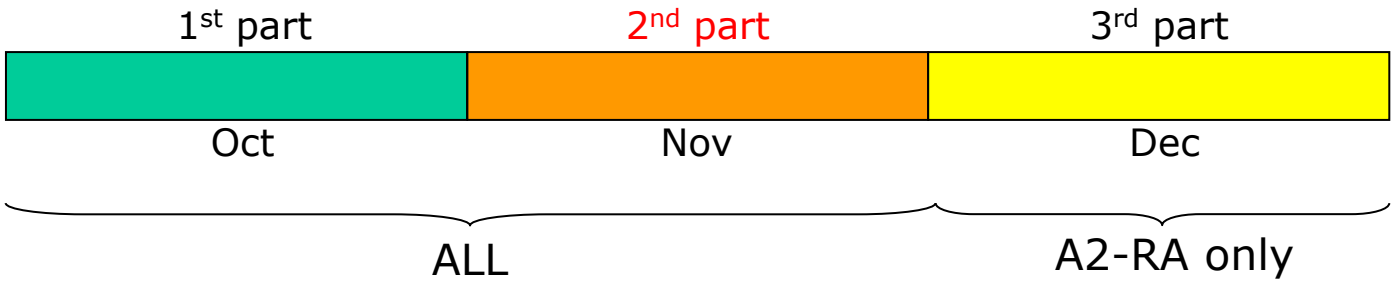
- ~ 60% lectures, ~ 40% tutorials

Syllabus (1/3)



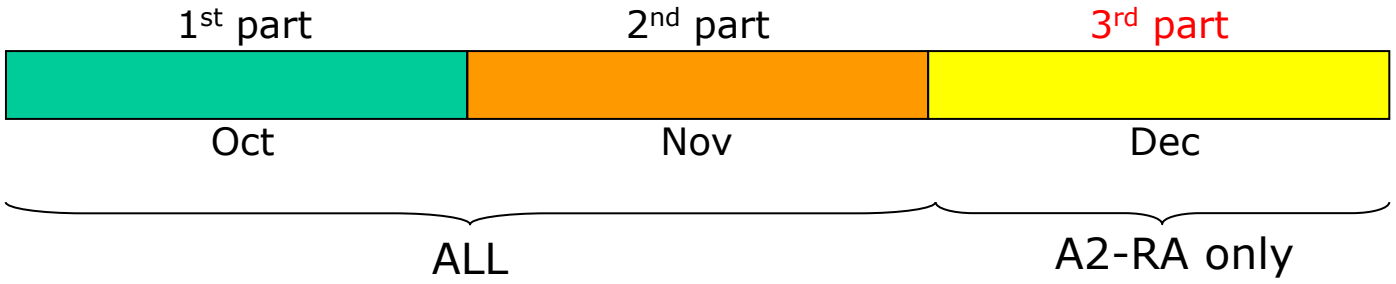
- Logical models of Discrete Event Systems (DES)
- Timed models of DES
- Stochastic timed models of DES

Syllabus (2/3)



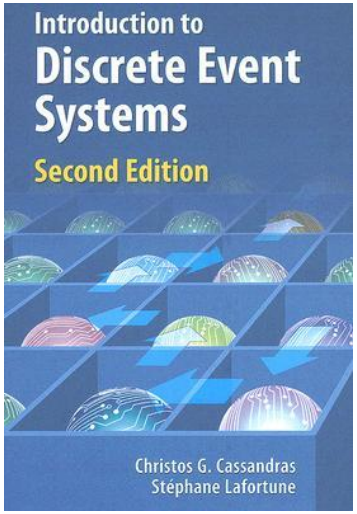
- Simulation of DES
- Continuous-time Markov chains
- Queueing theory

Syllabus (3/3)



- Discrete-time Markov chains
- Control applications of DES

Teaching material



- Textbook:

  C.G. Cassandras, S. Lafortune,

  "*Introduction to discrete event systems*", 2nd ed.

  Springer, 2008

- Available on the web page of the course (**free access**):
  - lecture notes
  - past exams and exercises with solutions

- Available on Google Drive (**only for registered students**):
  - videos covering the contents of the course

Required (minimal) background

- Algebra
  - Matrices and vectors
- Probability
  - Basic concepts (independence, conditional probability, etc.)
  - Random variables (univariate and multivariate)

➢ Among the topics covered by the *Introductory Course for MSc Degrees*

https://www3.diism.unisi.it/~paoletti/teaching/intro/2122/index.html

➢ The contents of that course will be taken for granted

Final exam (1/2)

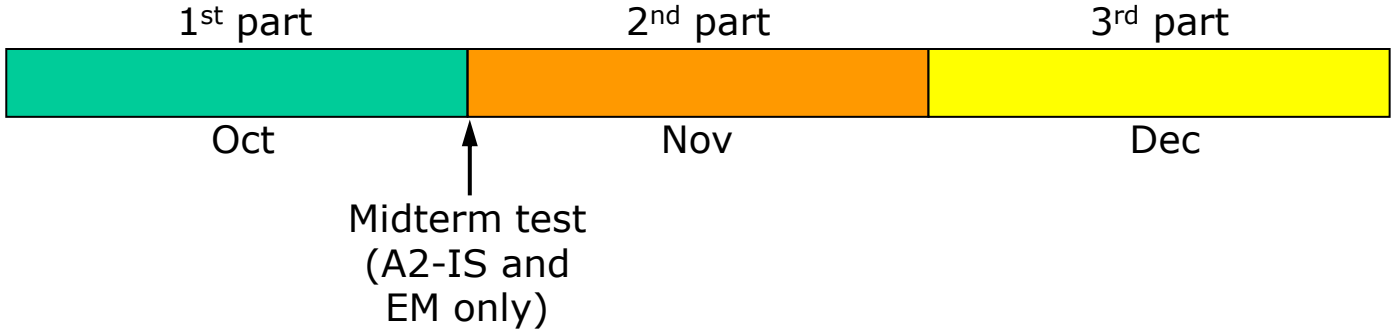
- The final exam can be taken in the available exam sessions
  - *1st session:* from January 24, 2022 to March 3, 2022
  - *2nd session*: from June 20, 2022 to July 29, 2022
  - *Recovery session:* from September 1, 2022 to September 30, 2022
- It consists of a written and an oral test
- The written test consists of exercises (typically two/three)
  - Past exams are available to see how a test looks like
  - Two dates for the written test in each session

Final exam (2/2)

- The oral test is a broad-spectrum discussion on the topics of the course, including theory and exercises
  - Enabled only if the grade of the written test is ≥18 out of 30
  - To be given within the same session as the written test
  - In case of failure, the student must repeat the written test
  - The language for the oral test can be either English or Italian
- The final grade takes the performance in both tests into account, with higher weight given to the oral test

A&QS: midterm test and project

- The written test of the final exam can be replaced with:
  - ✓ Midterm test + Matlab project
- The midterm test is concerned with the topics of the 1st part only



- Oral test enabled only if the average grade of midterm test and project is ≥18 and both grades ≥15 (out of 30)
- One may repeat the midterm test on the first exam date in the 1st session of exams

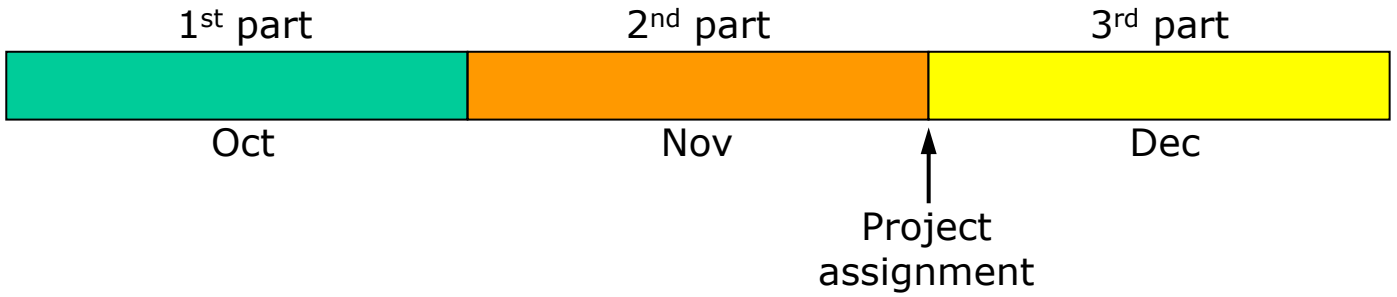
DES: endterm test and project

- The written test of the final exam can be replaced with:
  - ✓ Endterm test + Matlab project
- The endterm test is concerned with the topics of the 1st and 3rd part only

- Oral test enabled only if the average grade of endterm test and project is ≥18 and both grades ≥15 (out of 30)
- One may repeat the endterm test on the first exam date in the 1st session of exams

Matlab project

- The Matlab project is concerned with the topics of the 2nd part
  - ✓ Group project (2÷4 members)
  - ✓ Groups can be "mixed" (A2-IS, A2-RA, EM)
  - ✓ To be returned by mid February at the latest



Notice on written tests

All the written tests (including the midterm and endterm tests) will be done in presence only

Web page

https://www3.diism.unisi.it/~paoletti/teaching/sed/2122/index.html

Master of Science in Engineering
Università di Siena

Automata and Queueing Systems
Discrete Event Systems

October 2021 - January 2022

Tips

- Registration for the course (instructions on the course web page)
  - Needed to access course material (videos, etc.) reserved to registered students
- Attend ALL the lectures
  - Integral part of the learning process (notes, questions, etc.)
  - Enhances student's performance
- Start well
  - Study from the beginning… don't wait the midterm/endterm test!
- Take advantage of office hours
  - Ask questions and feedback on exercises, clarify your doubts

Questions?

Just for fun...