Discrete Event Systems

Automata and Queueing Systems

2020/21

About the instructor

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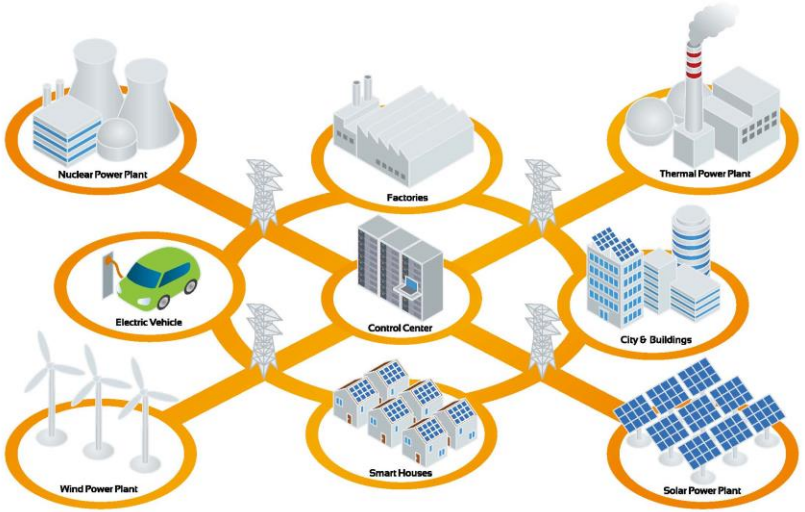
Research interests:

- Robust control
- System identification
- Smart grids



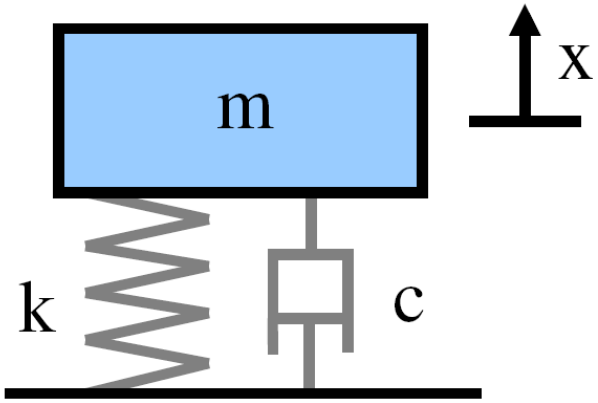
Find the differences…

Suspension system

Queueing system

Find the differences…

Suspension system (model)



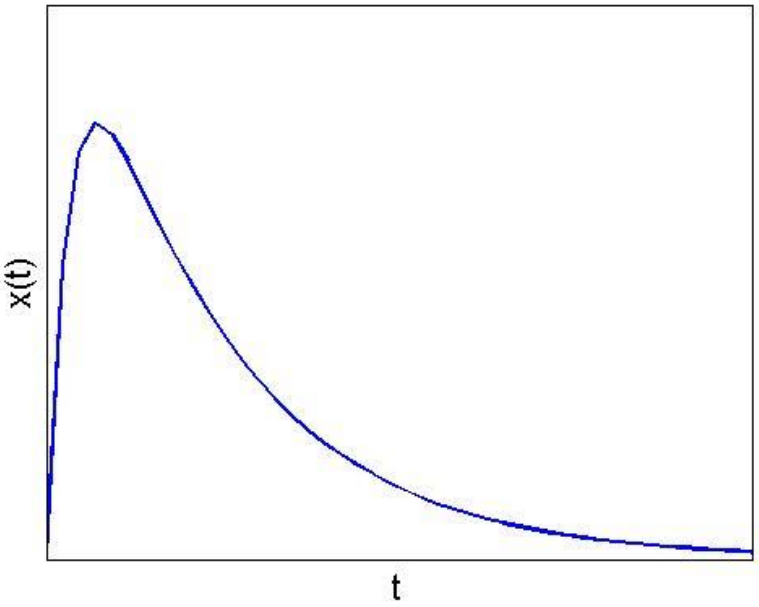
x: mass displacement

Queueing system

x: # of customers in the queue

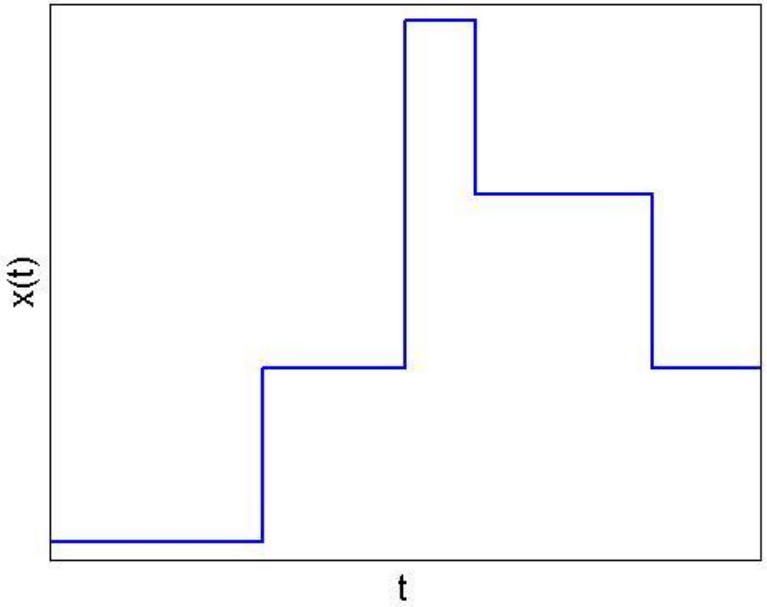
Find the differences…

x: mass displacement



"time-driven" dynamics

x: # of customers in the queue



"event-driven" dynamics

Time-driven vs Event-driven

- **Time-driven** dynamics are typically described by differential/difference equations, e.g.

$$\dot{x}(t) = Ax(t) + Bu(t) \quad \text{(continuous time)}$$
$$x(t+1) = Ax(t) + Bu(t) \quad \text{(discrete time)}$$

- LTI state space 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

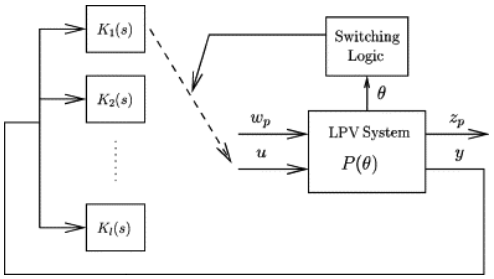
Examples of discrete event systems (2/3)

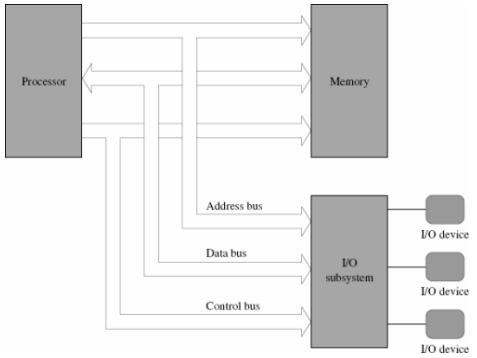
- a *switching control system* where it is possible to switch between different controllers
- an *electronic component* subject to deterioration and failures
- etc.

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** (6 CFU)
  - MSc Artificial Intelligence and Automation Engineering - *Information Systems* (A2-IS) – 1st year
  - MSc Engineering Management (EM) - 1st year
- **Discrete Event Systems** (9 CFU)
  - MSc Artificial Intelligence and Automation Engineering - *Robotics and Automation* (A2-RA) – 1st year

Course schedule

Teaching period:

- From October 1st, 2020 to January 14th, 2021

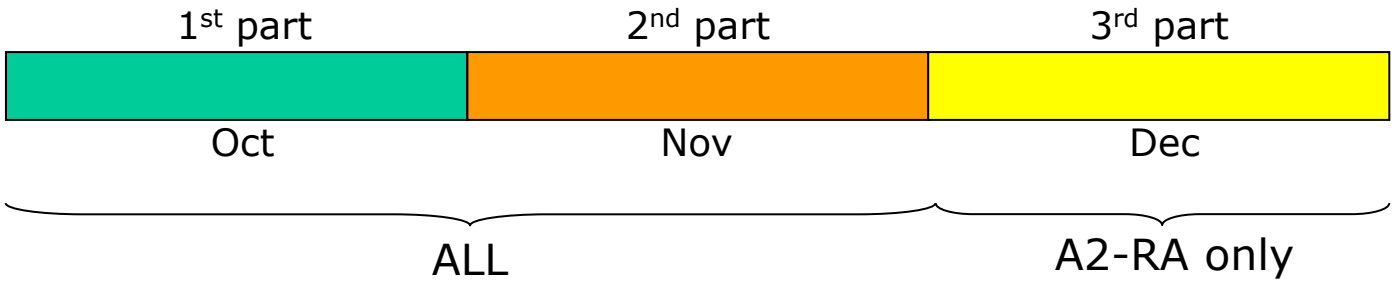
Timetable:

- Monday – from 8:30AM to 12PM (room 145)
- Thursday – from 12PM to 1:45PM (room 101)

Timing:

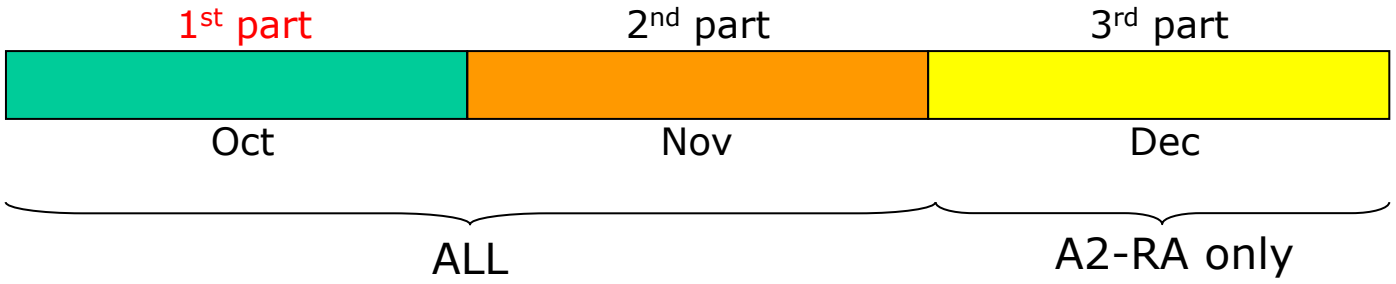
- ~ 60% lectures, ~ 40% tutorials

Timeline



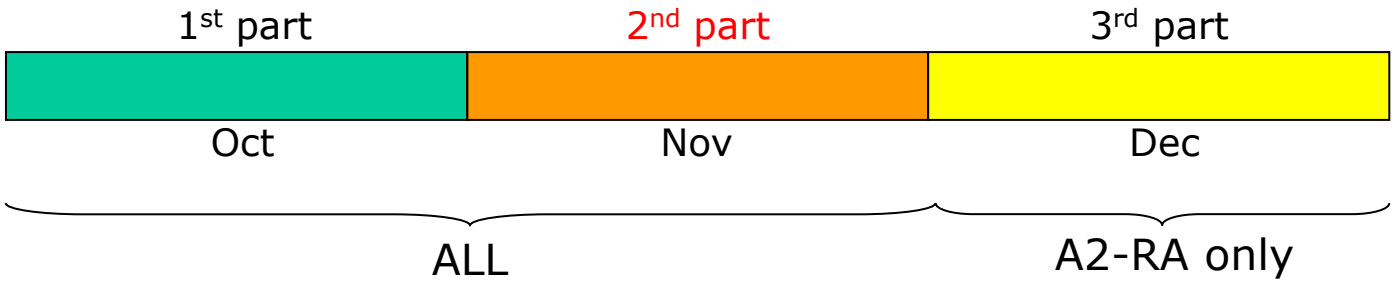
- 1st part + 2nd part: Automata and Queueing Systems
- 1st part + 2nd part + 3rd part: Discrete Event Systems

Syllabus (1/3)



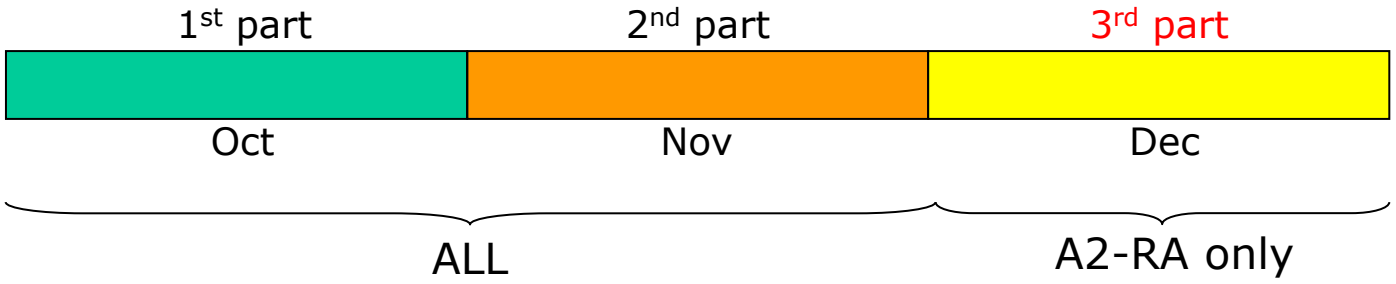
- Logical models of Discrete Event Systems (DES)
- Timed models of DES
- Stochastic timed models of DES

Syllabus (2/3)



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

Syllabus (3/3)



- Discrete-time Markov chains
- Control applications of DES

Background

- Dynamical systems
  - Concept of state
  - Linear time-invariant (LTI) systems

$$\dot{x}(t) = Ax(t) + Bu(t)$$

$$x(t+1) = Ax(t) + Bu(t)$$

- Probability
  - Basic concepts (independence, conditional probability, ecc.)
  - Random variables (univariate and multivariate)
- Statistics
  - Law of large numbers
  - Random number generation

Teaching material

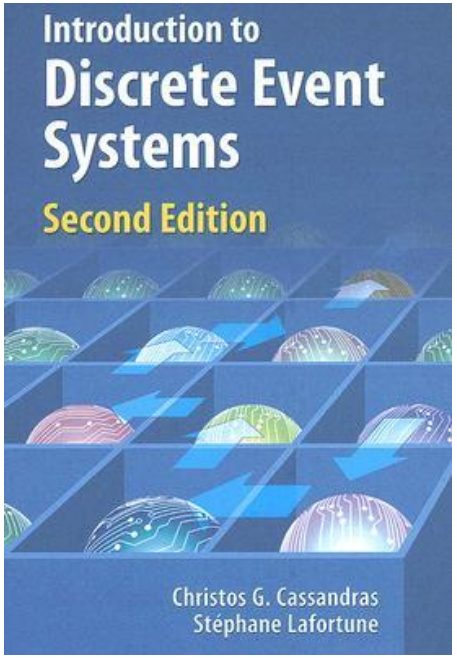
- Textbook:

  C.G. Cassandras, S. Lafortune,

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

  Springer, 2008

- Available on the web page of the course:
  - lecture notes
  - past exams and exercises with solutions
- Available on Google Drive:
  - video recordings of the lectures

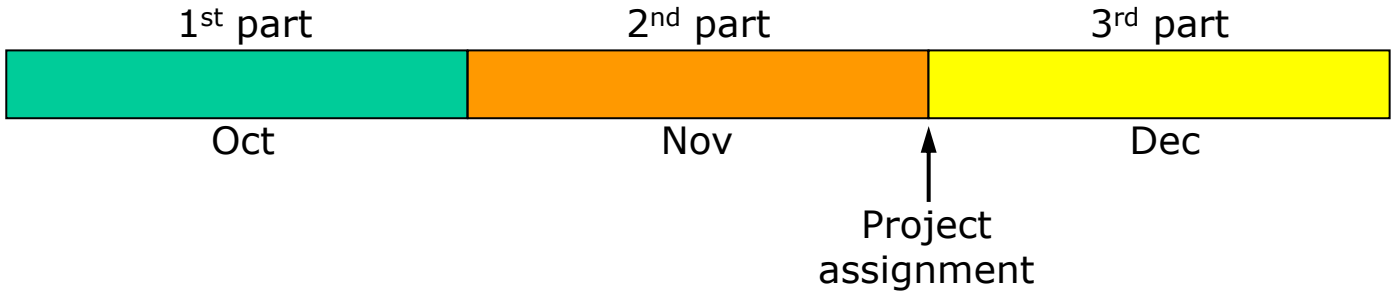


Final exam

- The final exam consists of both 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
- 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

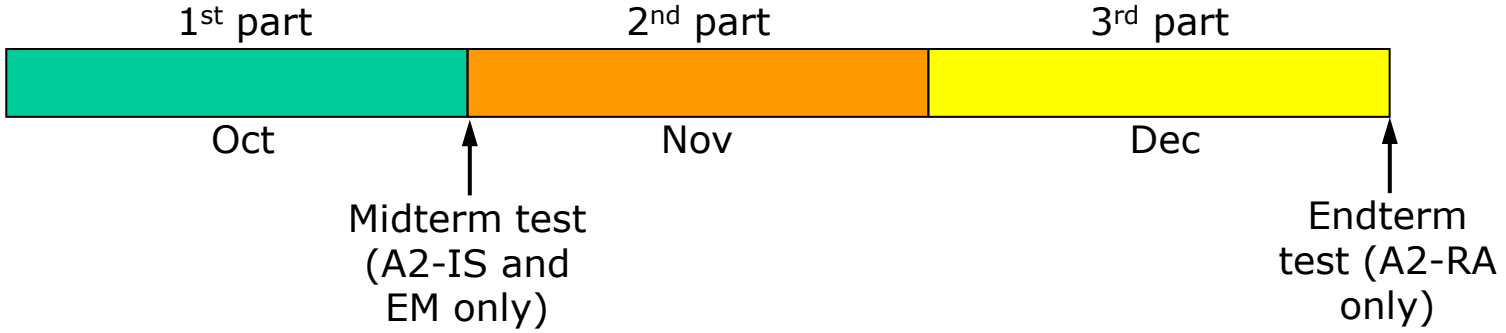
Midterm (endterm) test and project (1/2)

- The written test of the final exam can be replaced with:
  - ✓ Matlab project + midterm (endterm) test
- The Matlab project concerns the topics of the 2nd part
  - ✓ Group project (2÷4 members)
  - ✓ To be returned by mid of February at the latest



Midterm (endterm) test and project (2/2)

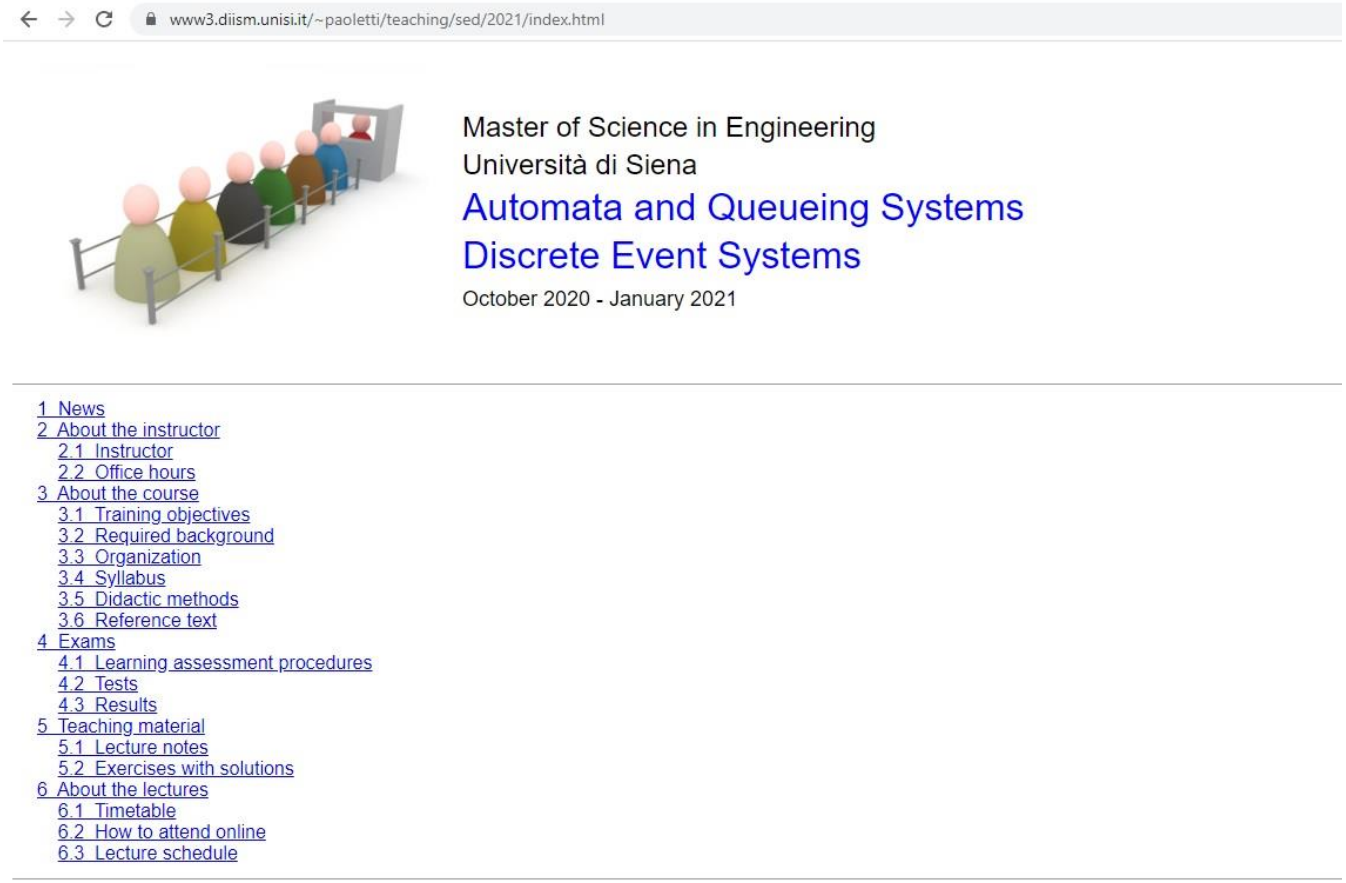
- Topics of the test:
  - ✓ A2-IS and EM: 1st part (midterm test)
  - ✓ A2-RA: 1st part + 3rd part (endterm test)



- 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 winter session of exams

Web page

https://www3.diism.unisi.it/~paoletti/teaching/sed/2021/index.html



Tips

- Registration for the course
  - Needed to share the video recordings and attend online
  - Link to the Google form available on the course web page
- How to attend online
  - Lectures streamed live on the platform Cisco Webex
  - Link to the virtual meeting room available on the course web page
  - Only registered students admitted into the meeting
  - Access not guaranteed after the start of the lecture

Survivor's guide

- 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 start by the midterm (endterm) test: it's too late…
- Take advantage of office hours
  - Ask questions, clarify your doubts
  - Feedback on exercises

Questions?

Just for fun...