Discrete Event Systems

2022/23

About the instructor

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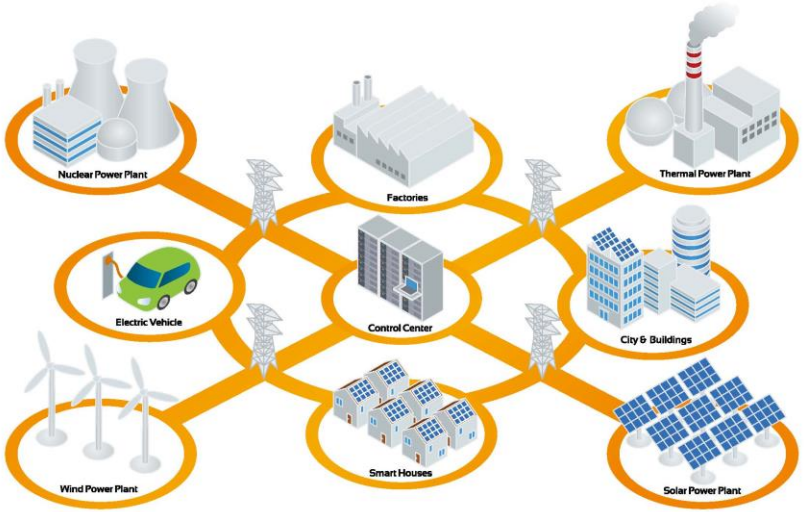
Research interests:

- Robust control
- System identification
- Smart grids



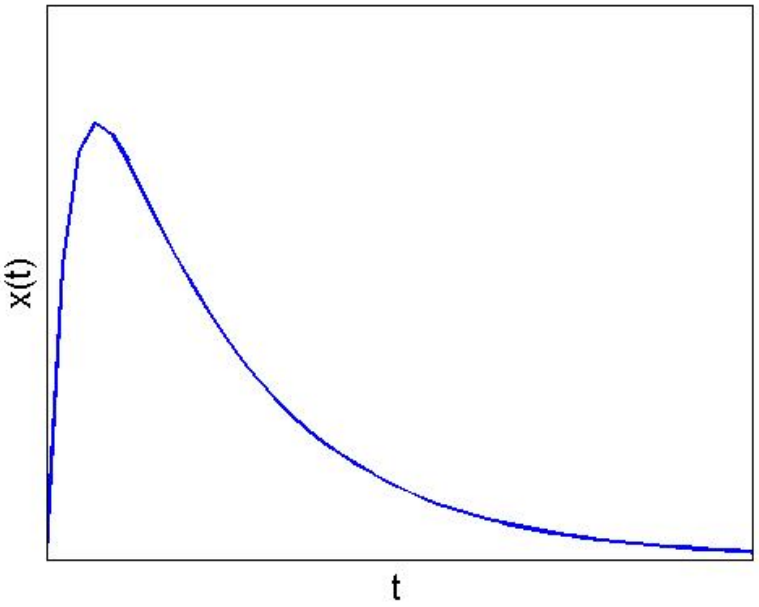
Find the differences… (1/2)

Suspension system

Queueing system

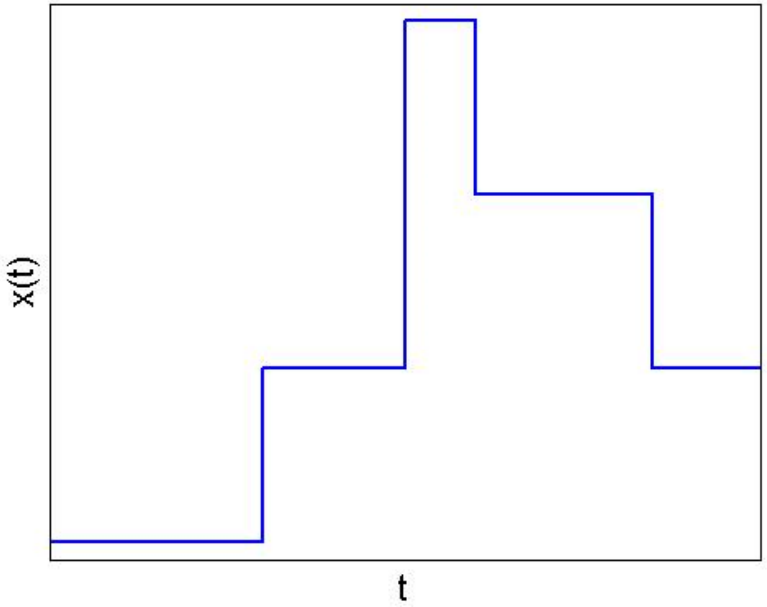
Find the differences… (2/2)

x: suspension displacement



"time-driven" dynamics

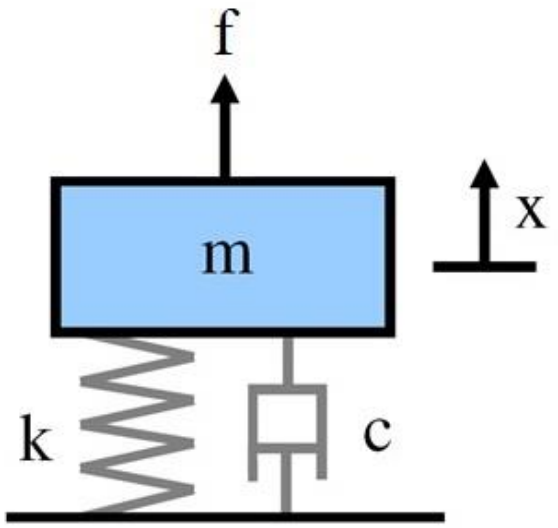
x: # of customers in the queue



"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

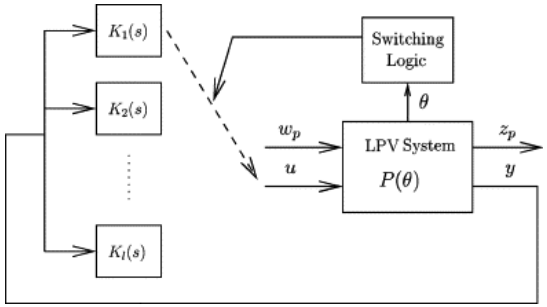
Examples of discrete event systems (2/3)

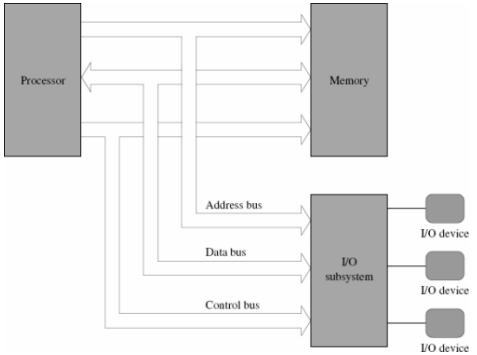
- a *switching control system* where it is possible to switch between different controllers
- an *electronic component* subject to deterioration and failures
- etc.

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

- **Students**
  - MSc Artificial Intelligence and Automation Engineering (A2) – 1st year
  - MSc Engineering Management (EM) - 1st year
- **Number of credits:** 6
- **Number of class hours:** ~ 54
- **Number of individual study hours (estimated):** ~ 150

Course schedule

Teaching period:

- From March 6, 2023 to June 15, 2023

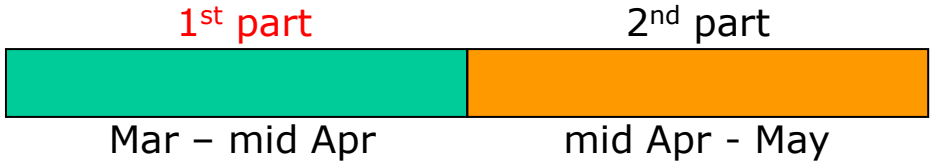
Timetable:

- Monday – from 8:30 AM to 11:45 AM (room F)
- Thursday – from 8:30 AM to 10:00 AM (room F)

Distribution:

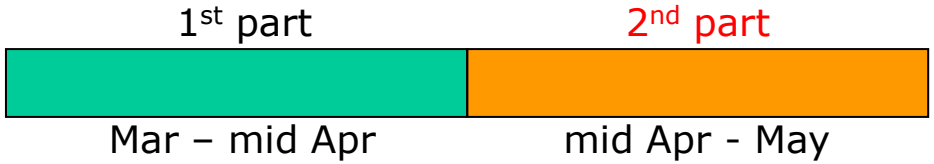
- ~ 60% lectures, ~ 40% tutorials

Syllabus (1/2)



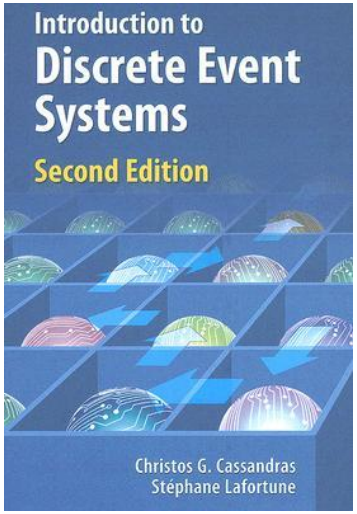
- Logical models of Discrete Event Systems (DES)
- Timed models of DES
- Stochastic timed models of DES

Syllabus (2/2)



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

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/~zanvettor/Teaching/Introductory_Course_MSc_Degrees/

➢ The contents of that course will be taken for granted

Final exam (1/3)

- The final exam can be taken in the available exam sessions
  - *2nd session*: from Jun 19, 2023 to Jul 28, 2023
  - *Recovery session:* from Sep 1, 2023 to Sep 30, 2023
  - *1st session:* to be scheduled
- It consists of three phases:
  - **Written test**
  - **Matlab project**
  - **Oral test**

Final exam (2/3)

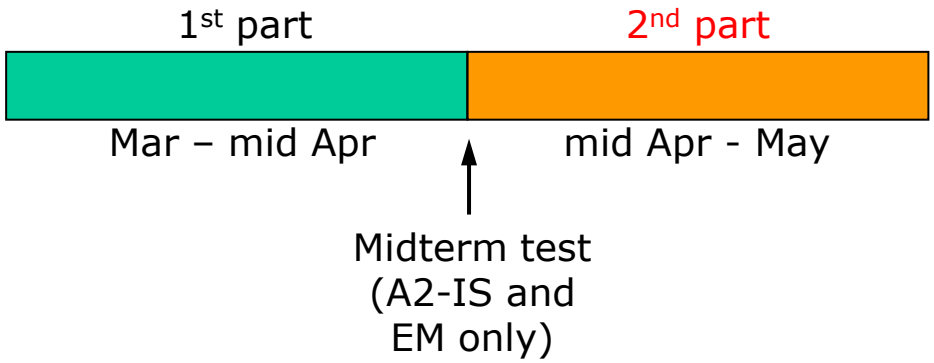
- The **written test** consists of exercises (typically two/three) on the 1st part of the course
  - Passed if the grade is ≥15 out of 30
  - Past exams are available to see how a test looks like
  - Two dates for the written test in each session
- The **Matlab project** is concerned with the topics of the 2nd part of the course
  - Assigned only to students who passed the written test
  - To be completed within one week from assignment
  - Groups can be formed

Final exam (3/3)

- The **oral test** is a broad-spectrum discussion on the topics of the course, including theory and exercises
  - Enabled only if the average grade of the written test and the project is ≥18 and both grades ≥15 (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 all the tests into account, with greater weight given to the oral test

Midterm test and project

- The written test of the final exam can be replaced with a **midterm test** which will be organized at the end of the 1st part of the course



- **Matlab project** assigned at the end of the 2nd part of the course

Web page

https://www3.diism.unisi.it/~paoletti/teaching/sed/2223/index.html

Master of Science in Engineering
Università di Siena

Discrete Event Systems

March 2023 - June 2023

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 test!
- Take advantage of office hours
  - Ask questions and feedback on exercises, clarify your doubts

Questions?