Discrete Event Systems and Supervisory Control

Course introduction

Prof. Gianmaria De Tommasi
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DIE TI. UNIVERSITA' DEGLI STUDI DI NAPOLI FEDERICO II
DIPARTIMENTO DI INGEGNERIA ELETTRICA E DELLE TECNOLOGIE DELL'INFORMAZIONE

- Course name → Discrete event systems and supervisory control
- Part of Advanced control engineering
- Included in the Automation & control engineering curricula

- Gianmaria De Tommasi
- email: detommas@unina.it
- If needed we can meet on Teams → Tue 14:30-16:30

Scope of the course

- Study of dynamic systems modelled as Discrete Event Systems (DES)

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    - nonlinear. . .
    - . . .with discrete state space. . .
    - . . .whose dynamic is driven by the occurrence of *asynchronous* events over time

Formal languages

A logical DES can be seen as a formal language *generator*

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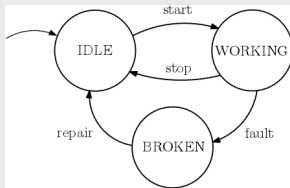
- The events that drive the system dynamic can be regarded as *letters of an alphabet E*
- The system trajectories become *words* (*strings*, *sequences*)
- The system itself can be regarded as a generator of words $\rightarrow$ a *generator* (*recognizer*) of a *formal language*
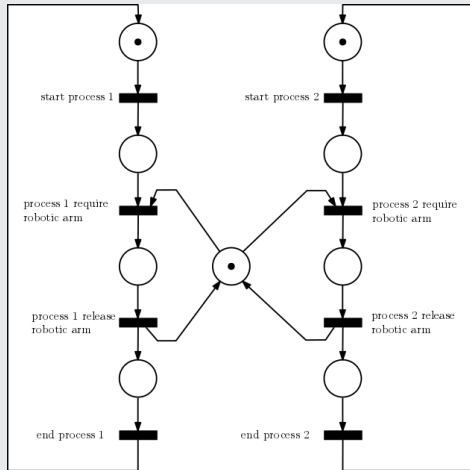
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- The system itself can be regarded as a generator of words → a *generator* (*recognizer*) of a *formal language*
- Different tools can be used to model DES at the logical level: queue systems, look-up-tables, automata, Petri nets
- Some of this tools can be also extended to study *timed* DES: timed automata and timed Petri nets, Markov chains, $(\max, +)$ algebra,...
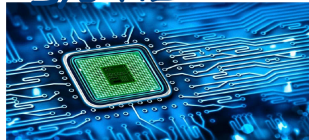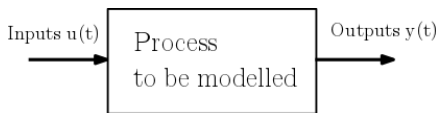
Automata

Petri nets

■ There are analysis and synthesis tasks that cannot be practically performed when dealing with large scale/complex systems, if these are modelled using differential equations (ODEs)

$$\dot{x}(t) = f(x(t), u(t), t),$$
$$y(t) = g(x(t), u(t), t).$$

Inputs u(t) → | Process to be modelled | → Outputs y(t)

Different levels of abstraction when studying dynamical systems

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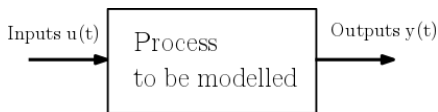
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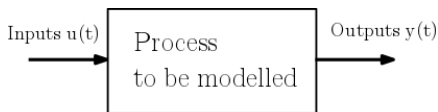
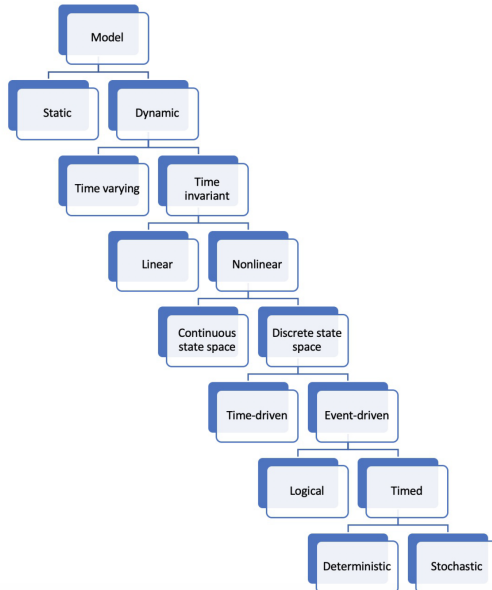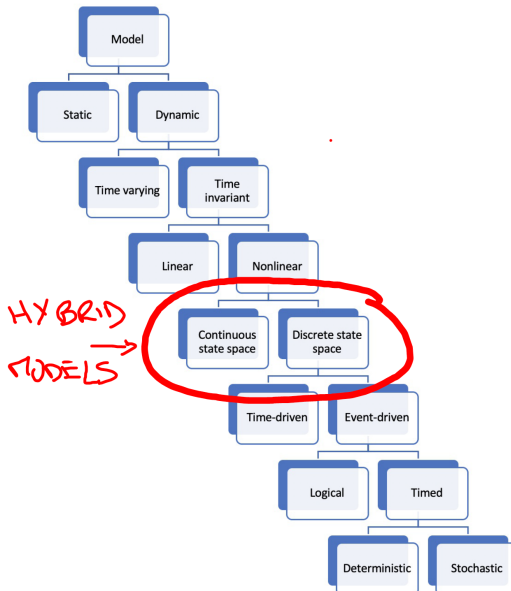$$\dot{x}(t) = f(x(t), u(t), t) ,$$
$$y(t) = g(x(t), u(t), t) .$$

Inputs $u(t)$ → Process to be modelled → Outputs $y(t)$

- The DES framework permits to move to a higher level of abstraction, where (some) physical details can be neglected
- When this is not possible some hybrid approaches are possible (both for modelling and control)

The DES research community

- Researchers in this field have different backgrounds: computer science, information theory, operations research, control & automation
- **Most of the concepts originated in the computer science community (some date back to Turing!)**
- These concepts have been brought in the control community in the 80's by Ramadge and Wonham (**Supervisory Control Theory, SCT**)
- Even earlier, in the mid 70's, Petri nets were used to derive the Grafcet programming language, which is used in PLCs (nowadays known as SFC)

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- The *jargon* adopted in this course is the one usually adopted by the *automation-oriented* researchers, as well as most of the reported results have been published on control and automation journals
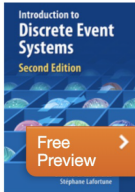
📄 W. M. Wonham, K. Cai, K. Rudie
Supervisory control of discrete-event systems: A brief history
Annual Reviews in Control, 2018

1. Introduction (**this lesson**)
2. Logic DES (deterministic & nondeterministic)
   - Languages & automata
   - Petri nets
3. Timed DES (*just some hints*)
4. Supervisory control
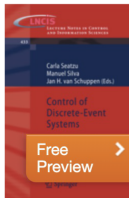5. Privacy and security in DES

Textbooks

© 2008

Introduction to Discrete Event Systems

Authors: **Cassandras**, Christos G., **Lafortune**, Stéphane

Lecture Notes in Control and Information Sciences

© 2013

Control of Discrete-Event Systems

Automata and Petri Net Perspectives

Editors: **Seatzu**, Carla, **Silva**, Manuel, **van Schuppen**, Jan H. (Eds.)

. . .and some papers :)

- Group project. . .

- Group project...
- ...to be presented/discussed during...

- Group project. . .
- . . .to be presented/discussed during. . .
- . . .Oral exam

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- A single mark will be given for Advanced control engineering

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- . . .Oral exam
- A single mark will be given for Advanced control engineering
  - Marks achieved in Discrete event systems and supervisory control and Control of complex systems and networks will be averaged

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