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ENGLISH

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STOCHASTIC MODELS (IA/0134/EN)

MS Teams code: b3dlww4

Alessandro Pilloni

Course	Curriculum	CFU	Length(h)
[70/91] INTERNET ENGINEERING	[91/00 - Ord. 2018] INGEGNERIA DELLE TECNOLOGIE PER INTERNET	5	50
[70/90] COMPUTER ENGINEERING, CYBERSECURITY AND ARTIFICIAL INTELLIGENCE	[90/00 - Ord. 2018] PERCORSO COMUNE	5	50

Lecturer

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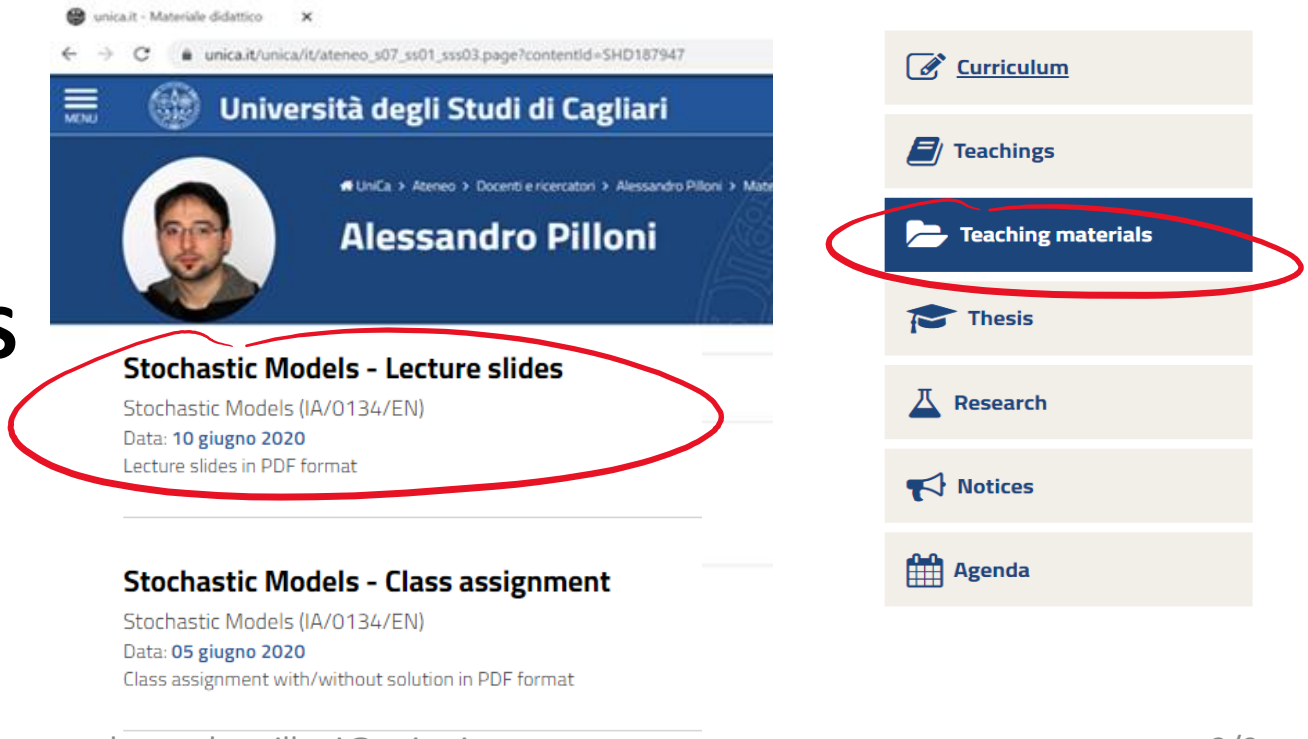
SSD: ING-INF/04

Office: Building M, 3° Floor

Reception: Appointment (TEAMS/Office)

STOCHASTIC MODELS

Tot. 50h



The course aims to…

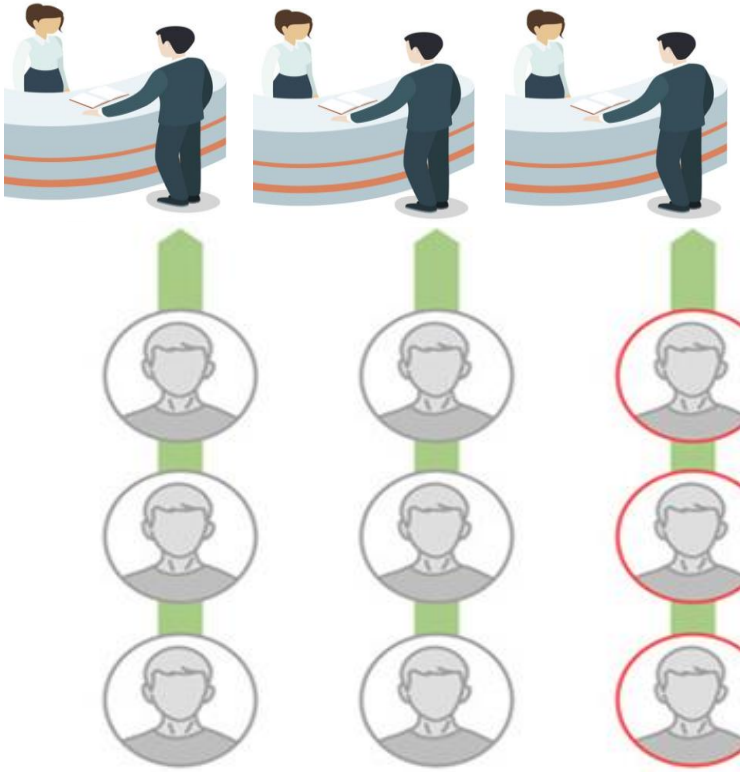
*… provide an introduction to "**stochastic models**" used in the ICT field for the **formal modelling** and **management** of **traffic, sizing** and **planning of shared resources**.*

It will provide to **YOU the "*math skills*"**

- **to understand** the **stochasticity** of "**man-made systems"**
- **to right-model applications** based of **its randomness**
- **to design/evaluate the QoS of** given **Client/Servers applications**

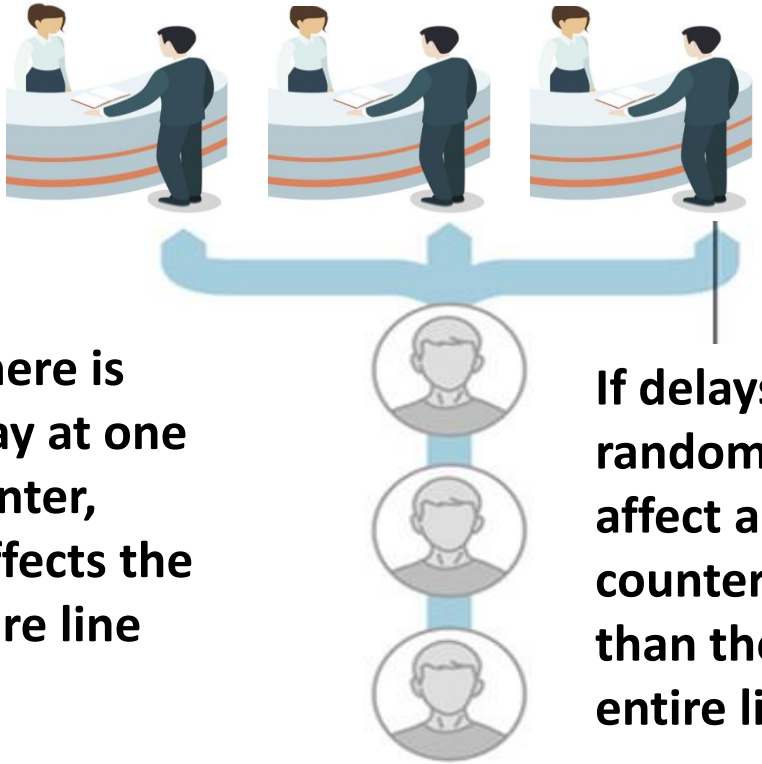
There was a time when…

3 COUNTERS / 3 LINEs



If there is delay at one counter, it affects the entire line

3 COUNTERS / 1 LINE

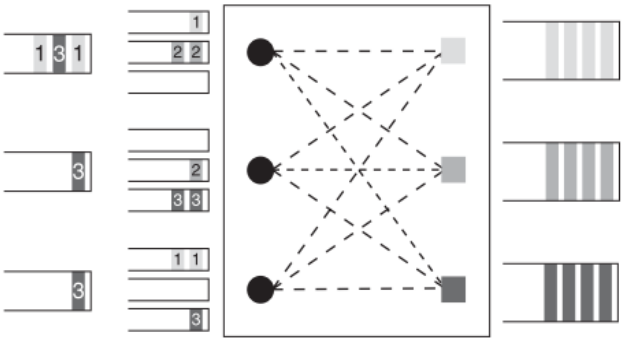


If delays are random. They affect a single counter rather than the entire line

*"**Stochastic models** and **queueing theory** helps businesses, computer networks, and others to figure out how **keep things moving…***
***…while saving money**"*

Real world applications

Switch with 3 I/O ports and 3 channels



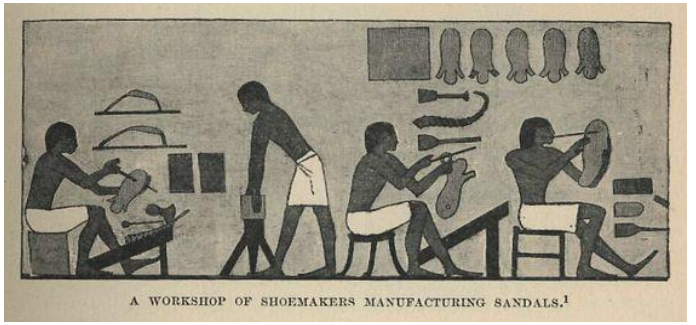
ICT systems

Packet queues enable modules to communicate asynchronously, have the side affect of impacting latency and the QoS.

- EX: dimensioning of links bandwidth, TDMA, CSMA, Client-Server systems etc..

Industrial and Manufacturing Systems

- EX: Systems where pieces to be produced pass through several working stations.


A WORKSHOP OF SHOEMAKERS MANUFACTURING SANDALS.[1]

Transportation and Logistics Management

- EX: Logistic systems of cargo ships, vehicles at toll station, traffic lights, etc…

Commercial and social service systems

- EX: Waiting lists for organ transplants, market queues, etc…

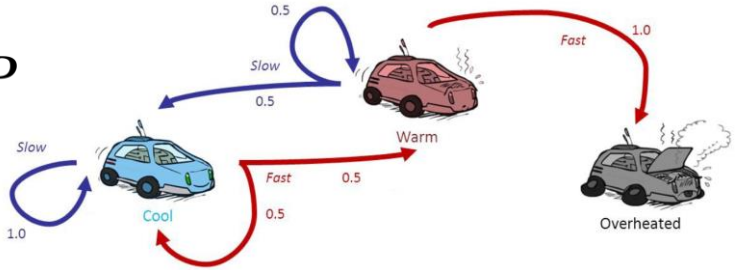
Contents

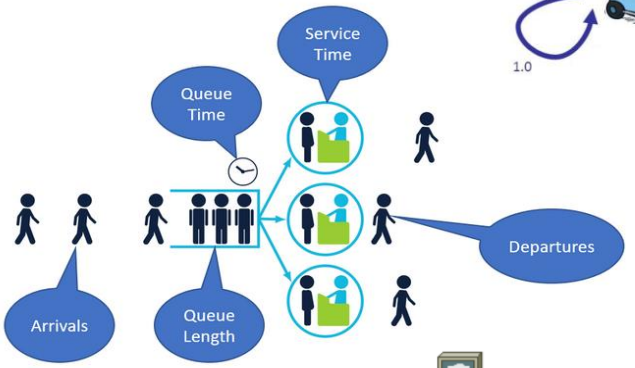
- Main modules (≈34h):
  - Probability Theory (12h)
  - Stochastic processes (4h)
  - Markov chains (7h)
  - Queuing theory (7h)
  - Queueing networks (4h)
- Classroom exercises (14/16h)

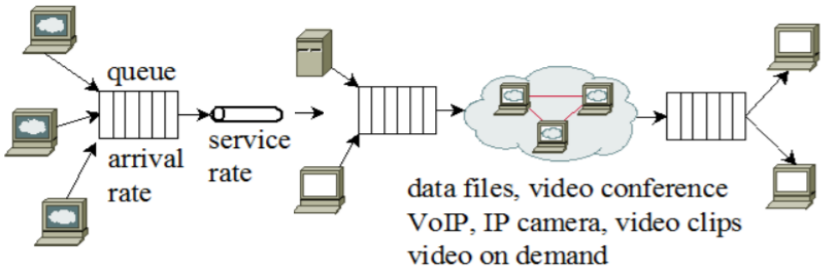
Tot. 50h

$$\{X_t, t = 0,1,2,\ldots\} = \{H,T,T,H,T,\ldots\}$$

$$\pi(k+1) = \pi(k) \cdot P$$



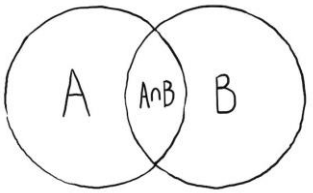




Prerequisites

Basic concepts of mathematics:

- Algebra and Set theory



- Differential and Integral calculus

Basic concepts of System Theory

- LTI systems $\frac{d\pi(t)}{dt} = \pi(t) \cdot \boldsymbol{Q}$ $\pi_i(t) = \Pr(X_t = i)$

Probability the experiment a time "t" takes value "i"

- Laplace's transformation

$$\boldsymbol{\Pi}(s) = \boldsymbol{\mathcal{L}}\{\pi(t)\} = \pi(0)\,(s \cdot \boldsymbol{I} - \boldsymbol{Q})^{-1}$$

$$\pi(t) = \boldsymbol{\mathcal{L}}^{-1}\{\boldsymbol{\Pi}(s)\} = \sum_{i=1}^{n} \boldsymbol{\mathcal{L}}^{-1}\left\{\frac{R_i}{(s - p_i)}\right\}$$

Exam's organization and mark

The final examination is **ORAL**, and lasts **≈1h/1.5h**. It **begins** by

- Asking the candidate to present a **topic of his/her choice** among the main ones of the course (**≈15 min of presentation**)
- Then, **the exam will continue by asking** s/he:
    - to answer other related questions
    - to solve exercises like those seen in the course

The **final marks** accounts:

- The **knowledge** of the topics of the course (**30%**)
- The **consciousness** to approach the solution of problems (**30%**)
- The **autonomy in making judgments** (**30%**)
- The **use of technical language** (**10%**)