

Performance Modeling of Computer Systems and Networks

Prof. Vittoria de Nitto Personè

Università degli studi di Roma Tor Vergata
Department of Civil Engineering and Computer Science Engineering

Copyright © Vittoria de Nitto Personè, 2021
<https://creativecommons.org/licenses/by-nc-nd/4.0/>



1

Course information

- Hours
 - Tuesday 9:30 – 11:15 lecture room A2
 - Wednesday 14:00 – 15:45 lecture room A2
 - Thursday 14:00 – 15:45 lecture room A2
- Teacher: Prof. Vittoria de Nitto Personè
 - Office: building Ingegneria dell' Informazione, Dipartimento di Ingegneria Civile e Ingegneria Informatica, (D body), room 16 (1rd floor)
 - e-mail: denitto@ing.uniroma2.it
 - Office hours: Friday 15:00 – 16:30
- Assistant teacher: ???

Prof. Vittoria de Nitto Personè

2

2

Web site

<http://didattica.uniroma2.it>

Course registration and exams registration by Delphi:

<https://delphi.uniroma2.it/totem/jsp/index.jsp>

within 31 Maggio 2021

Prof. Vittoria de Nitto Personè

3

3

Introduction and overview

Terminology

- **System:** a collection of hw and sw resources
- **Metrics:** “criteria” to compare the system performance
 - e.g. *response time* (time to complete a request/job/task)
 - throughput* (system “productivity” per time unit)
- **Workload:** requests submitted by users to the system
 - e.g. CPU instructions
 - DB queries
- **Techniques:** measurements, simulation and analytical models

Prof. Vittoria de Nitto Personè

4

4

The importance of Performance Modeling

Prof. Vittoria de Nitto Personè

5

5

Googledown, 14 Dic. 2020



February 26, 2021 All services available

Google Cloud Status Dashboard > Incidents > Google Cloud Infrastructure Components

Google Cloud Status Dashboard

This page provides status information on the services that are part of Google Cloud Platform. Check below. If you are experiencing an issue not listed here, please [contact Support](#). Learn more about information on these services, please visit [cloud.google.com](#).

Google Cloud Infrastructure Components Incident #20013

Google Cloud services are experiencing issues and we have an other update at 5:30 PDT

Incident began at **2020-12-14 04:07** and ended at **2020-12-14 06:23** (all times are **US/Pacific**).

DATE	TIME	DESCRIPTION
Dec 22, 2020	16:49	The following is a correction to the previously posted ISSUE SUMMARY amendment. All services that require sign-in via a Google Account Cloud service accounts experienced elevated error rates on request oauth2.googleapis.com. Impact varied based on the Cloud Service impacted and have further questions.

- h 2:15 down su scala mondiale, didattica a distanza e smart working bloccati
- blocco di qualsiasi servizio per l'accesso tramite autenticazione (Gmail, Drive, Meet, Classroom, ...)
- capacità ridotta del sistema centrale di gestione delle identità e di autenticazione di Google

Prof. Vittoria de Nitto Personè

6

6

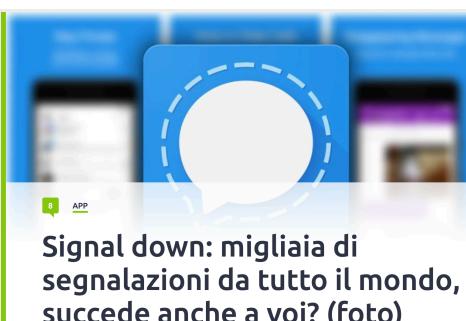
Cashback IO PagoPA, 7-10 Dic. 2020

- milioni di download e di accessi, sino a 14000/s autenticazione molto lenta, troppe richieste in attesa fino a saturare le porte disponibili
- blocco nell'inserimento dei metodi di pagamento, crollo servizio di push dovuto a lentezza autenticazione
- collo di bottiglia nell'autenticazione, gestione non appropriata delle richieste

Prof. Vittoria de Nitto Personè

7

7

Signal, 16 Gen. 2021

A two-word app recommendation from **Elon Musk** has turned into a massive rally in the shares of a tiny medical device company in another case of mistaken identity. "Use **Signal**," the Tesla Inc. chief executive officer wrote on **Twitter** on Jan. 7, apparently referring to the encrypted messaging service. 12 gen 2021

- aumento improvviso downloads di Signal di circa 4200% in una settimana
- primo rallentamento del servizio ed una successiva parziale interruzione dello stesso
- replica del back-end di Signal su altri server



Prof. Vittoria de Nitto Personè

8

8

Dazn
18 Ago. 2018 - Ott./Nov. 2018

INPS - Bonus COVID-19
1 Aprile 2020

Amazon
25 Nov. 2020

Bonus Mobilità
3-6 Nov. 2020
14-15 Gen. 2021

Prof. Vittoria de Nitto Personè

9

9

Introduction and overview

Performance evaluation

Today's computer systems are more complex
 more rapidly evolving
 more essential for business
 of even a few years ago.

Increasing need for tools and techniques that assist in
 understanding the behavior of these systems

- during design and implementation
- during sizing and acquisition
- during evolution of the configuration and workload (upgrade)

administrators, designers, ...

*Background and skills on
 performance evaluation
 techniques*

Prof. Vittoria de Nitto Personè

10

10

Introduction and overview

Performance evaluation

- | | |
|--|--|
| In academic research → | To prove the value of a new idea |
| In industry → | To maintain a high level of performance across the lifetime of a product |
| <p>ex. <i>Cloud services</i> promise (SLA) to maintain particular perf levels (QoS):
 <i>Service providers</i> must be able to detect when perf drops below acceptable levels and quickly identify and fix the problem</p> | |

Always Measure One Level Deeper
 John Ousterhout
Communications of the ACM, July 2018, vol.61,n.7

Prof. Vittoria de Nitto Personè

11

11

Introduction and overview

Performance evaluation

A **good** PE provides a deep understanding of a system's behavior

- why the system behaves the way it does
- what limits that behavior
- what problems must be addressed in order to improve the system

Done well, PE exposes interesting system properties that were not obvious previously

Prof. Vittoria de Nitto Personè

12

12

Introduction and overview

Performance evaluation goals

- Determine the number and the size of system components (capacity planning)

The diagram illustrates the architecture of the City of Pisa network. It features a central demilitarized zone (DMZ) connected to the Internet and various internal networks. Key components include:

- RETE DEMILITARIZZATA (Rete 1 G)**: A central hub connecting multiple segments.
- RETE INTERNA (Rete 2)**: Internal network segments connected via switches and routers.
- RETE ESTERNA (Rete 3)**: External connections to the Internet, Rete Telematica Regionale Toscana, and other entities.
- Firewalls**: Located at the boundaries of the DMZ and between internal and external networks.
- Switches**: Used for internal network segmentation and connectivity.
- Routers**: Managing traffic between different network segments.
- Modems**: Providing access to external networks like C.R.I. and C.P.R.
- System Units**: Various computer systems and databases (e.g., Sistemi di Immagine di back-up, Server rete civica di back-up, Sistemi di gestione della documentazione).
- Services**: Tele-diagnostics, Circoscrizioni - anagrafe, Enti Esterni - anagrafe, Email, Accesso siti d'interesse, Enti Professionisti, Associazioni, Collegamenti da data, Punti d'accesso pubblici.

Aut. Dott Franco Chiesi, Rete Comune di Pisa "freewall" 5 gennaio, Harvard OpenVox (0.9.06)

Prof. Vittoria de Nitto Personè
<https://www.comune.pisa.it/doc/forumpa/pisa.html>

13

13

Introduction and overview

Performance evaluation goals

- Determine the optimal value of a system parameter (system tuning)
- Determine the performance “bottleneck” (bottleneck identification)

The diagram shows a complex network architecture for mobile communication, likely a Short Message Service (SMS) system. Key components include:

- Web Client** connected to an **IIS Web Server**.
- POP3 Server** connected to a **POP3 SMS Gateway**.
- SMS Database Service** (highlighted with a red circle).
- SMTP Server** connected to a **Modern GSM** module.
- SMS Service** and **SMS Web Service** connected to the **SMS Database Service**.
- SMS Client Manager** and **SMS Client** connected to the **SMS Database Service**.
- Anagrafiche e rubriche aziendali** (Business contacts and address books) connected to the **SMS Database Service**.
- Applazioni di terze parti** (Third-party applications) connected to the **SMS Database Service**.

Prof. Vittoria de Nitto Personè

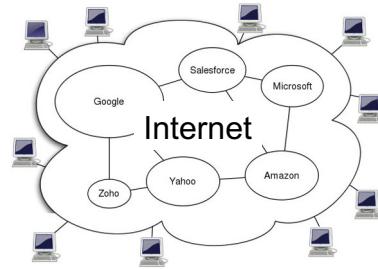
14

14

Introduction and overview

Performance evaluation goals

- Characterize the system workload
(workload characterization)



Prof. Vittoria de Nitto Personè

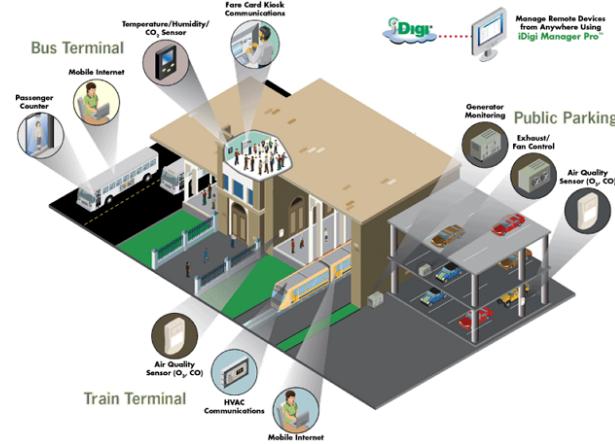
15

15

Introduction and overview

Performance evaluation goals

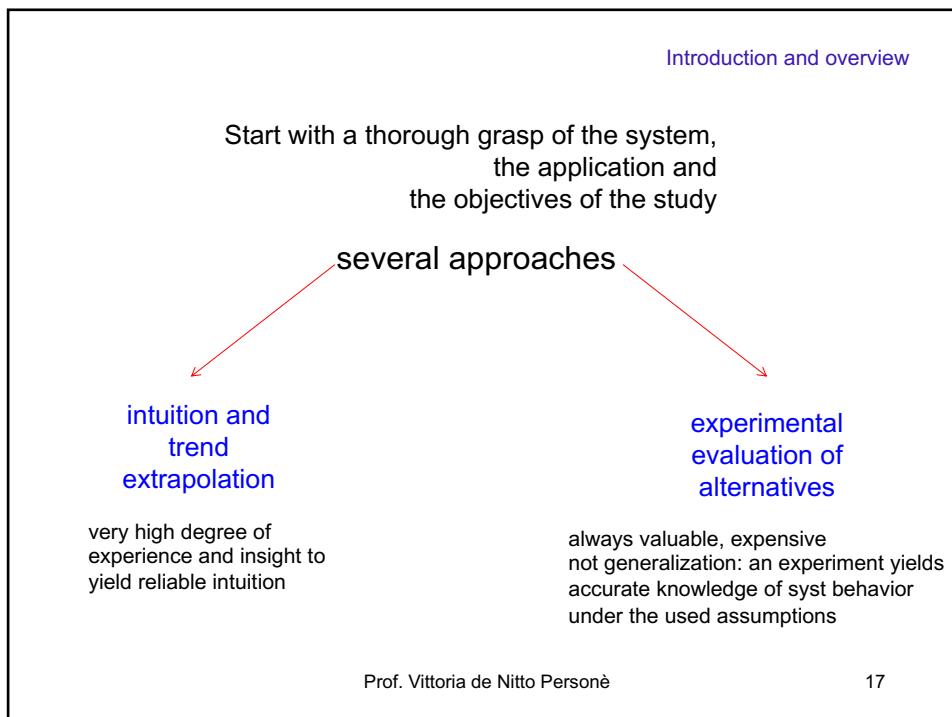
- Performance forecasting as the workload increases
(forecasting)



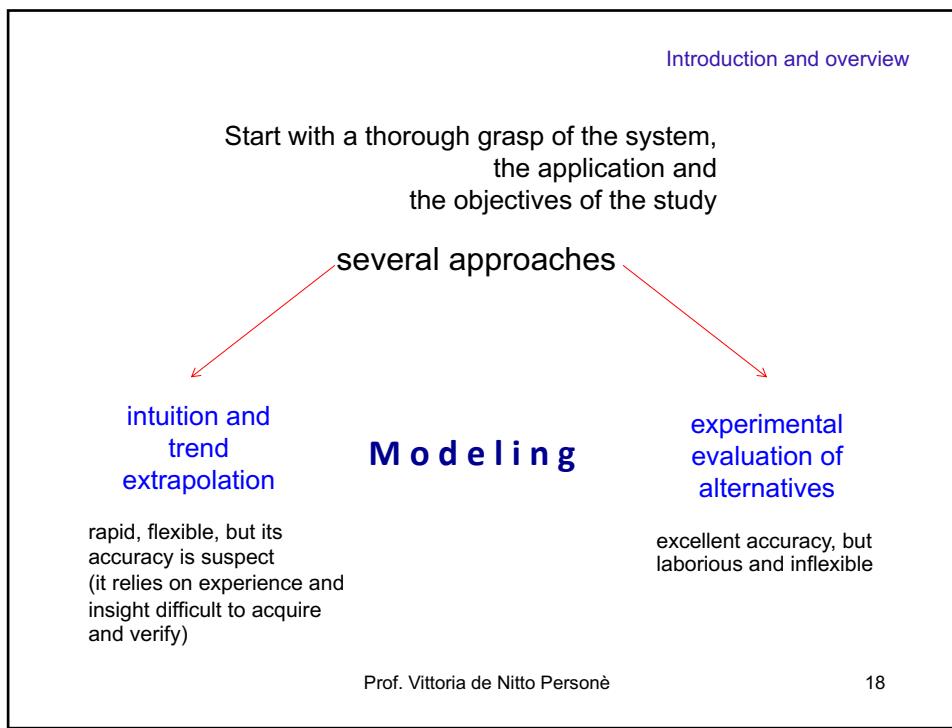
Prof. Vittoria de Nitto Personè

16

16



17



18

Introduction and overview

M o d e l i n g

A model is an abstraction of a system:

an attempt to distill, from the mass of details that is the *system* itself, exactly those aspects that are essential to the system's *behavior*

defined → through the abstraction process

parameterized → to reflect any of the alternatives under study

evaluated → to determine system behavior

Prof. Vittoria de Nitto Personè

19

19

Introduction and overview

intuition and
trend extrapolation

more reliable M o d e l i n g

experimental
evaluation of
alternatives

less laborious and
more flexible

Prof. Vittoria de Nitto Personè

20

20

10

Performance evaluation techniques

Computational and mathematical techniques to *model*, *simulate* and *analyze* the performance of *stochastic systems*

```

graph TD
    Modeling[Modeling: conceptual framework  
describing a system] --> solution[solution]
    measurement[measure  
ment] --> solution
    analytical[analytical techniques] --> solution
    simulate[simulate: perform experiments using  
computer implementation  
of the model] --> solution
    analyze[analyze: draw conclusions from output] --> solution
  
```

Prof. Vittoria de Nitto Personè 21

21

Introduction and overview

Three Rules of Validation

- ❑ Do not trust the results of a **simulation model** until they have been validated by analytical modeling or measurements.
- ❑ Do not trust the results of an **analytical model** until they have been validated by a simulation model or measurements.
- ❑ Do not trust the results of a **measurement** until they have been validated by simulation or analytical modeling.

©2006 Raj Jain www.raj Jain.com

Prof. Vittoria de Nitto Personè 22

22

Course programme

- Introduction to modelling:
performance evaluation and modelling techniques
- Queueing systems
 - Single and multi resources systems
- Analytical models:
 - Basic results
 - The Operational approach
 - Product Forms, Markov processes
- Simulation models:
 - trace driven, event driven, next event
 - Statistical methods for output analysis
- Applications:
 - Server Farms
 - Wireless Networks and Internet applications
 - Resource allocation
 - QoS management

Prof. Vittoria de Nitto Personè

23

23

Reference Books

M. Harchol-Balter

Performance Modeling and Design of Computer Systems

Cambridge, University Press, 2013

- Caps. 1, 2, 6, 7, 8, par. 10.1, 10.2, 11, 12, 13, 14, 15, 16, 17, 19, 20, 22, 23, 24, 28, 29, 30, 31, 32, 33

Lawrence M. Leemis, Stephen K. Park

Discrete-Event Simulation - A first course,

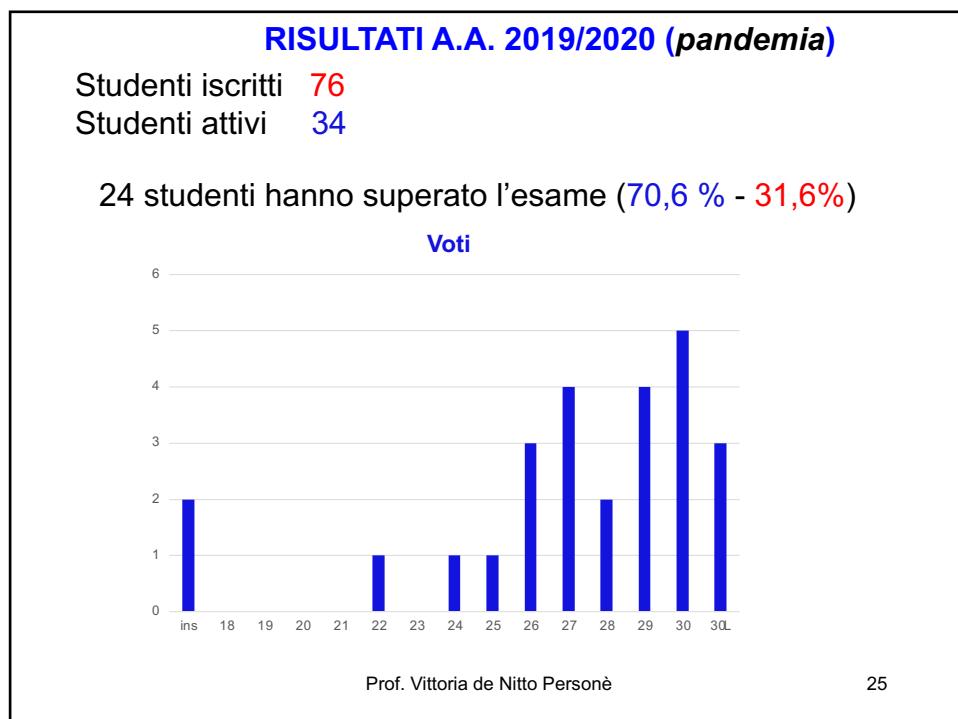
Pearson Education Prentice Hall, 2006.

- Cap. 1
- Cap. 2: par. 2.1, 2.2
- Cap. 3
- Cap. 4
- Cap. 5: par. 5.1, 5.2
- Cap. 6: par. 6.1, 6.2, 6.3, 6.4
- Cap. 7: par. 7.1, 7.2, 7.3, 7.4
- Cap. 8: par. 8.1, 8.3, 8.4
- Cap. 10: par. 10.1

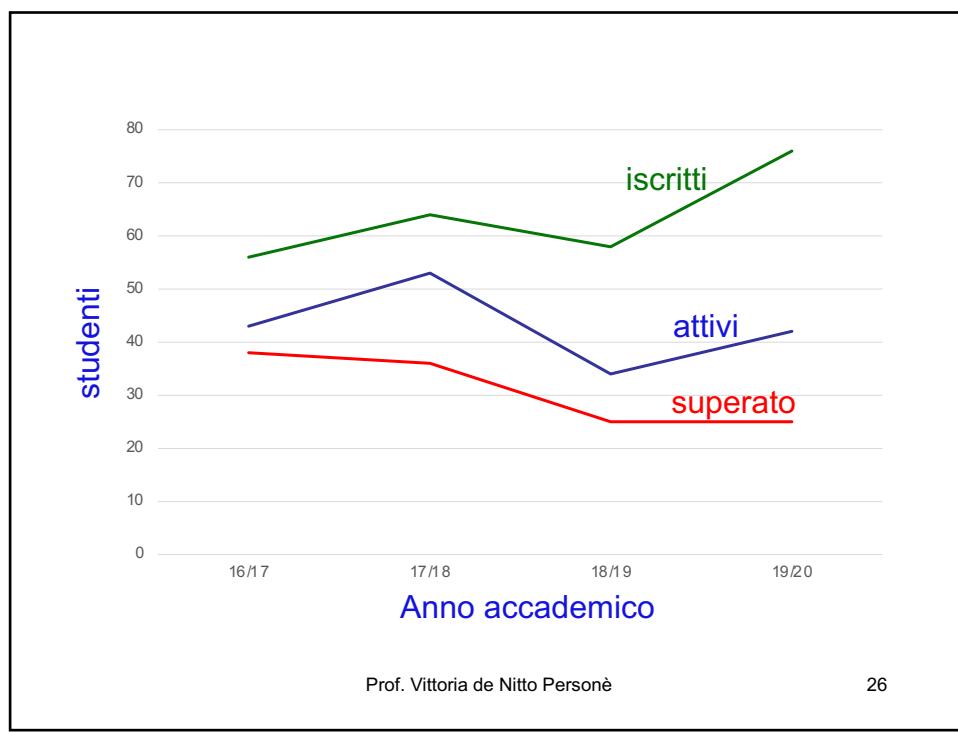
Prof. Vittoria de Nitto Personè

24

24



25



26

Modalità di esame

Performance Modeling of Computer Systems and Networks
A.A. 2020 / 2021

Per sostenere l'esame occorre essere **iscritti al corso**.

L'esame è composto da una **prova individuale scritta**, una **prova progettuale** preferibilmente di gruppo ed un **esame orale**.

Il gruppo può essere composto da un massimo di tre persone. Gli studenti che intendono **costituire un gruppo** devono darne comunicazione al docente (via **email**).

Prof. Vittoria de Nitto Personè

27

27

Modalità di esame Progetto

Performance Modeling of Computer Systems and Networks
A.A. 2020 / 2021

Il progetto sarà disponibile a conclusione del corso.

Il docente pubblicherà il testo del progetto sul sito del corso.

Il progetto completato dovrà essere consegnato al docente, per **email**, **entro la data** indicata nella prenotazione **dell'esame orale** a cui si intende partecipare.

Durante il corso, il docente potrebbe indicare una prima parte della prova progettuale che verrà consegnata con il progetto finale.

La prova progettuale ha validità per l'**intero A.A.**

Prof. Vittoria de Nitto Personè

28

28

**Modalità di esame
Scritto**

Performance Modeling of Computer Systems and Networks
A.A. 2020 / 2021

E' a discrezione del docente concedere la possibilità di ripetere la prova al II appello di una sessione, nel caso in cui lo studente abbia ottenuto un risultato insufficiente al I appello della stessa.

La **prova scritta** ha validità per due sessioni consecutive.

Lo studente che desideri migliorare il risultato della prova scritta, può ripetere la prova ad un appello successivo rinunciando al risultato già conseguito.

Prof. Vittoria de Nitto Personè

29

**Modalità di esame
Orale**

Performance Modeling of Computer Systems and Networks
A.A. 2020 / 2021

Per sostenere la prova orale, occorre aver superato la prova scritta.

Gli studenti appartenenti ad uno stesso gruppo, sosterranno l'orale nella stessa data.

Il voto conseguito con la **prova scritta** contribuisce per 1/2 al voto finale. Il voto conseguito con la **prova orale** contribuisce per 1/2 al voto finale.

Prof. Vittoria de Nitto Personè

30

30

Per superare l'esame

Performance Modeling of Computer Systems and Networks

1. Seguire il corso con impegno
2. Studiare sui libri/articoli
3. Non affrontare il progetto prima di aver assimilato la materia
4. Leggere con attenzione
5. Riflettere prima di risolvere
6. Rispettare le regole
 - Iscrizione al corso e all'esame entro i termini
 - Consegnare progetto entro i termini
 - Modalità di consegna

Prof. Vittoria de Nitto Personè

31