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

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Course information

- Hours
  - Tuesday 14:00 – 15:45 lecture room B9
  - Thursday 9:30 – 11:15 lecture room B10
  - Friday 11:30 – 13:15 lecture room B5
- 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: Wednesday 15:00 – 16:30
- Assistant teacher: ???

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Web site

http://didattica.uniroma2.it

Course registration and exams registration by Delphi:

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

within 31 Marzo 2022

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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

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The importance of Performance Modeling

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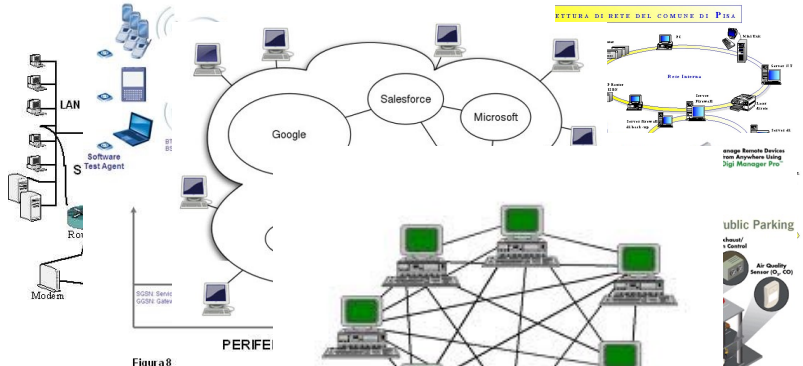
Office automation

Internet

Public networks



Mobile networks

Data centers
Server farm

- websites
- computing center
- call center
- …

Wireless network for transit systems

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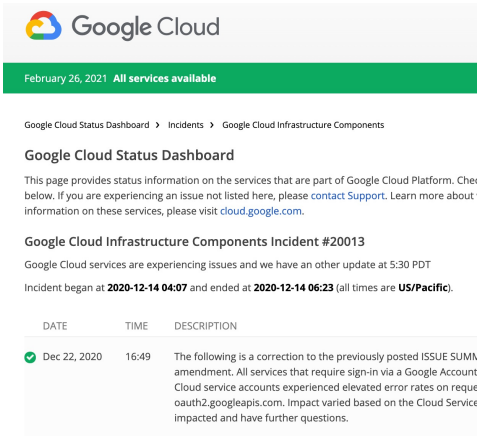
Googledown, 14 Dic. 2020

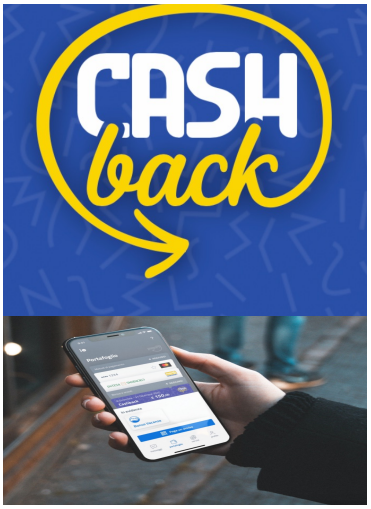
https://status.cloud.google.com/incident/zall/20013



- 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

Cashback IO PagoPA, 7-10 Dic. 2020

https://medium.com/pagopa-spa/cashback-retrospettiva-su-un-avvio-sfidante-con-lo-sguardo-rivolto-al-futuro-206cb609e4bb



- 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

Signal, 16 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

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

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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

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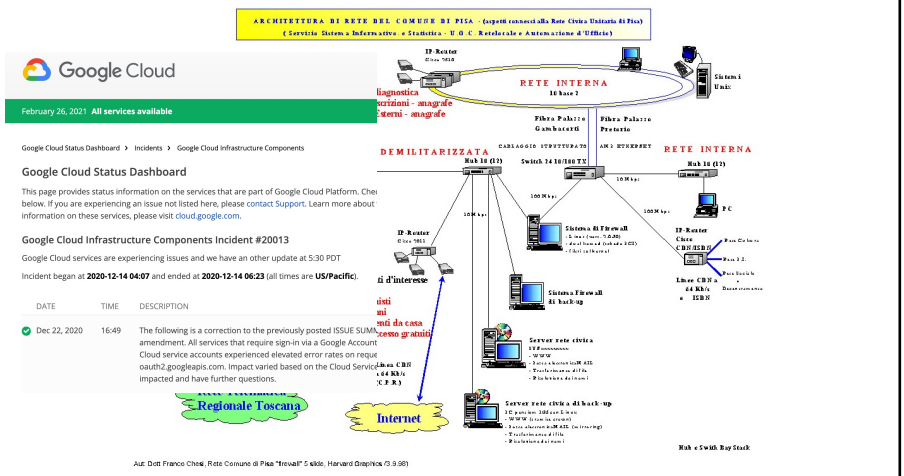
Performance evaluation goals

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

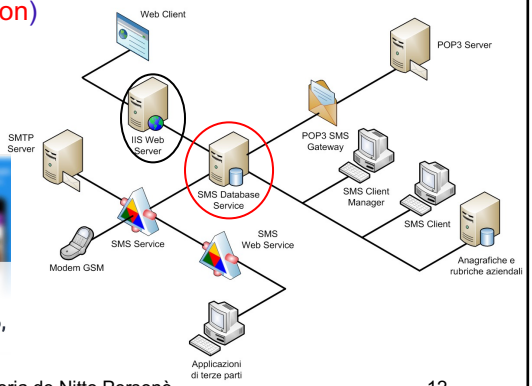


Aut. Dott Franco Chesi, Rete Comune di Pisa "firewall" 5 slide, Harvard GraphNet /3.9.98)

https://www.comune.pisa.it/doc/forumpa/pisa.html

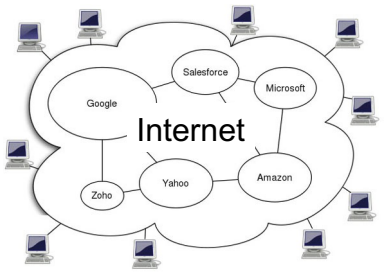
Performance evaluation goals

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



Performance evaluation goals

- Characterize the system workload
  (workload characterization)



Performance evaluation goals

- Characterize the system workload
  (workload characterization)

Self-Similarity in High-Speed Packet Traffic: Analysis and Modeling of Ethernet Traffic Measurements
Walter Willinger, Murad S. Taqqu, Will E. Leland and Daniel V. Wilson
Statistical Science, Vol. 10, No. 1 (Feb., 1995), pp. 67-85
https://www.jstor.org/stable/2246232

Self-similarity through high-variability: statistical analysis of ethernet LAN traffic at the source level
Walter Willinger (Bellcore), Murad S. Taqqu (Boston University), Robert Sherman (Bellcore)
and Daniel V. Wilson (Bellcore)
SIGCOMM '95: Proceedings of the conference on Applications, technologies, architectures, and protocols for computer communication October 1995 Pages 100–113,
https://doi.org/10.1145/217382.217418

Self-Similarity in World Wide Web Traffic: Evidence and Possible Causes
Mark E. Crovella and Azer Bestavros, Computer Science Department, Boston University
Methodology and Computing in Applied Probability, Vol 1 No. 1 (1999)

Self-Similarity in Social Network Dynamics
ACM Transactions on Modeling and Performance Evaluation of Computing SystemsVolume 2 Issue 1
March 2017 Article No.: 5pp 1–26 https://doi.org/10.1145/2994142

Performance evaluation goals

- Performance forecasting as the workload increases (forecasting)

Performance evaluation

Today's computer systems are
- more complex
- more rapidly evolving
- more essential for business and social life

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

Performance evaluation

In academic research → To prove the value of a new idea

In industry, services → To maintain a high level of performance across the lifetime of a product

For example, cloud services promise to maintain particular perf levels; service providers must thus be able to detect when perf drops below acceptable levels and quickly identify and fix the problem

Performance evaluation is rarely taught in computer science classes

As a result, performance measurement is often done poorly, even by experienced developers

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

Performance evaluation

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

- why the systems 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

Start with a thorough grasp of the system,
the application and
the objectives of the study

several approaches

intuition and trend extrapolation

very high degree of experience and insight to yield reliable intuition

experimental evaluation of alternatives

always valuable, expensive
not generalization: an experiment yields accurate knowledge of syst behavior under the used assumptions

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Start with a thorough grasp of the system,
the application and
the objectives of the study

several approaches

intuition and trend extrapolation

rapid, flexible, but its accuracy is suspect
(it relies on experience and insight difficult to acquire and verify)

Modeling

experimental evaluation of alternatives

excellent accuracy, but laborious and inflexible

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Modeling

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 riflect any of the alternatives under study

evaluated → to determine system behavior

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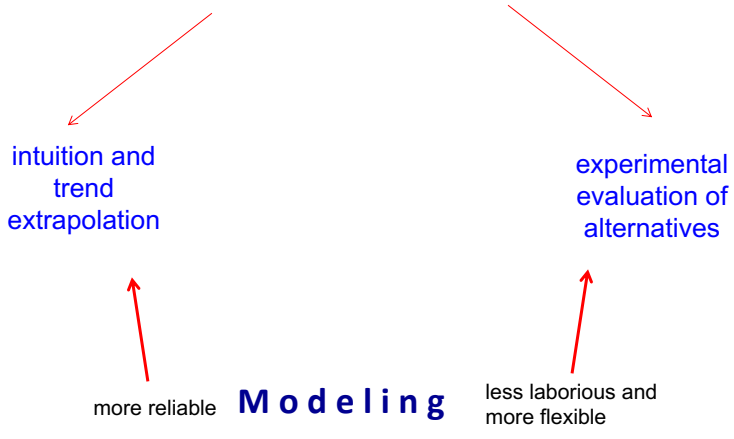

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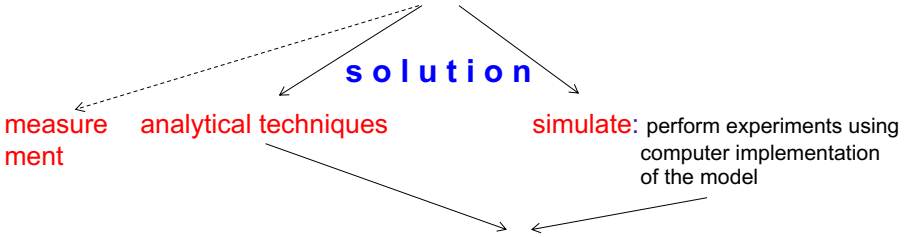
Performance evaluation techniques

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

Modeling: conceptual framework describing a system



analyze: draw conclusions from output

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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

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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, Sthephen 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*

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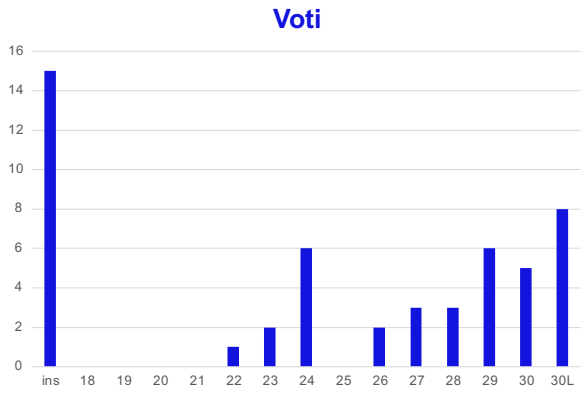
RISULTATI A.A. 2020/2021 (*semi-pandemia*)

Studenti iscritti 72
Studenti attivi 47

36 studenti hanno superato l'esame (77 % - 50%)



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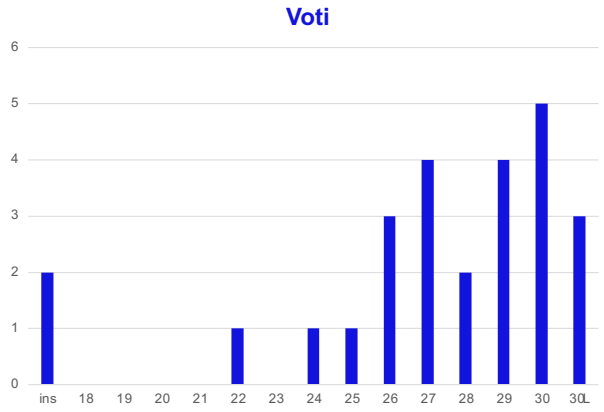
RISULTATI A.A. 2019/2020 (*pandemia*)

Studenti iscritti 76
Studenti attivi 33

24 studenti hanno superato l'esame (72,7 % - 31,6%)



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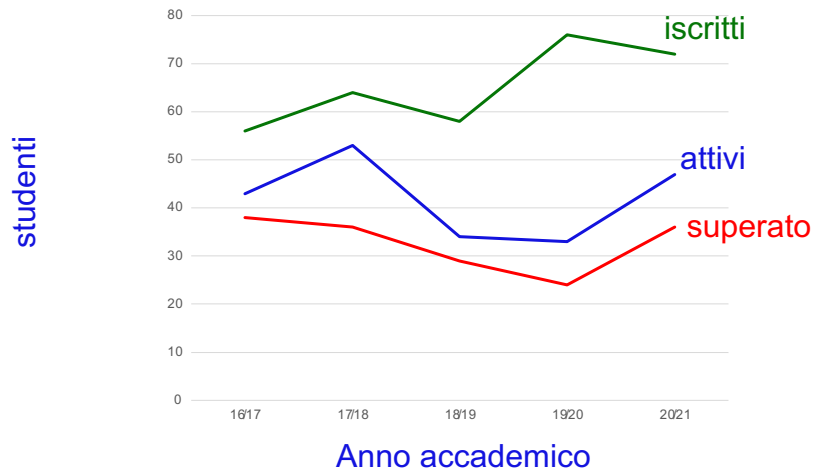

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Modalità di esame

Performance Modeling of Computer Systems and Networks

A.A. 2021 / 2022

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).

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Modalità di esame
Progetto

Performance Modeling of Computer Systems and Networks

A.A. 2021 / 2022

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..

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Modalità di esame

Scritto

Performance Modeling of Computer Systems and Networks

A.A. 2021 / 2022

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.

Modalità di esame

Orale

Performance Modeling of Computer Systems and Networks

A.A. 2021 / 2022

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.

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
   - Consegna progetto entro i termini