Performance Evaluation of Computer Systems

Jean-Marc Vincent and Arnaud Legrand [1]

[1] POLARIS Project
Laboratory of Informatics of Grenoble (LIG)
Université Grenoble-Alpes
{Jean-Marc.Vincent,Arnaud.Legrand}@imag.fr
https://team.inria.fr/polaris/
http://mescal.imag.fr/membres/arnaud.legrand/teaching/2016/

2016

Outline

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1. Scientific context
2. Methodology
3. Performance indexes

Research activities in performance evaluation

Teams in Grenoble

- Polaris project : Large systems (clusters and grids)
- DataMove project : Interactive parallel systems
- Drakkar team : Networking
- Erods (Sardes) : Middleware
- Verimag : Embedded systems
- etc

Industrial collaborations

- Orange-Lab : load injectors, performances of middlewares
- HP-Labs : cluster computing, benchmarking
- Bull : benchmarking, performances analysis
- ST-Microelectronics

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Application context (1)

Complexity of computer systems

- **hierarchy** : level decomposition : OS / Middleware / Application
- **distribution** : asynchronous resources : memory, CPU, network
- **dynamicity** : architecture and environment (reliability, mobility,...)
- **scalability** : number of components (autonomous management)

Typical problems

- Minimize losses in routing policies
- Minimize active waiting in threads scheduling
- Maximize cache hits
- Optimise block sizes in parallel applications
- Maximize troughput of communication systems
- Fix time-outs, reemission periods, ...
- Fix the granularity : pages, blocks, tables, message sizes...
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Application context (2)

Typical “hot” applications

- **Peer to peer systems** : dimensionning, control
- **Mobile networks** : ad-hoc networking, reactivity, coherence
- **Grids** : resources utilization, scheduling
- etc

Other application domains

- production systems : production lines, logistic,...
- embedded systems
- modelling of complex systems : biology, sociology,...
- etc

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Development of parallel/distributed aplications

Qualitative specifications : Is the result correct ?

- property verification : formal/automatic proofs
- testing : critical dataset

Quantitative specifications: Is the result obtained in an reasonable time ?

- performance model
- performance measurements

Problem identification: localization of the problem

- debugging, log analysis
- performance statistical analysis

Modification and control

- source code / libraries / OS / architecture
- parameters of the system : dimensioning
- control algorithms : tuning

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Dual analysis

Understand the behavior of a distributed application

1. identification of distributed patterns, states of the system
2. pattern verification
3. time evaluation
4. global analysis of the execution and performance synthesis
5. system monitoring
6. global cost evaluation for the application user

Understand resources utilization

1. hierarchical model of resources
2. evaluation of utilization at :
   application level; executive runtime;
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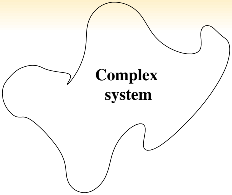

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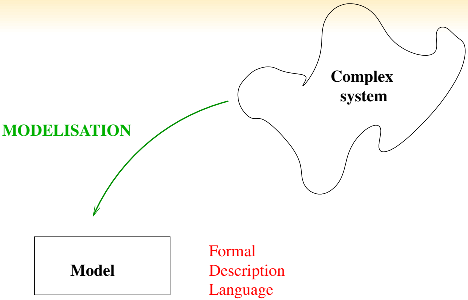

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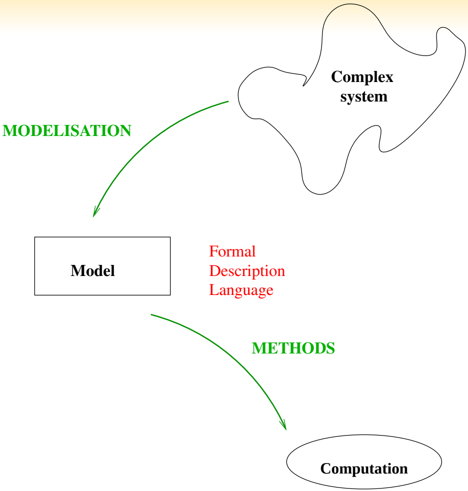

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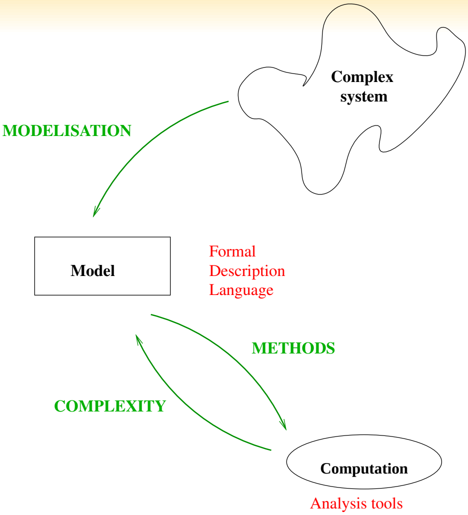

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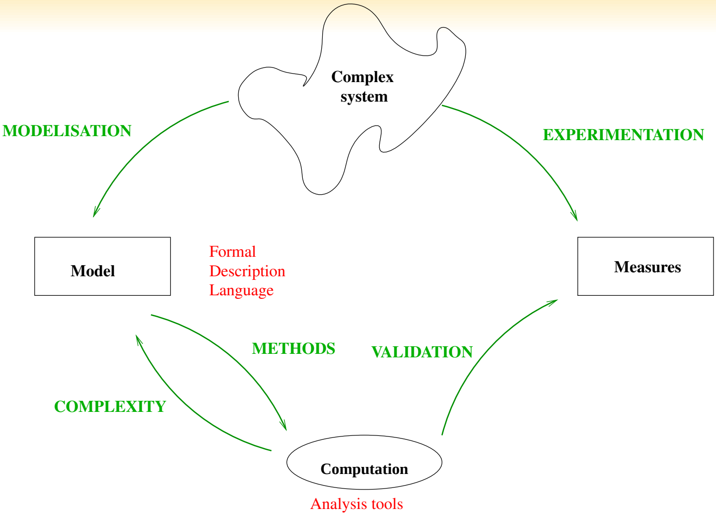

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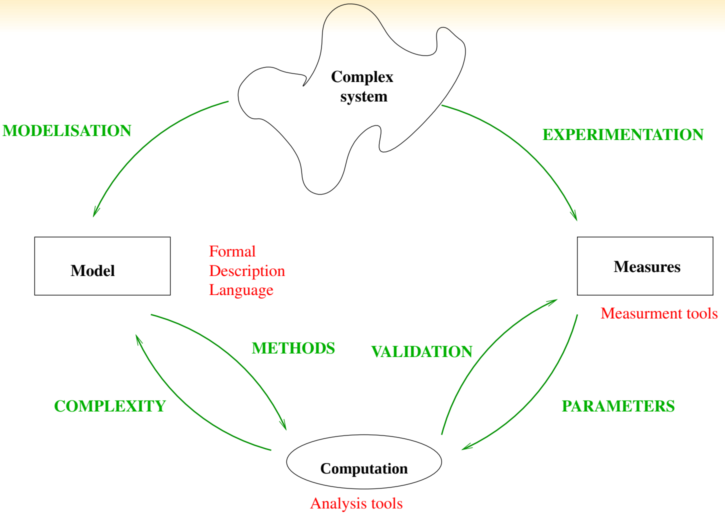

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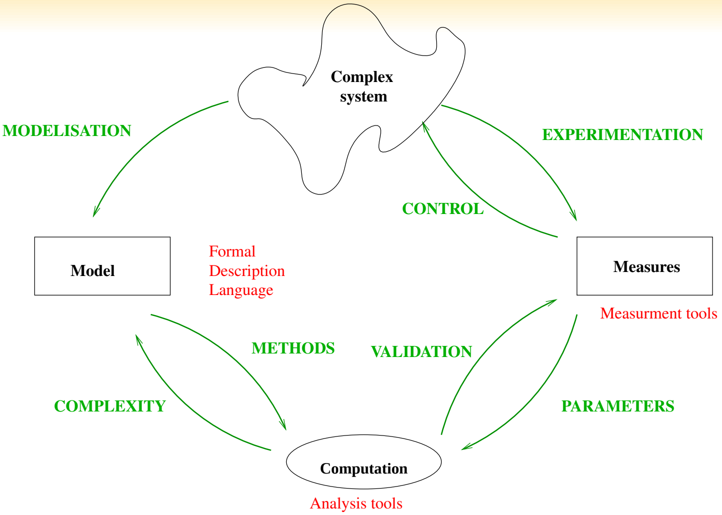

Evaluation methods

From abstraction to physical reality

Model **Method**

Remarks :

Hybrid methods (emulation, load injectors, synthetic programs,...)
Dynamical process of evaluation
Experimentation ⇒ Planning experiments methodology

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Steps for a Performance Evaluation Study (Jain)

1. State the goals of the study : level of decision, investment, optimization, technical,...
2. Define system boundaries.
3. List system services and possible outcomes.
4. Select performance metrics.
5. List system and workload parameters
6. Select factors and their values.
7. Select evaluation techniques.
8. Select the workload.
9. Design the experiments.
10. Analyze and interpret the data.
11. Present the results. Start over, if necessary.

Aim of the course

Objective

1. Be able to analyze and predict performances of computer systems
2. Be able to build a software environment that produces the performances indexes.

Methods

1. Specification and identification of problems : modeling
2. Analysis of quantitative models : formal, numerical, simulation
3. Experimentation and statistical data analysis.

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Organization of the course

Performance evaluation of systems 10 cours + 10 TD/TP

`http://mescal.imag.fr/membres/arnaud.legrand/teaching/2013/RICM4_EP.php`

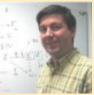
Evaluation

Experimental project

Organisation

Team


Arnaud Legrand
Simulation for large scale systems analysis and control


Jean-Marc Vincent
Markovian modeling of systems, simulation and dimensioning

References : text books

- **The Art of Computer Systems Performance Analysis : Techniques for Experimental Design, Measurement, Simulation and Modeling.** Raj Jain *Wiley 1991 (nouvelles versions)*

  Covers the content of the course, a complete book
- **Performance Evaluation** Jean-Yves Le Boudec EPFL electronic book `http://ica1www.epfl.ch/perfeval/lectureNotes.htm`

  Covers the statistical part of the course
- **Measuring Computer Performance: A Practitioner's Guide** David J. Lilja *Cambridge University press* 2000

  Covers the practical part of measurement and benchmarking
- **Discrete-Event System Simulation** Jerry Banks, John Carson, Barry L. Nelson, David Nicol, *Prentice Hall*, 2004

  Covers the part on simulation

References : journals and conferences

- **General**: JACM, ACM Comp. Surv., JOR, IEEE TSE,...
- **Specialized**: Performance Evaluation, Operation research, MOR, ACM TOMACS, Queueing Systems, DEDS, ...
- **Application**: IEEE TPDS, TC, TN, TAC, Networks,...
- **Theoretical**: Annals of Probability, of Appl. Prob, JAP, Adv. Appl. Prob,...
- **Conferences on performances**: Performance, ACM-SIGMETRICS, TOOLS, MASCOT, INFORMS, ...
- **Conferences on an application domain**: ITC, Europar, IPDPS, Renpar, ...
- **National seminars**: Atelier d'évaluation de performances,...

Outline

Networking

Flow performance

- latency, waiting time, response time
- loss probability
- jitter

Operator performance

- bandwidth utilisation
- achievable throughput
- loss rate

Quality of service

contract between user and provider
service guarantees
tradeoff between utilization and QoS

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Parallel processing

Program execution

- makespan, critical path
- speedup, efficiency
- active waiting, communication overlapping
- throughput

System utilization

- cpu utilization, idle time
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Parallel programming and scheduling

granularity of the application
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Distributed applications

Application

- response time
- reactivity
- throughput (number of processed requests/unit time)
- streaming rate

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- resource utilization
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- reliability (error-free period)
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User point of view

optimize its own performance
- get the maximum amount of resources for its own purpose
- guarantee the higher quality of service

Resource point of view

Contract between users and resources:
- guarantee of "equity"
- optimize the use of resources
- minimize costs by identifying performance bottlenecks

Tradeoff Performance - Cost

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Why experiments ?

Design of architectures, softwares

- System debugging (!!)
- Validation of a proposition
- Qualification of a system
- Dimensioning and tuning
- Comparison of systems

Many purposes $\Rightarrow$ different methodologies

Modeling fundamentals

Scientific Method

Falsifiability is the logical possibility that an assertion can be shown false by an observation or a physical experiment. [Popper 1930]

Modeling comes before experimenting

Modeling principles [J-Y LB]

- (Occam:) if two models explain some observations equally well, the simplest one is preferable
- (Dijkstra:) It is when you cannot remove a single piece that your design is complete.
- (Common Sense:) Use the adequate level of sophistication.

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Design of models (introduction)

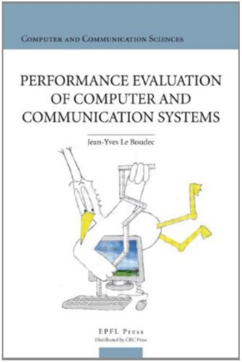
Formulation of the question

Give explicitly the question (specify the context of experimentation)

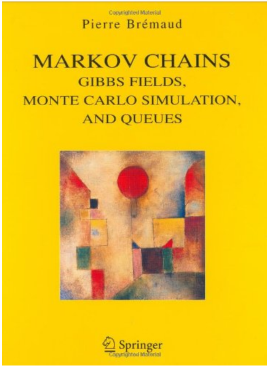
- Identify parameters (controlled and uncontrolled)
- Identify factors (set levels)
- Specify the response of the experiment

Minimize the number of experiments for a maximum of accuracy

Ouvrages de référence orientés évaluation de performances



Performance evaluation of computer and communication systems, Jean-Yves Le Boudec, EPFL Press 2011



Markov Chains, Pierre Brémaud, Springer 2001

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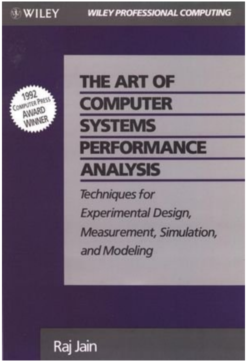
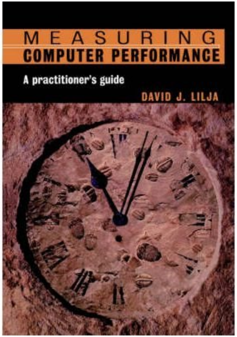


The art of computer system performance analysis, Raj Jain, Wiley 1991



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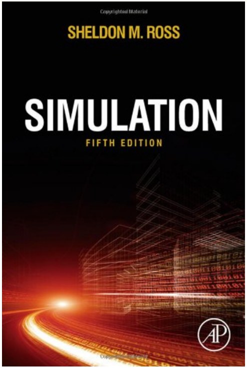

Simulation Sheldon M. Ross, Wiley 2012