### **Performance Evaluation**

A not so Short Introduction Why, Who, When and How ?

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## **Scientific context**

Software engineering : systems are more and more complex

- hierarchy of systems (multilevel architecture) OS / Middleware / Application
- distribution : distributed system with communications : asynchrony, heterogeneity
- dynamicity : temporal evolution of resources (reliability/availability)
- scaling : in space (Internet, grids) and in time (long run applications)

#### Examples and applications :

- P2P systems
- Mobile infrastructures, ad-hoc networks
- Clusters (Tera 10) and Grids (Grid 5K)
- Internet applications
- ...

#### Other applications domains

- production lines, supply chains
- embedded systems
- control systems
- microprocessors



# **Typical situations**

- Optimal routing
- Scheduling minimizing active waiting
- Page replacement policy
- Distribution of data
- Process scheduling according priorities
- Time out dimensioning
- Size of messages
- ...



## Motivations : development of distributed applications

- Qualitative specifications : Is the result correct ? Formal proofs, tests
- **Quantitative specifications :** Is the result obtained in a *good* manner? Are resources sufficient to get the result ?
- Problem identification Performance analysis and debugging
- Modification :
  - source code / libraries/ OS / platform
  - architecture parameters (dimensionning, capacity planning)
  - performances tuning



## **Scientific purpose**

#### Understand the behavior of a distributed application

- identification of specific patterns
- verification (debugging)
- time evaluation
- global evaluation of the execution
- operformances synthesis
- control policy (monitoring)
- Quantitative evaluation

#### Analysis of resources consumption

- application level
- 2 middleware
- operating system
- Ardware and network

## $\Rightarrow$ global evaluation bottleneck identification





















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Remarks : hybrid methods (emulations, synthetic workloads, black boxes, ...)

### **Experimental approach** $\Rightarrow$ **Planning experiments**

Choice of parameters and factors

### Aim of the course

Analysis and prediction of the performances of distributed/parallel applications Methods

- Specification and identification of the performance problem : modelling
- Analysis of stochastic model properties
- Prediction and dimensionning



# Organisation

Behavior Measurements, Visualization and Analysis of Systems : Keywords : traces in distributed systems, visualization tools, data aggregation, distributed performance debugging

#### **References :**

SBAC 2009 Tutorial : *Visualization for Performance Debugging of Large-Scale Parallel Applications* L. M. Schnorr, A. Legrand, and J.-M. Vincent *Multi-scale Analysis of Large Distributed Computing Systems*, L. M. Schnorr, A. Legrand, and J.-M. Vincent HPDC Workshop LSAP 2011

#### Statistical analysis of large computer systems :

Keywords : sample analysis, summarizing data, testing hypothesis References :

Discovering Statistical Models of Availability in Large Distributed Systems: An Empirical Study of SETI@home. B. Javadi, D. Kondo, J.-M. Vincent, D.P. Anderson. IEEE Transactions on Parallel and Distributed Systems, 99, 2011.

#### Stochastic modeling of computer systems

**Keywords** : stochastic automata, Markov chains, trafic modeling, queues **References** : classical introduction of performance evaluation : see books from Kleinrock, Jain,... given during the lecture

### Models for the dimensioning of systems

**Keywords** : networks of queues, dimensioning, distributed applications **References** : *Model-Based Performance Anticipation in Multi-tier Autonomic Systems: Methodology and Experiments.* N. Salmi, A. Harbaoui, B. Dillenseger, J.-M. Vincent. International Journal On Advances in Networks and Services, 3(3-4). 2010.



### **References : classical books**

- Methodology : The art of computer system performance analysis, Raj Jain, Wiley 1991
- Probability and applications Probability, stochastic processes, and queueing theory, R. Nelson. Springer-Verlag, Berlin, 1995.
- Measurement : Measuring computer performance, DavidJ. Lilja,Cambridge University Press 2000
- Elementary Markov chains : Finite Markov chains and algorithmic applications, Olle Häggström, Cambridge university press 2002
- Queueing networks : Queueing Networks and Markov chains, Bloch, Greiner, de Meer and Trivedi, Wiley 1998
- Web modelling : Capacity planning for web services, D. Menascé & V. Almeida, Prentice Hall, 2002
- Simulation : Discrete event system simulation Banks, Carson, Nelson, Nicol, Prentice Hall 2001



## **References : publications**

- General : JACM, ACM Comp. Surv., JOR, IEEE TSE,...
- Specialized : Performance Evaluation, Operation research, MOR, ACM TOMACS, Queueing Systems, DEDS, ...
- Applied : IEEE TPDS, TC, TN, TAC, Networks,...
- Theoretical : Annals of Probability, of Appl. Prob, JAP, Adv. Appl. Prob,...
- Conferences (domain): Performance, ACM-SIGMETRICS, TOOLS, MASCOT, INFORMS, ...
- Conferences (applications): ITC, Europar, IPDPS, Renpar, ...

