



# An overview of systems modelling and evaluation tendencies

G. Jomier

## ► To cite this version:

G. Jomier. An overview of systems modelling and evaluation tendencies. RR-0134, INRIA. 1982. inria-00076426

**HAL Id: inria-00076426**

**<https://hal.inria.fr/inria-00076426>**

Submitted on 24 May 2006

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**IRIA**

**CENTRE DE ROCQUENCOURT**

Institut National  
de Recherche  
en Informatique  
et en Automatique

Domaine de Voluceau  
Rocquencourt  
BP 105

78153 Le Chesnay Cedex  
France

Tél. 954 90 20

Rapports de Recherche

N° 134

**AN OVERVIEW  
OF SYSTEMS MODELLING  
AND EVALUATION TENDENCIES**

**Geneviève JOMIER**

**Mai 1982**

## AN OVERVIEW OF SYSTEMS MODELING

## AND EVALUATION TENDENCIES

Geneviève JOMIER

### RESUME

Dans ce papier nous présentons une synthèse des travaux de recherche récents et des tendances dans le domaine de la modélisation et de l'évaluation de performances de systèmes informatiques et des réseaux et ordinateurs. Cette étude inclut les problèmes de modélisation posés par les nouveaux systèmes répartis.

### ABSTRACT

This paper concerns the area of modelling and evaluation of computer systems, computer networks and distributed systems. What are the main publications and orientations in this domain and what are the new modelling problems involved by the evolution of computer science (especially by the architecture of new systems)?.

## I . INTRODUCTION

During the last ten years a lot of papers about modeling and performance evaluation of computer systems and computer networks have been published. Now new distributed systems are being built, integrating computers and communications. This involves new modeling and evaluation problems. The goal of this paper is to present the main developments and trends in this domain.

## II. MODELING AND PERFORMANCE EVALUATION OF COMPUTER SYSTEMS

On Figure 1 we show the different steps needed to evaluate a system, and two ways to procede.

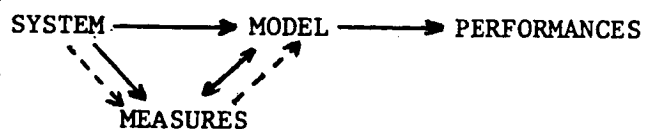


Fig.1

In the first one (solid arrows) a model is deduced from the system. The model is used to determine parameters which are measured or estimated from the system. There the measures are integrated in the model to obtain performances which are supposed to be representative of the system. An illustration of this procedure is the modelling of computer networks or computer systems (or part of them as central [Cour 77, Jomi 81] or secondary memory [Ge Mi 80, Bran 81, Arti 81] management etc...) using queues

and queueing networks [Klei 76] scheduling models [Coff 76] or Petri nets [Zube 81, Br FN 82].

In the second case (dashed arrows) empirical models are deduced from measures [Ferr 78, Svob 76, Fe Sp 80], using statistical techniques like regression, multidimensional analysis [Rala 79] chronological series, etc... They are mainly used in the study of systems workload.

In this part we will concentrate on computer systems modeling using queueing networks because this approach has been very successful and has produced a lot of important results. We begin by the fundamental theorem of Basket Chandy Muntz and Palacios [BCMP 75] which characterizes queueing networks with "product form solution". This means that these networks of queues with  $n$  nodes possess a steady state probability distribution  $P_s$  of the network state  $s$  of the form :

$$P_s = d \cdot f(s) \cdot \prod_{i=1}^n P_{s(i)} \quad (1)$$

where  $d$  is a normalizing constant,  $P_{s(i)}$  is the steady state probability of the corresponding state  $s(i)$  of the queueing system in the node  $i$ , and  $f(s)$  is a function of the number of customers depending on the state  $s$  [Ja Ko 80].

Two complementary approaches are developed to extend this type of solution to other networks. In the first one it is shown that some particular queueing networks admit product form solution. A.Hordijk and N.Van Dijk use it, for instance in [Ho VD 81] for certain cases of exponential queueing networks with blocking. We find it too in [Ja Ko 80] where U.Jansen and D.Konig use insensitivity properties to characterize an important family of open, closed or mixed networks admitting product form steady state probabilities. These results are based on the complementary approach in which more powerful new mathematical tools are developed. The outstanding works in this area have been made by Kelly [Kell 79] on reversibility and quasi-reversibility, and by Schassberger [Scha 77, He Sc 79] on insensitivity, connected with the last developments on point processes theory. A synthesis of this theory based on Palm's measure is presented, in [FKAS 79] by Franken, König, Arndt and Schmidt.

Due to the large number of states in the system, the computation of the normalization constant  $d$  in (1) may be untractable for real networks. As a result some computational algorithms have been presented by Chandy

and Sauer [ChSa 80] and by Bruell and Balbo [BrBa 80]. Other algorithms, possibly approximate, for large networks have been proposed by Mackenna and Mitra [MKMi 81] and Lavenberg [Lave 80]. Approaching it another way, for product form solution networks it is possible to directly obtain some parameters, thereby avoiding the normalization constant computation by the use of "mean value analysis" [ReLa 80].

The product form solutions [Pujo 80] are connected with an idea of "independence" between the different queues. This does not happen in some cases of computer systems or computer networks modelling which involve dependencies between queues. The exact analytical solution for some of these problems has been established, for instance, when it is possible to come to bidimensional markovian processus models [FaKM 80] and for a particular case of two coupled queues networks [Fayo 79].

However, at the present, in most cases the practical solution of such systems may be studied using :

- 1) numerical techniques [Stew 79, KiMi 80]
  - 2) approximations of the model by decomposition and equivalence [Bran 80] or by decomposability-aggregation [Cour 77, VaGL 80]
  - 3) or approximate solutions of the model by diffusion method [Koba 78], or isolation [LaPu 80], or by iterative techniques [DoAS 81, Mari 78].
- Different methods may be used simultaneously.

Some packages providing the facility of describing and solving (with exact or approximate methods) queueing networks have been developed, such as QNAP at INRIA [PoVe 79], QMOD [Gron 81], RESQ and QNET4 at IBM [ReSa 78, SaMS 80]. Among other solution techniques QNAP and RESQ offer the possibility of obtaining results using simulation.

To satisfy the needs of performance evaluation, important improvements in simulation [Lero 80, BaSa 81] have occurred. The latest deal with

- 1) the simulation inputs : how to build random numbers generators, and how to generate correlated number sequences [Bade 79]
- 2) the analysis of the simulator outputs : a lot of papers have been published on the regenerative method [IgSh 80, Igle 78, LaMS 79] and on the confidence interval accuracy [HeWe 81]..

### III. MODELING AND PERFORMANCE EVALUATION OF COMPUTER NETWORKS

The same tools are often used in computer systems and computer networks modeling, so it is difficult to draw a clear (and artificial) boundary between them.

The use of queueing networks to model computer networks is widespread. The importance of priorities, blocking (e.g. due to the limited size of buffers), the possible packet desequencing, etc., often need the use of approximate solutions or simulation, they can be used only when the number of system states is rather small. As a result other modeling techniques are used [TGPM 78] such as the stochastic processes theory (renewal theory, Markov chains, semi-markov processes, regenerative processes) and the markovian theory of decision.

M. Reiser, in a very interesting report [Reis 81], classifies the performance evaluation studies of data communication systems into four categories, (the first one being the most numerous) :

- 1) evaluation of a given protocol
- 2) design and configuration of real networks
- 3) performance evaluation of "products" (packets) of communication networks
- 4) performance evaluation of real networks based on their "products" and on workload measures.

It appears that the recent improvements in the performance evaluation of general networks have occurred in the modeling phase (transition from model to the expression of performance). The most important aspect in this approach has been the structuring of protocols into layers (7 for ISO) and their normalization [SRWG 80, ISO, PoZi 78, ZiPo 81]. Such structuring has been very useful in understanding their functioning and, as a result, in modeling them. Thus there are now results on the performance evaluation of different level protocols, such as HDLC (layer 2) [Sere 81, LaPu 79] or of a set of layers such as X.25 (CCITT) [GiJM 81] which integrates the three lowest layers. A special attention must be given to the interrelationship between the different level protocols [BuSc 81].

For the local networks the normalization is in progress, and the situation is characterized by a very wide variety of supports (and, as a consequence of theoretical throughput), topologies and access protocols.

A taxonomy and comparison of random access protocols for computer networks have been proposed in [Mi Na 81]. Fixed and dynamic schemes are distinguished, and for the dynamic one they are separated in centralized, centralized polling, contention networks and decentralized. A new distinction is made in the decentralized dynamic assignation schemes between the random access (different types of ALOHA and CSMA) and the non-random access (decentralized reservation, polling, round robin, alternating priorities, random order, minislotted). Many papers have been published on that subject : references and protocol comparisons may be found in [Reis 81, Mina 81, Bux 81], and studies on particular protocols in [To Hu 80, Ge Mi 81, Span 81].

Some special topics of networks gave rise to studies, such as the messages resequencing , a synthesis of which is in [Ba GP 81]. Yet, in other domains the emphasis is placed on ~~feasibility~~ feasibility more than on performance evaluation : the network interconnection [ISCA 80, ISCA 81, PWIN 80, FaMi 81] is an example of situation where very few papers appear on performance evaluation [Bern81] despite a real need. New performance evaluation problems arise with the use of networks to transport not only data but voice or pictures, in applications like burotics (office automation) or telematics. These uses involve different constraints in quality, speed and volume of tranfered data.

#### IV . DISTRIBUTED SYSTEMS :

The evolution of technology particularly the miniaturization (micro-processors) and the communications development (buses, local networks), and the fall of hardware prices involves the development of distributed systems. Beyond the versatility of such systems the idea is to use some small cooperating machines to perform tasks formerly devoted to large centralized systems [QED 78].

Therefore new systems oriented toward applications (like office automation, robotics, computer assisted instruction) are created. They are completely different form the universal centralized systems of the preceding generation.

These new distributed systems are sets of processors, specialized (like data bases machines) or universal, tightly coupled by buses or loosely



coupled by network (especially local network). In an application it is possible to distribute the computation and / or the data, and /-or the control. For each of these cases a great variety of choices is possible in distributing and in managing the distribution.

The diversity of distribution choices is superimposed on the diversity of applications. The performance evaluation must take into account these two aspects : thus in a distributed system every site requires the application software and the modules necessary to manage the communications and the distribution. The different parts of the software are in conflict for access to some resources of the system (memory and computation time). This has an impact on performance, particularly when synchronization between processes involves forced idleness of some processors.

As a result the studies on modeling and performance evaluation evolve along two axes : the evaluation of specific applications and the evaluation of the distribution.

The evaluation of applications poses the problem of the generality of the studied applications. Also numerous papers published on this subject are devoted to data base management systems (DBMS) because they are widespread and increasingly used in the heart of new systems [DWHa 81, Tsic 81]. They take an interest in the DBMS as a whole [Sevc 81, LoMa 81, HeWY 81] or in some specific point such as the concurrency control [RiSt 77, ShSp 81, Ries 81, ChGM 81, PdLe 80], the access paths to data [AsKS 80], and, when the relational model is used, the size of operations results [GeGa 82, Rich 80] and the query optimization [Kim 81] etc. The large variety of types of DBMS is an obstacle their modeling.

The quantitative evaluation of distributed systems is limited by lack of tools to model the synchronization. However evaluation studies are published on tightly connected architectures [Pate 81, BaWS 80, Gele 80, GrPa 80] and on loosely connected ones [BaFl 80] with a particular interest for distributed data bases [CoGP 80, Garc 79, Wilm 79]. Those papers are mainly based on theoretical algorithms to manage distributed systems and not on existing systems. Thus the count of messages necessary for the correct execution of a two phase commit in a distributed data base is interesting to compare different algorithms for maintaining concurrency

[Wilm 79] but it is clearly insufficient to determine the intrinsic performance of one particular algorithm. But in [Garc 79] we find analytic models and simulations for some of these algorithms. So a lot of work is to be

done to obtain a clear idea of distributed system performance. This will be possible with the implementation of systems and the development of experimental concrete models [BCEJK81] which will point out the crucial performance problems by measures.

#### V. CONCLUSION

In the course of this study we have seen how the theoreticians began with the modeling of computer systems and computer networks using queueing networks, and how they were obliged to improve more and more their mathematical tools. Simultaneously the evolution of technology and the creation of systems of increasing complexity, integrating processors and communications, raised new problems necessitating the development of new modeling tools. Many problem problems are still open in these different areas.

#### REMERCIEMENTS

Je tiens à remercier particulièrement mes collègues et amis Guy Pujolle François Baccelli et Philippe Nain dont l'aide m'a été précieuse pour la rédaction de ce papier.

BIBLIOGRAPHIE

- [ACMS 81] ACM/SIGMETRICS  
Conference on Measurement and Modelings of computer Systems -  
Sept. 1981 - Perf. Eval Review Vol 10, n° 3, Fall 1981 ,  
pp 175-215.
- [AdBD 81] G.ADORNI, A.BOCCALATTE, M.DIMANZO  
"Evaluation of Scheduling algorithms in the multiprocessor  
environment"  
Computer Performance Vol 2 n° 2 Juin 81 pp 70-76
- [Arti 81] H.P. ARTIS  
"Predicting the behavior of secondary storage management systems  
for IBM Computer Systems"  
Performance 81 - Amsterdam Nov 81 pp 435-444.
- [AsKS 80] M.M. ASTRAHAN, W.KIM, M.SCHKOLNICK  
"Evaluation of the System access path selection mechanism"  
IBM Research Laboratory, San Jose Californie 95 193 -  
RJ 2797 - 4/10/80 - 18 pages.
- [BaF1 80] F.BACCELLI et Th. FLEURY  
"On parsing in a multiprocessing environment"  
Rapport INRIA - 78153. Le Chesnay France, 1980 - To appear in  
Acta Informatica.
- [BaGP 81] F.BACCELLI, E.GELENBE, B.PLATEAU  
"An End to End Approach to the resequencing problem"  
Rapport de Recherche INRIA n° 97 - Nov 1981 - To appear in  
JACM.
- [Bade 79] M.BADEL  
"Generation de nombres aléatoires correlés"  
Mathematics and Computer in Simulation (IMACS) Vol XX, n° 4,  
1979.
- [BaWS 80] E.E. BALKOVICH, G.WHITBY-STREVEWS  
"On the Performance of decentralized software"  
Performance 80\* - Toronto - May 80 pp 175-180.
- [BaSa 81] Y.BARD and C.H. SAUER  
"IBM contributions to Computer Performance Modelling"  
IBM J. Res. Develop. Vol 25 . n°5 Sept 1981 p 562-570.

- [BCMP 75] F.BASKET, K.MANI CHANDY, R.R. MUNTZ, F.G. PALACIOS  
"Open, Closed, and Mixed Networks of Queues with Different  
classes of customers"  
JACM Vol 22, n° 2, April 75, pp 248-260.
- [Bern 81] G.BERNARD  
"Interconnection of Local Computer Networks : Modeling and op-  
timization problems"  
Submitted to IEEE transactions on Software Engineering  
Rapport de Recherche - LRI, Université Paris Sud - n° 77  
91405 - Orsay France
- [BCFJK 81] P.BOUCHET, A.CHESNAIS, J.M. FEUVRE, G.JOMIER, A.KURINCKX  
"PEPIN : An experimental multimicrocomputer database manage-  
ment system"  
2nd International Conference on Distributed Computing Systems  
IEEE/IFIP/AFCEC - Paris April 1981 pp 211-217.
- [Bran 80] A.BRANDWAJN  
"Further results on equivalence and decomposition in queueing  
network models"  
Performance 80\* , ACM Symetrics Vol 9, 2, Summer 80, p 93-104.
- [Bran 81] A.BRANDWAJN  
"Multiple paths versus memory for improving DASD subsystem  
performance"  
Performance 81 - Amsterdam Nov 81 - pp 415-434.
- [BrFN 82] G.BREGER, G.FLORIN, S.NATKIN  
"Un outil d'aide à l'évaluation de la sureté et des performan-  
ces de systemes informatiques "  
Colloque AFCEC "Mathematics for Computer Science"  
Mars 1982 - CNAM - Paris France
- [BrBa 80] S.C. BRUELL and G.BALBO  
"Computational Algorithms for Closed Queueing Networks"  
North Holland, NY 1980.
- [BuSc 81] A.BUTRIMENKO, G.SCOLLO  
"Protocol parameters and network characteristics : classifica-  
tion and some interrelations"  
Proc. of the meeting "Evolution of Computer Networks Theory  
and Experience" Ed. Petrentko Sept. 1981 -  
IIASA - Laxenburg Austria. 1e Dec 1979.
- [Bux 81 ] W.BUX  
"Local Area Subnetworks : a Performance Comparison Research  
Report RZ 1057 , 2/24/1981.  
IBM Zurich Research Laboratory, CH-8803 Ruschlikon Switzerland  
Or Proc fo the IFIP WG 6.4 International Workshop on local  
Area Networks Zurich - 27.29 Aug 1980, to be published by North-  
Holland, Amsterdam 1981.

- [ChSa 80] K.M. CHANDY and Ch.H SAUER  
"Computational Algorithms for Product Form Queueing Networks"  
Toronto May 1980 Performance 80\*  
Performance Evaluation review  
Vol 9 n°2 - pp 1 - 10.
- [ChGM 81] A.CHESNAIS, E.GELENBE, I.MITRANI  
"On the Modeling of concurrent access to shared data"  
Applied Probability / Computer Science : the Interface  
Boca Raton, Florida , Jan 1981.
- [Coff 76] E.G. COFFMAN  
"Computer and Job-shop Scheduling Theory"  
John Wiley 1970.
- [CoGP 80] E.G. COFFMAN, E.GELENBE, B.PLATEAU  
"Optimization of the number of copies in a Distributed Data  
base System"  
Performance 80\* - pp 257-264.
- [Cour 77] P.J. COURTOIS  
"Decomposability : queueing and computer system applications"  
Academic Press - New York 1977.
- [Deno 81] L.A. DENCIA  
"An Approach to the Cost / Performance comparison of distribu-  
ted Systems"  
Proc - 5th Berkeley Workshop on Distributed Data Management  
and Computer Networks.  
University of California Berkeley Feb 3-5, 1981 - pp 38-66.
- [DWHa 81] D.J. De WITT, P.B. HAWTHORN  
"A Performance Evaluation of Data base Machine Architecture"  
Proc 7 the Very Large Data Bases - Cannes France 9.11 Sept. 81  
Ed Zaniolo Delobel - pp 199-213.
- [DoAS 81] S.L. DODD, D.F. Mc ALLISTER, W.J. STEWART  
"An Iterative Method for the Exact Solution of Coxian Queueing  
networks"  
Performance Evaluation review Vol 10 n°3 Fall 1981 - p 97-  
104.
- [FaMe 81] A.FARO and G.MESSINA  
"Internetworking analysis"  
Computer communications Vol 4 n°4 August 81 - pp 169-173.
- [Fayo 79] G.FAYOLLE  
"Methodes analytiques pour files d'attente couplées"  
Thèse d'Etat - Université Paris 6, Paris France, Nov 79.

- [FaKM 80] G.FAYOLLE, P.J.B. KING, I.MITRANI  
"The solution of Certain two Dimensional Markov Models"  
Performance 80\* - Toronto - pp 283-289.
- [Ferr 78] D.FERRARI  
"Computer systems performance evaluation"  
Prentice Hall, Englewood cliffs, NJ, 1978.
- [FeSp 80] Ed. D.FERRARI and M.SPADONI  
Experimental Computer Performance Evaluation  
Lecture Notes of the 2nd Summer School on Computer Systems  
Performance Evaluation - Scogesta, Urbino Italy  
16-27 June 1980 - North Holland 1981.
- [FKAS 79] P.FRANKEN, D.KONIG, U.ARNDT, V.SCHMIDT  
"Queues and Point Processes"  
Akademie - Verlag - Berlin 1979.
- [Garc 79] M.GARCIA MOLINA  
"Performance of update algorithms for related data in a dis-  
tributed data base"  
Stanford University . 1977, Ph D Thesis, USA
- [Gele 80] E.GELENBE  
"Parallel computation of partial differential equations a mo-  
deling approach"  
19 th IEEE Conf.on Decision and Control - Nov 1980.
- [GeGa 82] E.GELENBE and D.GARDY  
"On the size of Projection I"  
"On the size of ProjectionII"  
Researchreport to be published  
LRI Univ. Paris-Sud Orsay France - 1982
- [GeMi 80] E.GELENBE and I.MITRANI  
"Analysis and Synthesis of Computer System"  
Academic Press - London - 1980.
- [GeMi 81] E.GELENBE and I.MITRANI  
"Analysis of retransmission control policies in CSMA local  
area networks"  
Rapport de recherche INRIA, 78153 Le Chesnay Cedex France  
1981.
- [GiSM 81] A.GLIESSLER, A.JAGEMANN and E.MASER  
"Simulation of an X25 Network Providing Throughput Guarantees"  
Performance of Data Communication Systems and their Applications  
G.Pujolle Ed. Paris Sept 81 - North Holland - pp 279-290.
- [GrPa 80] D.H.GRIT and R.L. PAGE  
"Performance of a multiprocessor for Applicative Programs"  
Performance 80\* - ACM Sigmetrics Vol 9, n°2, Summer 80 -  
pp 181-190 - Toronto.

- [Grow 81] L.H. GRONER  
"QMOD : a system for automatically generating and solving analytical queueing network models"  
APL 81 - Conf. San Fransisco - 21.23 Oct. 81 - pp 125-128.
- [Grub 81] J.GRUBER  
"Performance considerations for integrated Voice and data networks"  
Computer Communications Vol 4 n°3 - Juin 1981 - pp 105-126.
- [HeWe 81] P.HEIDELBERGER and P.D. WELCH  
"A spectral method for confidence interval generation and run length control in simulations"  
C.A.C.M. 1981 24, pp 233-245.
- [HeWY 81] P.HEIDELBERGER, P.D.WELCH and P.C. YUE  
"Statistical analysis of data base systems measurements"  
Performance 81 - Amsterdam - Nov 81 - pp 335-344.
- [HeSc 79] W.E HELM and R.SCHASSBERGER  
"Insensitive Generalized Semi-Markov Schemes with Point Process Input"  
Preprint n°502 October 1979.
- [HoVD 81] A.HORDIJK and N. VAN DIJK  
"Networks of queues with blocking"  
Performance 81 - Amsterdam - Nov 1981 - pp 51-65.
- [Igle 78] D.L. IGLEHART  
"The Regenerative Method for Simulation Analysis"  
Current Trends in Programming Methodology"  
Vol III : Software Modeling and its Impact on Performance -  
Chandy-Yeh Editors - Prentice hall - 1978.
- [IgSh 80] D.L. IGLEHART and G.S. SHEDLER  
"Regenerative Simulation of Response Times in Networks of Queues"  
Springer-Verlag , New York 1980.
- [ISCA 80] ISCA 7  
7th Symposium on Computer Architecture.  
La Baule France - 6.8 May 1980.
- [ISCA 81] ISCA 8  
8th Symposium on Computer Architecture.  
Mimeapolis (Minesota) USA - May 1981  
in SIGARCH Newsletter vol 9 n°3 - ACM.
- [ ISO ] ISO  
"Data Processing - Open - System interconnection Basic Reference Model"  
ISO TC 97 - sous comité 16  
Proposition de standard ISO/DP 7498.

- [JaKo 80] U.JANSEN and D.KONIG  
"Insensitivity and Steady - State Probabilistics in Product Form  
for Queueing Networks"  
Journal of Information Processing and cybernetics  
EJK 16 (1980) 8/9 pp 385-397.
- [Jomi 81] G.JOMIER  
"A Mathematical Model for the Comparison of Static and Dynamic  
Memory Allocation in a Paged System"  
IEEE Transactions on Software Engineering  
Vol SE-7 - n°4, July 1981. - pp 375-385.
- [Kell 79] KELLY  
Reversibility and Stochastic Networks  
Wiley - 1979.
- [Kim 81 ] W.KIM  
"Queueing Optimization for Relational Data base Systems"  
IBM Research Report RJ 3081 - San José (Ca) USA - 3/10/81.
- [KiMi 80] P.J.B. KING and I.MITRANI  
"Numerical methods for Infinite Markov Processes"  
Performance 80\* - Toronto - pp 277-282.
- [Klei 76] L.KLEINROCK  
"Queueing Systems" Vol 1 and 2  
Wiley - 1976.
- [Koba 78] H.KOBAYASHI  
"Modeling and Analysis : an introduction to system performance  
evaluation methodology  
Addison Wesley - 1978.
- [LaPu 79] J.LABETOULLE , G.PUJOLLE  
"Modeling and Performance evaluation of the protocol HDLC"  
Proc. Symp. Flow Control in Computer Networks  
Versailles, France 12.14 Fev 1979  
J.L. Grangé, M.Gien - Eds - North Holland.
- [LaPu 80] J.LABETOULLE and G.PUJOLLE  
"Networks of queues"  
IEEE Trans. Software Engineering , 6, 4, 1980. - 373-381.
- \*\*
- [LaMS 79] S.S LAVENBERG, T.L. MOELLER, C.H. SAUER  
"Concomitant Control Variables Applied to the Regenerative Si-  
mulation of Queueing System"  
Open. Res. 27, 1979 - pp 134-160.
- [Lero 80] J.LEROUDIER  
"La Simulation à événements discrets"  
Ed. Hommes et Techniques - (France) 1980,



- [LoMa 81] B.J. LOWNDES and J.W. MARTIN  
"A Comparative Study of form data base management systems"  
Data bases - Proc 1st Brit. Nat. Conf. on data bases  
Cambridge 13.14/7/81 - pp 187-205.
- [MKMi 81] J. Mc KENNA and D.MITRA  
"Integral representations and asymptotic expansions for closed  
markovian queueing networks : normal usage"  
Amsterdam - Nov 1981 - Performance 81 - pp 67-84.
- [Mari 78] R.MARIE  
"Methodes itératives de résolution de modèles math. de systèmes  
informatiques"  
RAIRO Informatique 12,2,1978.
- [MiNa 81] D.MINOLI and W.NAKAMINE  
"A Taxonomy and Comparison of Random Access protocol, for Com-  
puter networks"  
Data communication and Computer Networks  
S.Ramani (Edition) - North Holland  
CSI/IFIP - 1981 - PP 187-206.
- [pate 81] J.H. PATEL  
"Performance of Processor-Memory Interconnctions for Multiproces-  
sors"  
IEEE on Computers Oct 81 - Vol c30 n°10 - p 771-780.
- [PoLe 80] D.POTIER and Ph.LEBLANC  
"Analysis of Locking policies in data bases management systems"  
ACM 23,10 (Oct 1980) pp 584-593.
- [PoVe 79] D.POTIER and M.VERAN  
"QNAP : a Modeling Tool for computer Performance Evaluation"  
7th European Conference on Computer Measurement, Paris, Oct 79.
- [PoZi 78] L.POUZIN and H.ZIMMERMANN  
"A Tutorial on Protocols"  
Proc IEEE - Vol 66 - n°11 - Nov 1978 - pp 1346-1370.
- [PWIN 80] Proceedings of the Workshop on Interconnection Networks for pa-  
rallel and distributed processing  
April 21-28 1980 - Purdue University Howard Jay Siegel Editor.
- [Pujo 80] G.PUJOLLE  
"Réseaux de files d'attente en forme produit"  
RAIRO - Vol 14, n°4 - Nov 1980 - pp 317-330.
- [QED 78 ] "Distributed Processing : current practice and future develop-  
ments" Vol 2 Technical Report  
QED Information Sciences, 141 Lindon Street, Wellesley MA 02181

- [Rala 79] H.RALAMBONDRAIN  
"Application de l'analyse multidimensionnelle à l'étude de la charge d'un ordinateur"  
Thèse - Université Paris 6, France - Juin 1979.
- [Reis 81] M.REISER  
"Performance Evaluation of Data Communication Systems"  
RZ 1092 - 8/19/81 - IBM Zurich Research Laboratory.
- [Rela 80] M.REISER and SS. LAVENBERG  
"Mean Value Analysis of Closed multi Chain Queueing Networks"  
JACM - Vol 27 - n°2 - April 1980 - pp 313-322.
- [ReSa 78] M.REISER and C.H. SAGER  
"Queueing Network Models : Methods of Solution and their Program Implementation"  
Current Trends in Programming Methodology -  
Vol III : Software Modeling and its Impact on Performance.  
Chandy-Yeh Editors - Prentice Hall - 1978 - pp.115-167.
- [Rich 80] Ph.RICHARD  
"On the Evaluation of the size of the answer of a relational query"  
Rapport INRIA 78153 Le Chesnay France - n°51 - Dec 80.
- [Ries 81] D.R. RIES  
"The effects of concurrency control on the performance of data base management system"  
Rapport Univ. California Berkeley, CA, USA  
Electronics Research Laboratory - 222p.
- [RiSt 77] D.R. RIES, M.STONEBRAKER  
Effects of Locking Granularity in Data base Management system"  
ACM Transaction Data base Systems - Vol 2 n°3 - Sept 1977 -  
pp 233-246.
- [SaMS 80] C.H. SAUER, E.A. MACNAIR, S.SALZA  
"A Language for Extended queueing Network Models"  
IBM J. Res. Develop., 24 , 1980, pp 747-755.
- [Scha 77] R.SCHASSBERGER  
"Insensitivity of Steady - State Distributions of Generalized semi-Markov Processes"  
The Annals of Probability  
1977, Vol 5, n°1 - pp 87-99.
- [SRWG 80] G.D. SCHULTZ , D.B.ROSE, CH.WEST and J.P.GRAY  
"Executable Description and Validation of SNA"  
IEEE Transactions on Communications, COM.28,  
n°4, April 1980, pp 661-677.

- [Sere 81] D.SERET  
"Influence du degré d'anticipation sur les performances de la  
procédure HDLC"  
Performance of Data communication Systems and then Applications.  
G.Pujolle (ed) - Paris - Sept 1981 - pp 291-304 - North Holland.
- [Sevc 81] K.C. SEVCIK  
"Data base System Performance Prediction Using an Analytical  
Model"  
Proc. 7th Very Large Data Base - Cannes, France - 9.11 Sept 1981  
Ed Zaniolo-Delobel - pp 182-198.
- [ShSp 81] A.W. SHUM and P.G. SPIRAKIS  
"Performance analysis of concurrency control methods data base  
systems"  
8th International symp. on Computer Performance modeling  
and Evaluation  
4.6. Nov. 1981 - Amsterdam - p 1-20.
- [Span 81] O.SPANIOL  
"Analysis and Performance Evaluation of Hyperchannel Access Pro-  
tocols"  
Proc 2nd International Conf. on Distributed Computing Systems,  
Paris, France - April 8-10 1981.
- [Stew 79] W.J. STEWART  
"A Direct Numerical method for queueing networks"  
4th International Symposium on Modeling and Performance Evalua-  
tion of Computer Systems  
WIEN (Austria) - Feb 1979.
- [Svob 76] L.SVOBODOVA  
"Computer Performance Measurement and Evaluation methods :  
Analysis and Applications"  
Elsevier - New York - 1976.
- [TGPM 78] F.A. TOBAGI, M.GERLA, R.W. PEEBLES, E.G. MANNING  
"Modeling and Measurement Techniques in Packet Communication  
Networks"  
Proc. of the IEEE - Vol 66, n°11, Nov 78, pp 1423-1447.
- [ToHu 80] F.A. TOBAGI, V.B. HUNT  
"Performance Analysis of Carrier Sense Multiple Access with  
Collision detection"  
Computer Network - Vol 4, n°5, Oct.Nov 1980.
- [Tsic 81] TSICHRITZIS  
"Integrating data bases and message Systems"  
Proc. Very Large Data Bases  
Cannes - Sept 1981 - pp 356-362.

- [VaGL 80] H.T. VANTILBORGH, R.L. GARNER, E.D. LAZOWSKA  
"Near complete Decomposability of Queueing Networks"  
Toronto May 1980 - Performance 80 - pp 81-92.
- [Wilm 79] P.WILMS  
"Etude et Comparaison d'algorithmes de maintien de la cohérence  
dans les bases de données réparties"  
Thèse - I.N.P. Grenoble , France - 23/11/1979.
- [ZiPo 81] H.ZIMMERMANN and L.POUZIN  
"The standard Network Architecture Developed by ISO"  
Data Communication and Computer Networks  
S.Ramani Editor - North Holland  
CSI/IFIP 1981 - pp 1-15.
- [Zube 81] ZUBEREK  
"Timed-Petri Nets and Preliminary Performance evaluation"  
7th Annual Symposium on Computer Architecture. La Baule France  
Mai 1980 pp 88-96
- \*\* [Lave 80] S.S. LAVENBERG  
"Closed Multichain Product Form Queueing Networks with Large  
Population Sizes"  
IBM Research report - RC 8496, Sept 80.
- Performance 80\* - Toronto - May 80  
ACM Sigmetrics - Vol 9, n°2  
Summer 1980.

