François BACCELLI

RESUME
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Born : December 20, 1954

Nationality : French

Thèse de Doctorat d'Etat - Computer Science, Université de Paris-Sud. April 1983.

Positions

- From sept. 1998: Directeur de Recherche INRIA at Ecole Normale Supérieure, Computer Science Department, head of the *Trec* research group (*Théorie des Réseaux et Communications*)

  (http://www.di.ens.fr/~trec.html).

- 1991-2003: part time *Maître de conférence* and then *Professeur chargé de cours* at Ecole Polytechnique, Applied Mathematics Department.

- 1988-1998: Directeur de Recherche at INRIA Sophia Antipolis, head of the *Mistral* research group (Computer and Network Performance Evaluation).

- 1985-1988: Directeur de Recherche at INRIA Rocquencourt, *Meval* research group.

- 1984-1985: Visiting Professor at the University of Maryland (Electrical Engineering Department), visiting scientist at AT&T Bell Laboratories (Mathematical Center) and at Bell Communications Research (Mathematical Communications and Computer Sciences).

- 1979-1984: Chargé de Recherche at INRIA Rocquencourt, *Meval* group.

Professional Experience

A - Research (see the bibliography for the references)

1. Modeling of communication networks and distributed systems

- **Communication networks and protocols** :
    - **Rate, flow and congestion control**, with a main emphasis on IP networks ([C10], [J62], [C13], [C14], [C16], [C17], [C20], [C22], [C23], [C24], [J71], [J72], [J76], [J77], [J82]); The main results consist in new models for the dynamics of TCP over large networks developed with D. Hong which are the basis of a joint project with the Network Strategy Group of Alcatel (see in particular [J76] which was nominated for the IEEE INFOCOM'03 best paper award) and new IP multicast protocols (see [J71], nomination for the best paper award at IEEE INFOCOM'01 and [C22]). Earlier contributions include a proof of the instability of the pure rate matching ABR control scheme in ATM networks and the design of new stable rate control algorithms, which had an impact on the normalization of ATM networks [C10].
    - **Wireless communications** [C19], [C21], [J53], [J67], [J75], [J78], [J79]. The main contributions bear on CDMA and on mobile ad hoc networks. New distributed protocols have been proposed for admission and congestion control of UMTS networks, both on the uplink and the downlink. This is the basis of an ongoing interaction with FT, in collaboration with B. Blaszczyszyn. The conditions ensuring the connectivity of mobile ad hoc networks when taking into account signal to noise ratio were established in [J78] (nomination for best paper award, IEEE INFOCOM'03), where it is shown that densifying a network might disconnect it.

- **Wireline Network architecture**: development of a methodology ([J42], [J51], [J56], [J60], [J65], [C15]) (http://www.ens.fr/∼trec/sg), elaborated with and used by France Télécom for cost analysis of large wireline networks.
- **Analysis of communication networks**: analysis of resequencing protocols (see the survey article [J17] published in the *Proceedings of the IEEE*); analysis of abandonment queueing networks (see [C1], which established a formula frequently used today for the dimensioning of call centers and known as Erlang-A formula, and [J5]).

- **Parallel and distributed systems**:
  - **Consistency preserving algorithms**: analysis of timestamp ordering algorithms ([J17]).
  - **Performance evaluation parallel program execution** ([B2], [C5], [J2], [J9], [J15], [J22], [J23], [J24], [S2], [S4], [J40], [J45], [J69]); the results of the Qmips BRA project, which focused on this problem, were gathered in a book [B6].

These results bear on concrete networking problems, lead to patents and industrial collaborations, and are published in journals like **Performance Evaluation**, **Queueing Systems**, or in engineering journals like **Annales des Télécommunications**, **I.E.E.E Transactions on Computers**, **I.E.E.E Transactions on Networking**, or **Probability in Engineering and Information Sciences**. In the domain of communications, the main publications also take place in conferences such as **IEEE INFOCOM**, **ACM SIGCOMM** or **ITC** (International Teletraffic Conference).

2. Discrete Event Dynamical Systems

- **Queueing networks**: [B5], [J26], [J34], [J44], [J73], [J81]. The main results bear on the asymptotic properties of Jackson and Kelly networks (basic models for packet switching networks), and on the stability of synchronized Kelly networks.

- **Petri networks**: [B4], [J28], [J29], [J33], [J34], [J36], [J37], [J41], [C18]. A new algebraic theory was proposed for stochastic event graphs and for free choice networks; this was the object of several keynote lectures including at Informs 2000 and CDC 95. The current extensions bear on networks with non expansive dynamics.

- **Network simulation**: New simulation methods were designed in [C20], which is the basis of the N2NSoft simulation tool for large IP networks, and in [C9], where it was shown that the simulation of stochastic max-plus networks can be parallelized with unbounded speed-up both in time and space. See also [C13], [J38] and [J39].

This type of work on discrete event dynamical systems is published in journals like **Journal of the A.C.M**, **A.C.M. TOMACS** (Modeling and Computer Simulation), **Queueing Systems**, **J.D.E.D.S** (Discrete Event Systems) or **I.E.E.E Transactions on Automatic Control**. It has links with theoretical computer science. The framework developed with G. Cohen, J.P. Quadrat and G.J. Olsder has quite important continuations in the domain of network calculus (books of C.S. Chang in 2000 and of Le Boudec & Thiran in 2001).

3. Probabilistic tools for stochastic modeling

- **Stochastic geometry** : Introduction of the hierarchical Voronoi model and of new classes of coverage processes in connection with wireless network modeling: [J42], [J56], [J60], [J65], [J53], [J56], [J67], [C15].

- **Queues and point processes**: [B3], [B5], [J8], [J12], [J16], [J19], [J26], [J31], [J47], [J50], [J66]. The main achievements are the development of the "stationary ergodic" framework in the book [B5] and in particular of new methods for stochastic stability ([J46]) and for perturbation analysis ([J31], [J63]) all based on the theory of non expansive maps. The book [B5] with Pierre Brémaud became an international reference.

- **Computational methods for networks**: [J4], [J5], [J8], [J11], [J13], [J15], [J27], [J32], [J36], [J63]; the main results bear on:

- New asymptotic expansion methods which establish links with cluster expansions developed with V. Schmidt ([J50], [J52], [J55], [J58], [J61], [J68], [C11]).
- New martingale methods for assessing the stability and computing the transient and stationary laws developed in collaboration with A.M. Makowski [J6], [J10], [J20], [J30].

These results are published in journals like **Maths of O.R.**, **Annals of Proba**, **Queueing Systems**, **Applied Probability Journals**, **Annals of Applied Probability**, **Stochastic Processes and their Applications** etc.

4. Future Research Program

My research project focuses on the modeling and control of communication networks and on the development of the underlying methodology, namely the theory of dynamical discrete event systems.

To my opinion this requires to carry through methodological activities but also industry-linked investigations, as the ones I currently have with Alcatel, IBM and France Telecom.

The research on the theory of networks aims at continuing to improve our knowledge of discrete event dynamical systems in this context. The theory of network dynamics, which has been under construction for nearly a century, is still very incomplete even though several complementary theories have already been developed: I would quote queueing theory (e.g. J.W. Cohen) product form theory (e.g. F. Kelly), the max plus approach (e.g. our 92 book with G. Cohen, G.J. Olsder and J.P. Quadrat), the network calculus approach (e.g. C.S. Chang, J.Y. Le Boudec and P. Thiran), which builds upon the max plus, the point process approach (our 2002 book with Pierre Brémaud).

Much more has to be done as the control protocols and the applications used in the Internet or in wireless networks have radically changed these past years. The usual network dimensioning rules and performance evaluation tools are not suitable anymore and key new questions appear.

For example, normalization organisms recommend the introduction of priority classes in the Internet but we still know very little about some essential questions such as the stability conditions of multi-class networks, even in the non-controlled case. Control issues are very challenging even in a one-class situation (the present Internet). For example, the congestion control operated by TCP bears on a stochastic system, is highly non-linear, and is installed on extremely large networks. Furthermore, the control is decentralized and creates long range interactions between each source-destination pair. Together with my colleague D. Hong, I have proposed several new models on this class of problem and I find it particularly important to develop mathematical tools allowing one to understand this control over large networks.

Concerning wireless networks, stochastic geometry appears to be a very promising tool for modeling mobility and also for representing protocols with spatial characteristics. We have developed this new mathematical approach with a few colleagues and we already used it in the context of CDMA, ad hoc networks, as well as the design of scalable multicast protocols. This opens quite interesting new avenues on the theory side, where new classes of spatial random objects have been identified and studied (such as the CDMA cells of the connected subsets of an ad hoc network). I intend to continue the investigation of further potential application of this approach to sensor networks, mobile IP or overlay networks to quote a few.

B - Teaching :

- **Ecole Normale Supérieure de la rue d'Ulm** :
    - Course on communications networks between 1989 and 1994, in collaboration with Christian Huitema, and since 1998.
    - Course on probability for computer science (with Pierre Brémaud and Jean-François Le Gall), started in 2003.
- **DEA Algorithmique** : new track on communication networks with J. Mairesse; B. Gaujal and S. Gaubert (1999 − 2002).

- **University Paris 6, DEA de probabilités**: graduate course on queueing theory, since 1990, in collaboration with P. Brémaud and then J. Mairesse and L. Massoulié.
- **Ecole Polytechnique** :
    - Course on the modeling of communication networks, common to the Applied Maths and the Computer Science Departments (1999-2003).
    - Course on Markov Chains, Applied Maths Department, in collaboration with P. Brémaud (1995 – 1999).
- **École Nationale Supérieure des Télécommunications, Paris** : course on queueing theory (1981 – 1990).
- **Université Paris-Sud, DEA d'informatique, LRI**: graduate course on the modeling of computer systems, (1980 – 1989).

C - PhD Thesis supervision
- **C. Bordenave**, (Ecole Polytechnique, in progress).
- **A. Chaintreau**, (ENS, in progress).
- **J. Reynier**, (ENS, in progress).
- **M. Lelarge**, (Ecole Polytechnique, in progress).
- **A. Proutières**, (Applied Maths, Ecole Polytechnique, 2003), now with France Télécom Research;
- **F. Tournois** (Ecole des Mines, 2002), now with INSEE;
- **E. Lety** (Computer Science, UNSA, 2000), now with the Udcast start-up;
- **D. Hong** (Applied Maths, Ecole Polytechnique, 2000), now with the N2NSoft startup;
- **T. Bonald** (Applied Maths, Ecole Polytechnique, 1999); now with France Télécom Research;
- **K. Tchoumatchenko** (Computer Science, UNSA, 1999); now with France Télécom Research;
- **J. Mairesse** (Applied Maths, Ecole Polytechnique, 1995); now with CNRS-LIAFA, Paris;
- **B. Gaujal** (Computer Science, UNSA, 1993); now with INRIA R-A & ENS Lyon;
- **M. Canales** (Computer Science, UNSA, 1993); now with Knowledge Adventure, USA;
- **Z. Liu** (Computer Science, University of Paris Sud, 1990); now with IBM Research, USA;
- **A. Jean-Marie** (Computer Science, University of Paris Sud, 1987); now with Université de Montpellier and INRIA.

D - Europeans and Industrial Projects

- Partner and member of the steering committee of the **European Network of Excellence EURO-NGI** (started in 2003).
- Coordinator of 2003 and 2004 CRE grants on the densification of UMTS networks with France Télécom R&D.
- Coordinator of *Opération Stratégique Conjointe* **Alcatel – INRIA** "End to end performance evaluation of packet communication networks", started 2001.
- Partner of the project **RNRT Georges** (Stochastic Geometry for Large Communication Networks), 1999–2002.
- Partner of the European project **TMR Alapedes** (Algebraic Approach for Performance Evaluation of Discrete Event Systems, 1996 – 2001) in relation with [B4].
- Coordinator of the European project **BRA Qmips** (Quantitative Modeling in Parallel Systems) 1992 – 1995 (see [B6]).
- Coordinator of two **CTI – France Télécom R&D** (1994 – 2001) on cost analysis of communication networks.

- Coordinator of three European **INTAS** projects with IPIT (Moscow) and the university of Novosibirsk, on stochastic networks (1996 – 2001).
- Partner of the European projet **ESPRIT 2 IMSE** (Integrated Modeling Software Environment) 1989 – 1992 : which lead to the simulation software **MODLINE**, in collaboration with ICL, Thomson and Simulog; this software is marketed by Simulog.
- Research Grants with Industry : **Thomson ASM** (High Speed Networks), **Simulog** (Parallel Simulation), **Electricité De France** (High Speed Networks).

E - Other Scientific Activities

- Member of the **NSF** evaluation panel for ITR large proposals (2003).
- Member of the steering committee of the *Stochastic Networks* chapter of **Eurandom** (since 1999).
- Member of **IFIP Working Group WG 7.3** (since 1986),
- Member of the TCP of **IEEE INFOCOM** (since 2000).
- Associate Editor for **Queueing Systems** (since 1993), **Annals of Applied Probability** (1995 – 2002), **JDEDS** (since 1990), **Mathematics of Operations Research** (1992 – 2003), **Mathematical Methods of Operations Research** (since 2001), **Markov Processes** (1994 – 2001).
- Member of the evaluation board of **RNRT** *Réseau National de la Recherche en Télécommunications*, 1998-2000.
- Consultant for Alcatel (2000 – 2003).
- Member of the visiting committee of **CWI** (1999).
- Chairman of **groupe MAS** (Modélisation Aléatoire et Statistique) of the SMAI (1995 – 1999).
- Scientific Adviser for **Centre National d'Etudes des Télécommunications** (1986 – 1989).
- Coordinator of the **INRIA-NSF** project on performance evaluation, with **UC Berkeley** and the universities of **Maryland** and of **Massachusetts** (1988 – 1992).
- Member of the direction of C^3 **-CNRS** Project (1985-1990),

F - Plenary/Keynote Lectures

- **Mathematical Theory of Networks and Systems (MTNS'04)**, Louvain, Belgium, 2004 (lecture on network overlays).
- **Applied Mathematics Conference in the Memory of J.L. Lions**, Collège de France, 2002 (lecture on interacting TCP flows).
- **European Mathematical Society − Diderot Forum** on mathematics of communications, EPFL, Switzerland, 2001 (lecture on non-expansive maps).
- **3rd European Conference of Mathematics**, Barcelona, 2000 (lecture on flow and congestion control).
- **Cost−257 Final Conference**, Würzburg, Germany (lecture on cdma coverage), 2000.
- Conference and Workshop on **Stochastic Networks**, 2000 (lecture on tcp modeling) Madison, Wisconsin.
- **Informs Applied Probability** 1999, Ulm, Germany (lecture on stochastic networks).
- **International Teletraffic Conference ITC 16**, Edimburgh, UK, 1999, (lecture on stochastic geometry for communications networks).
- **Conference on Decision and Control CDC 34**, New Orleans, USA 1995, (lecture on discrete event systems).
- **International Conference on Industrial and Applied Mathematics ICIAM'95**, Hamburg, Germany 1995, (lecture on (max, +)-linearity).
- **Stochastic Processes and their Applications (SPA)**, Technion, Israel, 1991, (keynote lecture on stochastic (max, +) systems).

G - Awards

- **Marcel Neuts Prize 2000**, of the Applied Probability Foundation of America.
- *Grand Prix France Télécom 2002*, of the **French Academy of Sciences**.
- **IBM Academic Award 2003**, for research on multicast overlays.

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[B6]   F. B., A. JEAN-MARIE and I. MITRANI (Ed.) "Quantitative Methods in Parallel Systems", Basic Research Series, **Springer Verlag**, 1995.

[B5]   F. B. and P. BREMAUD, "Elements of Queueing Theory", **Springer Verlag**, Applications of Mathematics, 1994. Second edition 2003.

[B4]   F. B., G. COHEN, G. OLSDER and J.P. QUADRAT "Synchronization and Linearity", **Wiley**, 1992.

[B3]   F. B. and P. BREMAUD, "Palm probabilities and Stationary Queues". **Lecture Notes in Statistics No. 41**, Springer Verlag, March 1987.

[B2]   F. B., "Modèles Probabilistes de systèmes informatiques distribués". **Thèse de Doctorat d'Etat**, April 1983, Université Paris-Sud.

[B1]   F. B., "Files d'attente avec pannes et applications à la modélisation des systèmes informatiques". **Thèse de 3e cycle**, janvier 1980, Université Paris-Sud.

Publications in journals

[J82]   F. B., A. CHAINTREAU, D. DE VLEESCHAUWER and D. Mc DONALD, "A Mean-Field Analysis of Short Lived Interacting TCP Flows", Proceedings of **ACM Sigmetrics'04**, NY, June 2004. to appear in **Performance Evaluation**.

[J81]   F. B., S. FOSS, and M. LELARGE, "Asymptotics of Subexponential Max Plus Networks; the Stochastic Event Graph Case, Proceedings of the Edinburgh Workshop Modern Problems in Probability, 2002, to appear in **Queueing Systems**.

[J80]   E. LETY, T. TURLETTI, and F. B., "Cell-based Multicast Grouping in Large-Scale Virtual Environments" to appear in **IEEE Transactions on Networking**.

[J79]   F. B., B. BLASZCZYSZYN, B. and M. KARRAY, "Up and Downlink Admission and Congestion Control and Maximal Load in Large Homogeneous CDMA Networks" Proceedings of **WIOPT'03**, Sophia Antipolis, to appear in **ACM MONET**.

[J78]   O. DOUSSE, F. B. and P. THIRAN, "Impact of Interferences on the Connectivity of Ad Hoc Networks", Proceedings of **IEEE INFOCOM'03** (nomination for the best paper award), San Francisco, 2003, to appear in **IEEE Transactions on Networking**.

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