Professional Statement of Muriel Médard

The motivation of my work is the fact that communications have moved away from point-to-point, or link, models, to networked models. Moreover, the nature of these networks is increasingly heterogeneous, relying on a federation of different physical layers, ranging from optical fiber communications to wireless links. This heterogeneity allows for flexibility and quasi-ubiquitous access to networked systems, but often at the expense of robustness and reliability. Growing societal reliance on networked services renders an interruption or degradation of service, whether by malicious attack or inherent variability of the physical layer, particularly grievous. I seek to determine, in my research, a means of providing effective and reliable networked communications, with strong consideration of the physical layer.

My goals in the areas of research and education are to:
- Contribute to the understanding of the fundamental limits of reliable communications in networked environments,
- Establish, based upon theoretical understanding, applications to enhance the reliability of networks,
- Provide teaching and research services which will train our future engineers in a way that directly connects theoretical understanding to practical implementations.

My research interests lie in three main areas: wireless communications, particularly the information-theoretic investigation of fading channels; high-speed networks, particularly in the areas of robustness and security; and network coding, which brings together coding and networking to change dramatically the way in which networks operate. All three of these areas relate to end-to-end transmission reliability and efficient use of resources. My main contributions in the investigation of fading channels is establishing explicitly how channel estimation fundamentally affects channel capacity and how channel estimation crucially determines what type of signaling can be used in wide band channels. This research has crucially affected the design of signaling for wide-band channels. In the area of high-speed networks, my main contributions are characterizing the effects that physical layer phenomena have on security and reliability of optical networks and establishing novel protection mechanisms for wide-area and local area networks that do not use traditional ring-based approaches. This work has led to a whole new direction in optical network security, particularly for government and military applications. In the area of network coding, my main contributions are in the establishment of network coding as an algebraic problem, and using this powerful framework to show that multicast network systems can be operated optimally using at network nodes random and distributed approaches. The impact of this work has been very rapid, having immediately spawned industry demonstrations.

My research style lies at the juncture of theory and practice. While much of my work tends to be mathematical in terms of the tools I use, the problems I seek to solve originate from practical engineering considerations in communications and networks. I am particularly interested in determining the theoretical limitations of systems, and in determining how these theoretical limitations guide the architecture of new communication systems.

The transition from link-based system design to network-based design has posed for me an unique opportunity to merge communications and networking. My work in the area of fading channels has led to better understanding of the fundamental limits of wireless channels. My work on the effect of channel estimation error was recognized by the IEEE Leon K. Kirchmayer Prize Paper Award 2002 for my paper, "The Effect Upon Channel Capacity in Wireless Communications of Perfect and Imperfect Knowledge of the Channel," IEEE Transactions in Information Theory. The IEEE Leon K. Kirchmayer Prize Paper Award was established in 1997 as the successor to the Browder J. Thompson Memorial Prize Award. It is presented by the IEEE Board of Directors for the most outstanding paper by an author(s) under 30 years of age, at the date of submission of the original manuscript. The paper established a relation among channel estimation error, channel variation, and the fundamental limits of wireless channels. This work showed that

communications in wireless environments are governed by the fact that changes in the transmission conditions lead to unavoidable uncertainty in the measurement of the channel. Channel variations are therefore as intrinsic as energy or spectrum in determining the limitations of wireless networks. An excerpt of the IEEE announcement of the prize reads that I am "credited by her colleagues with changing the fundamental understanding of communication difficulties over wireless, time-varying channels."

I have continued to study how time variations affect the fundamental limits of communications. For communications at high carrier frequency, where the traditional decoupling of inter-symbol interference and channel variations no longer hold, my work with A. Goldsmith at Stanford has given a framework for designing codes that withstand both ISI and time variations. My recent work with R. Srikant at UIUC has analyzed the effect of coupled fast and slow fades. My joint work, with U. Madhow at UC Santa Barbara and I. Abou-Fayçal at American University of Beirut, in the area of signaling to adapt to channel error has for the first time shown that significant gains can be reaped from adapting to channel error at the receiver, even in the absence of feedback.

A second significant area of my research in wireless communications is my work with R. G. Gallager at MIT on wideband channel capacity, which is widely recognized as being the first to show that ultra-wideband fading channels, when used with the type of signals that achieve optimum results in non-fading channels, perform very poorly. These results in particular mean that the types of systems that are currently in use for commercial wireless applications cannot be extended to ultra-wideband systems. This work showed that ultra-wideband channels require an entirely different approach, using impulsive signals. My work in ultra-wideband channels has led to extensive follow-on work at the University of California at Berkeley, Bell Labs and the University of Illinois Urbana-Champaign (UIUC). My joint work with D. Tse at UC Berkeley and my student C. Zheng at MIT in signaling over ultra-wideband channels established, from an information-theoretic point of view, the region in which current commercial spread-spectrum systems can achieve good results. My work in this area, with my students C. Luo and D. Lun and with postdoctoral lecturer I. Abou-Fayçal, and with J Huang and S. Meyn, both at UIUC, has included proposing practical near-optimal schemes and showing that optimal schemes designed for the infinite-bandwidth regime are not applicable in practical regimes. Recently, my work, with L. Zheng at MIT and D. Tse at UC Berkeley, has characterized in terms of both energy and channel characteristics the capacity of channels in the low energy regime. We have extended this work, with my student S. Ray, to multiple-input, multiple-output channels.

My interest does only lie in characterizing the performance of wideband channels, but also in determining practical means of attaining near-optimal performance. My recent work with L. Zheng and our student C. Luo has shown that performance of the order of the theoretical optimal can be achieved over wideband channels using multi-tone frequency-shift keying with simple coding. This method, which differs sharply from the current schemes proposed for wideband channels, may provide a new and effective manner to use such channels effectively.

A third area for my research in wireless networks capacity of packetized wireless networks. The theoretical literature in the area of multi-user systems is concerned almost exclusively with systems in which there is a constant stream of bits to be communicated at any time. However, the vast majority of wireless data systems rely on packetized schemes, which are intrinsically bursty. One of my contributions in this area, in conjunction with two of my students (J. Huang at UIUC and T. Coleman at MIT) and my collaborators (A. Goldsmith at Stanford and S. Meyn at UIUC), has been to show that burstiness does not affect capacity. This means in effect that burstiness affects only delay but not the reliably achievable throughput of a system. Also, we described a vast family of codes that achieve the capacity region. This research combines coding, information theory and control to solve a problem which connects the practice of packetized networks with the study of fundamental limitations of networks.

In the area of network reliability, I am an author of much of the original work in the area of optical network reliability and security. I am a frequent invited speaker, invited author, conference organizer and editor in this area, as well as a consultant to the industry. I am the author of several widely referenced papers in optical network reliability. In particular, my collaborators and I were the first to introduce generalized loopback and thereby show that mesh networks may recover from link failures without the use of rings, in a bandwidth-efficient manner (joint work with R. Gallager at MIT, R. Barry of Sycamore Networks S. Finn of MIT LL, S. Lumetta at UIUC and our students Y.C. Tseng and W. He of UIUC).Until then, network recovery was done through the use of rings or overlay of rings, leading to very complicated solutions and placing significant restrictions on the physical topology of networks. My contributions in this area have blended practical applications with different areas of graph theory. This work, along with my work in reliable trees solutions (joint work with R. Gallager at MIT, R. Barry of Sycamore Networks and S. Finn of MIT LL), has been the source of much follow-on work at several universities and Bell Labs, as well as leading to patents. The Advances in Circuits and Systems (quarterly news service of the IEEE Circuits and Systems Society) of August 2004 recently pointed our papers as important new research. My work in network robustness has expanded to consider area how physical layer information affects recovery (joint work with E. Modiano at MIT and our student H.J. Wang) and in the reliability of random graphs (joint work with my student M. Kim at MIT). My recent work in high-speed networking has considers robust and reliable access to optical networks, such as robust optical local area networks (LANs) with simple access (joint work with S. Lumetta at UIUC), robust access overlay networks (joint work with my student A. Libarikian). With V. Chan and our student G. Weichenberg, I have considered the reliability of optical LANs under stress, for such applications as airplane networks. Our work recently received the Best Paper award at the Fourth International Workshop on the Design of Reliable Communication Networks (DRCN 2003).

My contributions in the area of optical network security have shown how physical layer parameters affect the reliability of networks and have shown how countermeasures can alleviate the deleterious effects induced by lower layers. With my student P. Saengudomlert at MIT, I developed theoretical limits to the detectability of security attacks at the physical layer rather than the software layer, with which almost the entirety of the security work is concerned. My work in countermeasures encompasses devices to detect failures (joint work with S. Chinn at MIT Lincoln Laboratory (LL), my student P. Saengudomlert at MIT and D. Marquis at MIT LL), algorithms to localize failures (joint work with R. Bergman at MIT LL and our student S. Chan at MIT) and to recover from failures. The latter class of countermeasures has significant impact in the management of high-speed networks

Recently, I have combined my interests in network reliability and in information theory to work in the area of network coding. My work in this area has led, with my students T. Ho (now graduated, will join the faculty at Caltech in Fall 2005), D. Lun, S. Ray at MIT, with my Postdoctoral Researcher S. Deb, my colleagues D. Karger at MIT, R. Koetter at UIUC, M. Effros at Caltech, to my taking a fresh look at the issue of network capacity, using an algebraic approach. Our approach allows the succinct characterization of the load that a network can carry in an optimized environment. This work moves away from using the network simply to route traffic and allows coding to be performed within the network. Moreover, with T. Ho, we have found clear conditions for network recovery, protection against network failures, and the amount of overhead necessary to protect a network from failing links. This work, which will appear in the IEEE Transactions on Information Theory, holds the promise of being a significant stepping stone towards a deeper understanding of optimal network operation and management, thus leading to improved efficiency networks in scenarios as widely varying as ad hoc sensor networks and the Internet backbone. Our work in an algebraic approach to network capacity has received much attention and was selected as one of the two top papers of the 2002 IEEE Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM). One of our reviewers pointed out that: “it could be one of the papers which will eventually lead to a whole area of network algebraic theory.”

We recently have created the concept of random network coding, by having nodes independently take random algebraic combinations of their inputs over large enough fields and mapping those combinations to their outputs, they can with probability very close to one equal or outperform any multicast routing scheme. This approach entirely radically differs from previous approaches for disseminating information. Instead of coordination and control, it allows complete decentralization and randomness. In October 2003, a few months after our presentation at the International Symposium of Information Theory, Microsoft demonstrated their implementation of distributed random network coding over several networks. Such a very rapid turn-around from theory to practice is very unusual. We have recently demonstrated, along with students B. Leong and Y. Chan of MIT, the usefulness of such random codes in wireless settings. Our work in this area recently received the Best Student Paper Award at the 2004 International Workshop on Wireless Ad-hoc Networks.

We have recently shown that this distributed coding approach can be combined with a distributed cost minimization algorithm, which we designed with my student D. Lun at MIT, my collaborators R. Koetter and his student R. Ratnakar at UIUC. This algorithm not only outperforms, through the use of the properties of coded networks, optimum multicast trees, but is computationally simple and distributed, while multicast trees require centralized processing and are known to be NP-complete and difficult to solve in practice.

There are now whole sessions at several major conferences (Communication Theory Workshop, Conference on Information Sciences and Systems, International Symposium on Information Theory, Allerton Conference on Communication, Control, and Computing) devoted to the subject of network coding. Almost every paper that appears in this topic since 2002 credits our work for setting the algebraic framework for network coding.

My research in network coding has naturally led me, along with my students T. Coleman, A. Lee, T. Ho and my colleague M. Effros at Caltech, to investigate new ways of implementing compression in networks. Our work uses random coding approaches, as well as recent developments in channel coding, to establish new ways to perform compression in a parallelized and distributed way.

My research program is tightly integrated with my educational activities. At the graduate level, my students have received recognition for their work both within MIT and outside MIT. My students publish widely and contribute to the intellectual life of our research community. I also regularly oversee research with MIT undergraduate students and am involved in research projects with high school students through the Center for Excellence in Education, to encourage promising students to pursue careers in science and engineering. I have recently been recognized as an Outstanding Mentor by Siemens for my work with high school students. I strive to play a strong role in mentoring my students' careers and encourage interaction with industry, other faculty at MIT, and other universities.

My three main goals in teaching and advising are to:
- Create intrinsic motivation for performance,
- Encourage collaboration while maintaining individual accountability,
- Recognize the different learning styles of students.

My teaching and advising philosophy has been considerably shaped by my experience as an educator. I was fortunate, as a GE Fellow at UIUC, to participate in the year-long Faculty Teaching College, led by faculty in the School of Engineering and the School of Education. The class is designed for academics to learn more about teaching. Although it was a considerable time commitment, this class helped me understand the different types of learning styles of students and the way to motivate students. In particular, I helped me to realize that most students had very different learning styles from my own and to find means of tailoring the curriculum to different styles. In order to encourage collaboration, I introduced group

exercises and group projects in class. Individual testing allows me to maintain individual accountability. I have also tried to present material in more than one way, when possible, in order to engage students with different learning styles. I have found this last endeavor to be the most challenging of my three goals.

I play a very active role in the teaching activities of the Department. In particular, I have taught and am currently teaching 6.041/6.431 (Probabilistic Systems Analysis and Applied Probability), one of the largest classes in EECS, with an enrollment of about 300 undergraduate students and 50 graduate students. This class is of particular importance to the Institute at large, as it is taken not only by most students in EECS, but is also a required class for undergraduate students in the Department of Management and in the Department of Aeronautics and Astronautics. At the graduate level, I am in charge of 6.441 (Transmission of Information), and have done significant curriculum development for the class. In particular, I have changed the approach of the class so that it integrates tightly our curriculum in the areas of communications and of estimation theory. I have also introduced much material from the recent research literature in a way that is simple, yet rigorous, so that our students are aware of some of the most exciting areas of current research in information theory. These changes have led to my revising the curriculum fundamentally and creating a full set of notes for the class, as well as an extensive set of supplementary readings of research papers in the topic, thematically linked to different lectures and arranged according to difficulty. I am significantly involved with students in 6.441, personally supervising all individual projects. The students have responded very well to this approach to a challenging but very exciting. With D. Katabi, I have significantly revised the material for 6.263 (Data Networks), introducing new material, readings and student projects.

My mentoring role to both undergraduate and graduate students extends well beyond the classroom. My husband and I are Associate Housemasters at Simmons Hall, the new undergraduate dormitory, in whose opening I have been heavily involved. We live in the dormitory, along with our three daughters. We are able to have the type of general, open-ended discussions, with undergraduates that would very seldom occur in the context of a class or of academic advising. We hold weekly events for undergraduates, assist in supervising graduate resident tutors and are always available to counsel, support and advise them on how to balance their academic and personal lives. We also work with visiting scholars program, in which five scholars visiting MIT live at Simmons and participate in the life of the undergraduates, to establish weekly residence-based academic and cultural events. I have also been House Fellow for Green Hall, the women's graduate dormitory, holding discussion events regarding several topics of interest to women in science and engineering. Recently, my various contributions to the MIT community were recognized by my being a co-recipient of the Harold E. Edgerton Faculty 2004 Achievement Award, established in 1982 to honor junior faculty members "for distinction in research, teaching and service to the MIT community,"

I have also been very active in my service to the profession, both in the information-theoretic and optical networking arenas, serving both as a regular associate editor and as a guest editor for special issues in both areas. I have also served on very many program committees for conferences in information theory and in networks, and will be the technical program co-chair for the IEEE Symposium on Information Theory in 2007. I assist the profession in non-technical areas, for instance by being Treasurer of the IEEE Information Theory Society. Finally, I am active in advising industry and government in technical matters, for instance as a member of the Information Science and Technology group (ISAT), or providing briefings for DARPA or the Pentagon.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: January, 2005

Name: Muriel Médard
Department: Electrical Engineering
and Computer Science

1. Date of Birth: February 1, 1968

2. Citizenship: US

3. Education:

School	Degree	Date
MIT	Bachelor of Science in Electrical Engineering	1989
MIT	Bachelor of Science in Mathematics	1989
MIT	Master of Science in Electrical Engineering	1991
MIT	Bachelor of Science in Humanities (Russian Studies)	1991
MIT	Doctor of Science in Electrical Engineering (minor in Management)	1995

4. Title of Sc.D. Thesis:

   The Capacity of Multiple User Time Varying Channels in Wireless Communications.

5. Principal Fields of Interest:

   Information Theory. Networks, Communications.

6. Name and Rank of Other Faculty in the Same Field:

   Vincent W. S. Chan, Professor
   Robert G. Gallager, Professor
   Jeffrey H. Shapiro, Professor
   G. David Forney, Adjunct Professor
   David Karger, Associate Professor
   Gregory W. Wornell, Professor
   Lizhong Zheng, Assistant Professor

7. Name and Rank of Faculty in Other Departments in the Same Field

   Eytan Modiano, Associate Professor without tenure (Aeronautics and Astronautics)
   Moe Win, Associate Professor without tenure (Aeronautics and Astronautics)

8. Non-MIT experience:

Employer	Position	Beginning	Ending
University of Illinois Urbana-Champaign	Assistant Professor	August 1998	December 1999
NYNEX Science & Technology	Intern/consultant	June 1989	December 1989

9. History of MIT Appointments:

Rank	Beginning	Ending
MIT Lincoln Laboratory Staff Member	September 1995	June 1998
Assistant Professor	January 2000	January 2003
Associate Professor (without tenure)	January 2003	May 2005
Associate Professor (with tenure)	May 2005	present

10. Consulting Record:

Firm	Beginning	Ending
NYNEX Science and Technology	September 1989	December1989
Sycamore Networks	March 2000	June 2000
Pebbles Technologies/Malachite Technologies	June 2000	January 2004
Vanu Incorporated	June 2002	September 2003

11. Department and Institute Committees, Other Assigned Duties:

Activity	Beginning	Ending
Graduate Counselor (Dept)	September 2000	present
Graduate Admissions Reader (Dept) (domestic and international, for different years: Africa and Australia; Korea; China and Taiwan)	December 2000	present
House Fellow, Green Hall (Institute)	September 2001	August 2002
Associate House Master, Simmons Hall (Institute)	March 2002	present
Undergraduate Admissions Reader (Institute)	January 2004	January 2004
Organized "Meet Course VI" outreach event (Dept)	Fall 2003, Fall 2004	
Lemelson Prize Committee (Institute)	Fall 2000	
Sprowls Award Committee (Dept)	Spring 2003	
Baker Housemaster Search Committee (Institute)	Fall 2004	
EECS Graduate Admissions Coordinator for Areas I and VII (Dept)	Fall 2004	present

12. Professional Service:

Activity	Beginning	Ending
Program Committee Member for International Society for Optical Engineering (SPIE), Conference on Computer and Network Security	1996	1997
Co-organizer of session for Miniconference on Information Theory at the 1999 International Conference on Communications	1998	1999
Co-organizer of the new optical networking track for the Allerton Conference on Communication, Control, and Computing	1998	2003
Associate Editor for Networks, Journal of Optical Networks of the Optical Society of America	2001	2002
Member of the Information Science and Technology (ISAT) study group for DARPA on "Robust Networks for Critical Missions and Critical Infrastructure"	2002	2002
Organizer of the Optical Networks session for the 17thIEEE Computer Communications Workshop	2002	2002
Technical Program Committee member for the High Speed Networking Conference, 2002	2001	2002
Technical Program Committee member for the 2004 IEEE International Symposium on Information Theory	2002	2004
Session Organizer, Wireless Communications and Networking Conference, 2003	2002	2002
Technical Program Committee member for the	2002	2003

International Workshop on Design of Reliable Communication Networks (DCRN) 2003 (IEEE)		
Technical Program Committee member for ITCom 2003 (SPIE)	2002	2003
Guest Editor, IEEE Journal of Lightwave Technology Special Issue on Optical Networks.	2002	2003
NSF Career review panelist	2002, 2003	
Co-organizer of the new Network Coding track for the Allerton Conference on Communication, Control, and Computing,	2003	present
Program Committee Member, 2003 International Workshop on Optical Networks Control and Management (ONCM'03) (in conjunction with the 32nd International Conference on Parallel Processing)	2003	2003
Associate Editor, Optical Communications and Networking Series of the IEEE Journal on Selected Areas in Communications	2003	present
Technical Program Committee Member, 2004 International Workshop on Wireless Ad-hoc Networks (IWWAN)	2003	2004
Associate Editor, Communications, for the IEEE Transactions on Information Theory	2003	present
Treasurer, IEEE Information Theory Society	2004	present
Co-organizer of an invited session on Network Coding for the 38th Annual Conference on Information Sciences and Systems, Princeton University	2003	present
Co-organizer of an invited session on Network Coding for the Communication Theory Workshop	2003	2004
Member of the Information Science and Technology (ISAT), an advisory group to DARPA	2003	present
Technical Program Committee member for Globecom 2004 Workshop on GMPLS	2004	2004
Technical Program Committee Member for the 2004 Information Theory Workshop	2003	2004
Technical Program Committee Member, 2005 International Workshop on Wireless Ad-hoc Networks (IWWAN)	2004	present
Guest Editor, Joint Special Issue of the *IEEE Transactions on Information Theory* and the *IEEE/ACM Transactions on Networking* on Networking and Information Theory	2004	present
Technical Program Committee Member, Symposium on Information Theory of Wireless Networks, as part of IEEE WirelessCom 2005	2004	present
Technical Program Committee Member for the 2006 IEEE International Symposium on Information Theory	2004	present

Technical Program Committee member for the International Workshop on Design of Reliable Communication Networks (DCRN) 2005 (IEEE)	2004	present
Technical Program Committee member for Broadnets 2005	2005	present
Co-organizer of Netcod 2006 (Second Workshop on Network Coding, Theory, and Applications) in combination with WiOpt	2005	present
Technical Program Committee member for the 2006 Information Theory Workshop	2005	present
Session Organizer for the 2006 International Zurich Seminar on Communications (IZS)	2005	present
Technical Program Committee Co-Chair for the 2007 IEEE International Symposium on Information Theory	2004	present

13. Awards Received:

Award	Date
NSF Career Award	2001
IEEE Leon K. Kirchmayer Prize Paper Award, presented by the IEEE Board of Directors for the most outstanding paper by an author(s) under 30 years of age, at the date of submission of the original manuscript for M. Médard, "The Effect Upon Channel Capacity in Wireless Communications of Perfect and Imperfect Knowledge of the Channel," IEEE Transactions on Information Theory, Volume 46 Issue 3, May 2000, Pages: 935-946.	2002
Recipient of a 2003 Esther and Harold E. Edgerton MIT Chair	2002
Best Paper Award for G. Weichenberg, V. Chan, M. Médard, "Reliable Architectures for Networks Under Stress," Fourth International Workshop on the Design of Reliable Communication Networks (DRCN 2003), October 2003, Banff, Alberta, Canada	2003
Co-recipient of the Harold E. Edgerton Faculty Achievement Award, established in 1982 to honor junior faculty members "for distinction in research, teaching and service to the MIT community,"	2004
Recognized in 2004 as a Siemens "outstanding mentor" for my work with high school students in science and engineering	2004

14. Current Organization Membership:

Organization	Offices Held
IEEE Information Theory Society	Treasurer, starting January 2004
IEEE (senior member)	

Eta Kappa Nu
Tau Beta Pi
Sigma Xi

15. Patents and Patent Applications Pending:

1. M. Médard, S.G. Finn, R.A. Barry, R.G. Gallager., "Method and Apparatus for Automatic Protection Switching," Patent # 6,047,331

2. M. Médard et al. "A Pseudorandom Noise Sequence Noise Generator," patent # 6,201,870

3. M. Médard, S.R. Chinn., "Method and Apparatus for Detecting Security Attacks in Communication Networks," Patent # 6,507,012 and # 6,507,012 B1

4. M. Médard, S.R. Chinn., "Method and Apparatus for Detecting Security Attacks in Communication Networks," Patent # 6,603,112

5. R. Bergman, M. Médard, "Fault Isolation for Communication Networks for Isolating the Source of Faults Comprising Attacks, Failures, and Other Network Propagating Errors," Patent # 6,442,694

6. S. Lumetta, M. Médard, "Fault Tolerant Optical Data Communication Network," filed 2002, Application #10/186,178

7. S.R. Chinn, S. Lumetta, M. Médard, "An Integrated System and Method for Controlling Telecommunication Network Data Communicated over a Local Area Network and Storage Data Communicated over a Storage Area Network," filed 2002, patent pending

8. G. Ciancaglini et al., "Fault Tolerant Optical Data Communication Network Having Auto Discovery," filed 2002, patent pending

9. M. Garofalo et al., "Multiple Switch Protected Architecture," filed 2002, patent pending

10. M. Médard et al., "Method and Apparatus for Medium Access Control for a Communications Network," filed 2003, patent pending

11. T. Ho, R. Koetter, M. Médard, D. Karger, N. Effros, "Randomized Distributed Network Coding Method and Apparatus," provisional patent application

12. D.S. Lun, M. Médard, T. Ho, R. Koetter, "Minimum Cost Routing with Network Coding," provisional patent application

13. S. Deb, M. Médard, "A Network Coding Approach to Rapid Information Dissemination," provisional patent application

14. S. Deb, M. Médard, R. Koetter, “A Random Linear Coding Approach to Distributed Data Storage,” provisional patent application

15. G. Ciancaglini et al., “Method and Apparatus for Provisioning Connection Oriented, Quality of Service Capabilities and Services,” patent application

16. T. Ho, B. Leong, R. Koetter, D. Karger, M. Médard, M. Effros, “Byzantine Modification Detection in Multicast Networks Using Randomized Network Coding,” provisional patent application

16. Professional Registration: NA

17. Major New Products: NA

Teaching and Educational Contributions of Muriel Médard

1. Teaching Experience

Term	Subject Number	Title	Role	Course Type	Course evaluation survey given
FT 98	ECE 434 (University of Illinois Urbana-Champaign)	Random Processes	Lecturer, in charge	Graduate Course	
ST 99	ECE467 (UIUC)	Communication Network Analysis	Lecturer, in charge	Graduate Course	
FT 99	ECE 313 (UIUC)	Probability with Engineering Applications	Lecturer, co-in charge	Undergraduate Course	
ST 00	6.441	Transmission of Information	Lecturer, in charge	Graduate Course	Yes
FT 00	6.263/16.37	Data Communication Networks	Lecturer, co-in charge	Graduate Course	Yes
FT 01	6.041/6.431	Probabilistic Systems Analysis & Applied Probability	Lecturer, in-charge	Undergraduate and Graduate Course	Yes
ST 02	6.441	Transmission of Information	Lecturer, in charge	Graduate Course	Yes
FT 02	6.041/6.431	Probabilistic Systems Analysis & Applied Probability	Lecturer, in-charge	Undergraduate and Graduate Course	Yes
FT 03	6.263/16.37	Data Communication Networks	Lecturer, co-in charge	Graduate Course	Yes
IST 04	6.441	Transmission of Information	Lecturer, in charge	Graduate Course	Yes
FT 04	6.041/6.431	Probabilistic Systems Analysis & Applied Probability	Recitation instructor	Undergraduate and Graduate Course	Yes

Teaching and Educational Contributions of Muriel Médard

2. Teaching Evaluation Data

Term	**Subject Number**	**Total # students registered**	**Total # survey responses**	**Survey Form Used**	**Instructor Teaching Quality** **Average**	**Overall Course Quality** **Average**
FT 00	6.263/ 16.37	30	28	EECS	4.0	4.8
FT 01	6.041/ 6.431	256	117	EECS	3.9	4.6
ST 02	6.441	30	14	EECS	6.4	6.4
FT 02	6.041/ 6.431	229	54	EECS	4.4	4.6
FT 03	6.263/ 16.37	17	11	EECS	6.0	5.6
ST 04	6.441	9	6	EECS	5.7	5.5
FT 04	6.041/ 6.431	200 (55 in recitation)	36 (out of 55 in recitation)	EECS	4.7	5.3 (for 6.041 overall)
ST 05						

3. Other Educational Contributions

a) Teaching materials

i. In 6.441, developed in Latex an all new set of lecture handouts, completely re-designed the syllabus, developed a substantial set of supplementary readings of relevant research papers, organized by relevance to different topics and by difficulty, introduced a research project on major papers in the literature

ii. In 6.263, significantly revised the course, wrote new lecture handouts, in particular in the areas of the use of transforms in analyzing queuing systems, of switching theory, of rerouting, of wireless networks and coding (including network coding); introduced a research design project and reading of major papers in the area

b) Other education contributions:

i. Summer Professional Institute: co-instructor for 6.20S, Digital Communication Networks; significantly updated the curriculum

ii. Developed a new one-day course on network coding in conjunction with Ralf Koetter of UIUC and Phil Chou of Microsoft; the course was given at Centre for Wireless Communications at the University of Oulu and at the IEEE Global Telecommunications Conference (Globecom)

Publications of Muriel Médard

1. Books: N.A.

John
Comment:

2. Papers in Refereed Journals:

1. M. Médard, D. Marquis, R.A. Barry, S.G. Finn, "Security Issues in All-Optical Networks," IEEE Network Magazine, Volume 11, Issue 3, May 1997, pp. 42-48.

2. M. Médard, S.R. Chinn, P. Saengudomlert, "Attack Detection in All-Optical Networks," in Trends in Optics and Photonics (TOPS) – Volume 20 - Optical Networks and their Applications, R.A. Barry, editor, published by the Optical Society of America, 1998, pp. 227-232 **

3. S.G. Finn, M. Médard, R.A. Barry, "A New Algorithm for Bi-directional Link Self-Healing for Arbitrary Redundant Networks," in Trends in Optics and Photonics (TOPS) – Volume 20 - Optical Networks and their Applications, R.A. Barry, editor, published by the Optical Society of America, 1998, pp. 222-226

4. M. Médard, R.A. Barry, S.G. Finn, R.G. Gallager, "Automatic Protection Switching for Multicasting in Optical Mesh Networks," in Trends in Optics and Photonics (TOPS) – Volume 20 - Optical Networks and their Applications, R.A. Barry, editor, published by the Optical Society of America, 1998, pp. 216-221

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107. T.P. Coleman, M. Médard, M. Effros, "Linear Complexity Universal Decoding with Exponential Error Probability Decay", Symposium on Information Theory, Wireless Com 2005, (6 pages, proceedings pending), June 2005**

108. D.S. Lun, M. Médard, R. Koetter, "Efficient Operation of Wireless Packet Networks Using Network Coding", **invited paper**, International Workshop on Convergent Technologies, (5 pages, proceedings pending), June 2005**

109. T.P. Coleman, E. Martinian, M. Effros, M. Médard, "Interference Management via Capacity-Achieving Codes for the Deterministic Broadcast Channel", accepted to the Information Theory Workshop, August 2005**

110. T.P. Coleman, M. Effros, E. Martinian, M. Médard, "Rate Splitting for the Broadcast Channel", accepted to the International Symposium on Information Theory, September 2005**

111. A. Lee, M. Médard, "Simplified Random Network Codes for Multicast Networks", accepted to the International Symposium on Information Theory, September 2005**

112. S. Ray, M. Médard, L. Zheng, "Wideband Non-coherent MIMO Capacity", accepted to the International Symposium on Information Theory, September 2005**

113. C. Luo, M. Médard, L. Zheng, D.S. Lun, "Multi-tone FSK with Feedback", accepted to the International Symposium on Information Theory, September 2005**

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114. D.S. Lun, M. Médard, R. Koetter, M. Effros, "Further Results on Coding for Reliable Communication over Packet Networks", accepted to the International Symposium on Information Theory, September 2005**

115. M. Vehkaperä, M. Médard, "A Throughput-Delay Trade-Off in Packetized Systems With Erasures", accepted to the International Symposium on Information Theory, September 2005

116. S. Deb, M. Médard, C. Choute, "On Random Network Coding Based Information Dissemination", accepted to the International Symposium on Information Theory, September 2005**

4. Other publications: Book Chapter: M. Médard, S.S. Lumetta, "Network Reliability and Fault Tolerance," Wiley Encyclopedia of Engineering, Editor: J.G. Proakis

5. Internal Memoranda:

1. H. Wang, E. Modiano, M. Médard, " Partial Path Protection for WDM Networks – End-to-end Recovery using Local Failure Information," Technical Report LIDS-2517, Sept. 2001

2. D. S. Lun, M. Médard, T. Ho, R. Koetter, "Network Coding with a Cost Criterion," Technical Report LIDS-P-2584, April 2004

3. J. K. Sundararajan, F. Zhao, P.G. Youssef-Massaad, M. Médard, "A Modification to RED AQM for CIOQ Switches," Technical Report LIDS-2585, April 2004

4. J. K. Sundarajan, S. Deb, M. Médard, "To Copy or not to Copy: Extending the Birkhoff-von Neumann Switching Strategy to Multicast S," Technical Report LIDS-2624, August. 2004

5. D. S. Lun, N. Ratnakar, R. Koetter, M. Médard, E. Ahmed, H. Lee, "Achieving Minimum Cost Multicast: A Decentralized Approach Based on Network Coding". Technical Report LIDS-P-2629, September 2004.

6. Invited Lectures:

Spring 1997 "Optical Network Security," Steering Committee Lecture, MIT Lincoln Laboratory

Fall 1997 "Spreading and Recovery: topics in communications," **invited** seminar, University of California, Berkeley

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Fall 1997 "Topics in Communications," **invited** seminar, University of Illinois Urbana-Champaign

Spring 1998 "Topics in Optical Network Security," **invited** seminar, University of Maryland and MIT

Spring 1998 "Security in Optical Networks," **invited** seminar, Rensselaer Polytechnic Institute

Fall 1998 "Restoration in Optical Networks," Coordinated Science Laboratory (CSL) Seminar, University of Illinois, Urbana-Champaign

Fall 1998 "Spreading in Time-varying Channels," **invited** seminar, University of Michigan

Spring 1999 "Capacity of Time-varying Channels with Side Information," **invited** seminar, University of Michigan and MIT

Summer 1999 "Capacity of Time-varying Channels with Side Information," **invited** seminar, Northwestern University

Fall 1999 "An Overview of Security for Optical Networks," Coordinated Science Laboratory (CSL) Seminar, University of Illinois Urbana-Champaign

Fall 1999 "Capacity of Fast Time-varying Channels with Side Information," Coordinated Science Laboratory (CSL) Seminar, University of Illinois Urbana-Champaign

Fall 2000 "Restoration in Optical Networks," **invited** seminar, Carnegie-Mellon University

Spring 2001 M. Médard, "Robustness and Recovery in Optical Networks," **invited** presentation, *IEEE Gigabit Networking Workshop*, also **invited** seminar, George Washington University

May 2001 "Some different aspects of adaptive coding for wireless communications," **invited** seminar, Stanford University and **invited** seminar, Lucent Bell Labs (June 2001)

June 2001, "Robust Optical Communications," **invited** seminar, Lucent Bell Labs

May 2001 and August 2001 "Robustness and Security in Optical Networks," presentation for AFOSR URI kickoff at Stanford University and AFOSR program review at Wright-Patterson Air Force Base

October 2001 "Some New Directions in Communications and Networking," **invited**

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tutorial, Federal Communications Commission

December 2001, "Network Coding for Capacity and Robustness," **invited** talk at the DIMACS (Center for Discrete Mathematics and Theoretical Computer Science at Rutgers University) Workshop on Codes and Complexity

December 2001, "Optical Network Security," **invited** talk to the DARPA Information Assurance for Optical Networks (OpticIA) Workshop

March 2002, "When the Physical Layer Matters - a perspective on networking aspects of wireless communications," **invited** talk, Information Science and Technology (ISAT) study group for DARPA on "Robust Networks for Critical Missions and Critical Infrastructure"

April 2002, "Some Aspects of Robustness in Wireless Networks," **invited** seminar, University of Massachusetts, Amherst

June 2002, "Overview of New Results in Optical Access Networks Robustness," **invited** Photonics Series seminar at the University of Illinois Urbana-Champaign

October 2002, M. Médard , M. Kim, "A Bound on Backup Path Lengths Using a Random Graph Approach," **invited** paper, IEEE Annual Computer Communications Workshop, 2002

October 2002, "Network Coding and Network Management – Towards Fundamental Limits?," **invited** seminar, Cornell University, also **invited** seminar, Boston University

November 2002, "Security in Optical Networks," **invited** briefing to the Assistant Secretary of Defense (C3I) (Highland Forum), at the Pentagon (Washington, D.C.)

Spring 2003, "Network Coding: Towards an Unified View of Routing, Network Management, Coding and Compression?," **invited** seminar, Applied Mathematics Department, Brown University, also **invited** seminar, ECE Department, Georgia Tech, also **invited** IBM Lecture, Notre Dame University

Fall 2004, "Network Coding: Towards an Unified View of Routing, Recovery, Coding and Compression?," **invited** seminar, Harvard University

Spring 2004, "Coding for Networks," **invited** presentation, the Annual Lee Center Workshop (Caltech's Lee Center for Advanced Networking), in which 4 guest speakers present to Caltech faculty, students and alumni

May 2004, D.S. Lun, M. Médard, T. Ho, R. Koetter, "Network Coding with a Cost Criterion," **invited** talk, Communication Theory Workshop

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May 2004, "Network Coding: an Introduction," a one-day course given to the Centre for Wireless Communications at the University of Oulu, Finland (co-taught with Ralf Koetter of UIUC)

August 2004, "Towards a Random, Distributed Operation of Networks," **invited** presentation, Lucent Bell Labs, also Colloquium, Northeastern University, October 2004

October 2004, "Byzantine Modification Detection in Multicast Networks Using Randomized Network Coding," **invited** seminar, Northeastern University

October 2004, "On the Implications of Optical Splitting for Multicasting," **invited** presentation, 19th IEEE Annual Computer Communications Workshop

December 2004, "Network Coding," one-day tutorial at the IEEE Global Telecommunications Conference (Globecom) (co-taught with Ralf Koetter of UIUC and Phil Chou of Microsoft)

January 2005, "An Overview of the Use of Distributed Mechanisms in Network Coding," **invited** presentation, DIMACS (Center for Discrete Mathematics and Theoretical Computer Science at Rutgers University) Workshop on Network Coding

April 2005. "Network Coding for Cost, Reliability and Ease of Management", **invited** seminar, Yale University

June 2005, "Network Coding in Wireless Networks", **Plenary Speaker**, IEEE Workshop on Signal Processing Advances in Wireless Communications (SPAWC), New York

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Theses Supervised by Muriel Médard

Summary

	Total	Completed	In Progress
Bachelor			
Master of Engineering	5	3	2
Master of Science	13	12	1
Engineer			
Doctoral			
As Supervisor	10	2	10
As Reader	18	13	5

Bachelor's Theses and other student projects

Chan, Serena, "Localization of Attacks in Optical Networks," Summer 97 and January, 6-A student at MIT Lincoln Laboratory (Serena is now in the doctoral program at MIT)

Lin, Alvin, "Computer Simulation of Algorithms for Creating Minimal weight Redundant Trees in Edge-Redundant Graphs," Summer 00, project through the Research Science Institute, run by the Center for Excellence in Education, to encourage promising U.S. high school students to pursue careers in science and engineering

Chan, Derrick, "Coding for ALOHA Systems," 6.199 Advanced Undergraduate Project, Fall 2000

Divi, Vijay, "Heuristic Methods for Tree Selection," UROP project, Spring 2001

Abdallah, Rami, "Error Probability in Wireless Channels," Summer 2001, project through the Research Science Institute

Frey, Claudio, "Optimal Spreading Bandwidth in Ultrawideband Channels," Summer 2001, project through the Research Science Institute

Tang, Jie, "Cycles in Large Networks," Summer 2003, project through the Research Science Institute (project was semi-finalist in the Siemens competition)

Ryu, Ho Seung (Paul), "Distribution of Node Degrees in Large Networks," Summer 2003 project through the Research Science Institute (**Project was Semi-Finalist at the Siemens-Westinghouse Competition**)

Bdeir, Ayah, "SNR adaptation for PSAM systems," Summer 2003, undergraduate visiting from American University of Beirut

Theses Supervised by Muriel Médard

Lee, Anna, "Rate-Splitting Implementation of Slepian-Wolf Source Coding," UROP project, Summer, Fall 2003 and Spring 2004

Fink, Evan, "Random Multicast Network Coding," UROP project, Summer 2003

Choute, Clifford, "Network Coding in Gossip Networks," UROP project, Spring 2004

Lee, Hyunjoo (Jenny), "Network Coding with a Cost Criterion," AUP, Spring 2004

Muñoz-Torres, Enrique A., "Cycles and Reliability in Large Random Graphs," AUP, Spring 2004

Ahmed, Ebad, "Distributed Optimization for Multicast Network Coding," UROP Summer 2004, Fall 2004

Tan, Jianlong, "Network Coding for Security," UROP Fall 2004

Master's of Engineering Theses

Zheng, Changqing, "Optimum Spreading Bandwidth for DS-CDMA on Time and Frequency Fading Channels," May 2002

Rettig, Pascal,"Transmit Simulation and Receive Optimization for 802.11b Networks" (6-A student at Qualcomm), May 2002

Le Cocq, Cécile, "Delay Improvements from Multiple Wavelengths in an Optical Folded Bus," September 2003

Choute, Clifford, "Performance of Random Network Coding for Data Dissemination", June 2005

Lee, Anna, "Simplified Random Network Codes for Multicast Networks", June 2005

Theses Supervised by Muriel Médard

Master's Theses

Saengudomlert, Poompat "Analysis and Detection of Jamming Attacks in an All-optical Network," June 1998 (co-supervised with Robert G. Gallager)

Huang, Jianyi, "Capacity of Time-slotted ALOHA Systems," June 2000, University of Illinois Urbana-Champaign (co-supervised with Sean P. Meyn)

He, Wenbo, "Heuristic Algorithms for Failure Recovery in Mesh Networks," August 2000, University of Illinois Urbana-Champaign

Wang, Hung Jen ,"Routing Policy on Robustness in Optical Networks," March 2002 (co-supervised with Eytan Modiano)

Libarikian, Ari "Robustness of Bus Overlays in Optical Networks," April 2002, **winner of a MIT Masterworks (one of 9 in EECS)**

Coleman, Todd,"Trade-off Between Power Consumption and Delay in Wireless Packetized Systems," April 2002, **winner of the Morris J. Levin Award (First Prize) at the MIT Masterworks**

Lun, Desmond, "Error Exponent for Multipath Fading Channels: Strong Coding Theorem," September 2002 (co-supervised with Ibrahim Abou-Faycal)

Weichenberg, Guy,"High-Reliability Architectures for Networks Under Stress," June 2003 (co-supervised with Vincent Chan)

Kim, Minkyu,"Robustness in Large-Scale Random Networks," June 2003

Ray, Siddharth, "Achievable Rates Over Bursty Multiple-Access Noise-Free Channels," September 2003 (co-supervised with Jinane Abounadi)

Youssef-Massaad, Pamela, proposal submitted, started Fall 03 (co-supervised with Lizhong Zheng)

Sundararajan, Jay Kumar, "Extending the Birkhoff-von Neumann Switching Strategy to Multicast Switching" June 2005 (co-supervised with Supratim Deb), **winner of a Morris J. Levin Award at the MIT Masterworks**

Sheng Jing, started Fall 04 (co-supervised with Lizhong Zheng)

Theses Supervised by Muriel Médard

Doctoral Theses, Supervisor

Ho, Tracey, "Networking from a Network Coding Perspective," May 2004. Committee: David Karger, Ralf Koetter (UIUC), Michelle Effros (Caltech) (**received an Honorable Mention from the George M. Sprowls Award for the best doctoral theses in computer science**)

Peranginangin, Nathanael, "On Capacity of Relay Networks with Finite Memory Relays," September 2004. Committee: Robert G. Gallager, Ralf Koetter (UIUC), Vincent Chan

Luo, Cheng, started Fall 01, proposal submitted, "Communications over Wideband Fading Channels," (co-supervised with Lizhong Zheng)

Coleman, Todd, started Fall 02, proposal submitted

Lun, Desmond, started Fall 02

Ray, Siddharth, started Fall 03 (co-supervised with Lizhong Zheng)

Weichenberg, Guy, started Summer 03 (co-supervised with Vincent Chan)

Kim, Minkyu, started Summer 03

Zhao, Fang, started Fall 03

Doctoral Theses, Reader

Visotsky, Yevgeny, "Space-time Transmit Precoding and Interference Suppression for a Wireless Downlink," June 2000 (supervised by Upamanyu Madhow), University of Illinois Urbana-Champaign

Abou-Fayçal, Ibrahim, "An Information Theoretic Study of Reduced Complexity Receivers for Intersymbol Interference Channels," January 2001 (supervised by Amos Lapidoth)

Yeh, Edmund, "Successive Decoding in Multiple-user Communications," June 2001 (supervised by Robert G. Gallager)

Klein, Thierry, "Capacity of Gaussian Noise Channels with Side Information and Feedback," June 2001 (supervised by Robert G. Gallager)

Laneman, Nicholas, "Cooperative Diversity in Wireless Networks: Algorithms and Devices," July 2002 (supervised by Greg Wornell)

Theses Supervised by Muriel Médard

Roy, Sandip, "Moment Linear Stochastic Systems and Their Applications," June 2003 (supervised by George Verghese)

Yao, Huan, "Efficient Signal, Code, and Receiver Designs for MIMO Communication Systems," June 2003 (supervised by Greg Wornell)

Min, Rex, "Energy and Quality Scalable Wireless Communication," June 2003 (supervised by Anantha Chandrakasan)

Shulman, Nadav, "Communication over an Unknown Channel via Common Broadcasting," July 2003 (supervised by Meier Feder), Tel Aviv University

De Couto, Douglas, "High-Throughput Routing for Multi-Hop Wireless Networks," May 2004 (supervised by Robert Morris)

Huang, Jianyi, "Characterization and Computation of Optimal Distributions for Channel Coding," August 2004 (supervised by Sean Meyn), University of Illinois Urbana-Champaign

Wu, Xin Zhou, "Wireless Communications in the Energy-Limited Regime," October 2004 (supervised by R. Srikant), University of Illinois Urbana-Champaign

Rasala-Lehman, April, "Network Coding", (supervised by Madhu Sudan), January 2005

Gentry, Sommer, "Dancing Cheek to Cheek: Haptic Communication between Partner Dancers and Swing as a Finite State Machine"(supervised by Eric Feron), June 2005

Wen, Yonggang, (supervised by Vincent W.S. Chan), expected May 2006

Chen, Li-Wei, "A Study on the Tradeoff between Efficient Resource Allocation and Node Complexity in WDM Optical Networks", (supervised by Eytan Modiano), expected September 2005

Sethuraman, Vignesh, (supervised by Bruce Hajek), University of Illinois Urbana-Champaign

Ratnakar, Narajan, (supervised by Ralf Koetter), University of Illinois Urbana-Champaign

Postdoctoral Associates and Fellows Supervised by Muriel Médard

Previous Postdocs

Name: Supratim Deb

Dates of Appointment: September 2003 – January 2004

Ph.D. Granting Institution: University of Illinois Urbana-Champaign

Current Position: Postdoctoral Fellow (joined Lucent Bell Labs in India at Member of Technical Staff at the end of January 2004)

Name: Ibrahim C. Abou-Fayçal

Title: Post-Doctoral Lecturer

Current Employer: American University of Beirut

Current Position: Assistant Professor