MASSACHUSETTS INSTITUTE OF TECHNOLOGY School of Engineering Faculty Personnel Record.

Date: June, 2001

Name: Muriel Médard Department: Electrical Engineering and Computer Science

- 1. Date of Birth: February 1, 1968
- 2. Citizenship: US
- 3. Education:

<u>School</u>	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:

Networks, Communications, Information Theory.

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

Vincent W. S. Chan, Professor Robert G. Gallager, Professor Sanjoy K. Mitter, Professor Jeffrey H. Shapiro, Professor G. David Forney, Adjunct Professor Gregory W. Wornell, Associate Professor David D. Clarke, Senior Research Scientist Hari Balakrishnan, Assistant Professor Robert T. Morris, Assistant Professor Vahid Tarokh, Assistant Professor

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

Eytan Modiano, Assistant Professor (Aeronautics and Astronautics) Kai-Yeung Siu, Assistant Professor (Mechanical Engineering)

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 Assistant Professor	September 1995 January 2000	June 1998 present
10.	Consulting Record:		
	<u>Firm</u>	Beginning	Ending
	NYNEX Science and Technology Sycamore Networks Pebbles Technologies/Malachite Technologies	September 1989 March 2000 June 2000	December 1989 June 2000 present
11.	Department and Institute Committees, Other Assigned	Duties:	
	Activity	Beginning	Ending
	Graduate Counselor (Dept) Graduate Admissions Reader (Dept)	September 2000 December 2000	present 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
	Organizer of the new optical networking track for the Allerton Conference on Communication, Control, and Computing, 1999, 2000, 2001, 2002	1998	present
	Associate Editor for Networks, Journal of Optical Networks of the Optical Society of America	2001	present
	Member of the Information Science and Technology (ISAT) study group for DARPA on "Robust Networks for Critical Missions and Critical Infrastructure"	2002	
	Organizer of the Optical Networks session for the 17 th IEEE Computer Communications Workshop	2002	
	Technical program committee for the High Speed Networking Conference, 2002	2001	present
13.	Awards Received:		
	Awards	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

14. Current Organization Membership:

Organization

Offices Held

2002

IEEE (senior member) Eta Kappa Nu Tau Beta Pi Sigma Xi

- 15. Patents and Patent Applications Pending:
 - M. Médard, S.G. Finn, R.A. Barry, R.G. Gallager., "Method and Apparatus for Automatic Protection Switching", filed 2/19/97, issued 1999
 - 2) M. Médard et al. "A Pseudorandom Noise Sequence Noise Generator", filed 3/6/98, issued 2001
 - 3) M. Médard, S.R. Chinn., "Method and Apparatus for Detecting Security Attacks in Communication Networks", filed 2/24/99, patent pending
 - 4) R. Bergman, M. Médard, "Fault Isolation for Communication Networks with Propagating Errors", filed 2/27/98, patent pending
- 16. Professional Registration: NA
- 17. Major New Products: NA

Teaching Experience of Muriel Médard

Term	Subject Number	Title	Role
FT 98 (Univer	ECE 434 sity of Illinois Urbana-Cha	Random Processes mpaign)	Lecturer, in charge
ST 99 (Univer	ECE467 sity of Illinois Urbana-Cha	Communication Network Analysis mpaign)	Lecturer, in charge
FT 99 (Univer	ECE 313 sity of Illinois Urbana-Char	Probability with Engineering Applications mpaign)	Lecturer, co-in charge
ST 00 (MIT)	6.441	Transmission of Information	Lecturer, in charge
FT 00 (MIT)	6.263/16.37	Data Communication Networks	Lecturer, co-in charge
FT 01: (MIT)	6.041/6.431	Probabilistic Systems Analysis & Applied Probability	Lecturer, in-charge
ST 01: (MIT)	6.441	Transmission of Information	Lecturer, in-charge

Publications of Muriel Médard.

- 1. Books: NA
- 2. Papers in Refereed Journals:
 - 1) R. Koetter, M. Médard. "Beyond Routing: An Algebraic Approach to Network Coding", accepted to *IEEE/ACM Transactions on Networking* (selected as one of the outstanding papers from INFOCOM for transfer to *IEEE/ACM Transactions on Networking*)
 - M. Médard, S.S. Lumetta, L. Li, "A Network Management Architecture for Robust Packet Routing in Mesh Optical Access Networks", to appear as an invited paper in *IEEE Journal on* Selected Areas in Communications
 - 3) P. Saengudomlert, M. Médard, "Guaranteeing BER in Transparent Optical Networks Using OOK Signaling", to appear in *IEEE Journal on Selected Areas in Communications***
 - M. Médard, R.G. Gallager, "Bandwidth Scaling For Fading Multipath Channels", *IEEE Transactions on Information Theory*, Volume 48, Issue 4, Apr. 2002 Page(s): 840 -852
 - M. Médard, R.A. Barry, S.G. Finn, W. He, S.S. Lumetta, "Generalized Loop-back Recovery in Optical Mesh Networks", *IEEE/ACM Transactions on Networking*, Volume: 10, Issue: 1, February 2002, pp. 153-164
 - 6) M. Médard, S.S. Lumetta, "Architectural Issues for Robust Optical Access", *IEEE Communications Magazine*, Volume 39, Issue 7, July 2001, Pages 116-220
 - M. Médard, S.R. Chinn, P. Saengudomlert, "Node Wrappers for QoS Monitoring in Transparent Optical Nodes", *Journal of High Speed Networks*, 2001 (yearly publication), IOS Press, pp. 247-268 **
 - S. Lumetta, M. Médard, Y. Tseng, "Capacity Versus Robustness: A Tradeoff for Link Restoration in Mesh Networks", *IEEE Journal of Lightwave Technology*, Volume: 18, No: 12, March 2001 Pages: 1765 -1775 **
 - 9) 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, No: 3, May 2000, Pages: 935-946 (Winner of the IEEE 2002 Leon Kirchmayer Prize Paper Award)
 - M. Médard, S.G.Finn, R.A. Barry, R.G. Gallager, "Redundant Trees for Preplanned Recovery in Arbitrary Vertex-Redundant or Edge-Redundant Graphs", *IEEE/ACM Transactions on Networks*, Volume: 7, No: 5, Oct. 1999, Pages: 641-652
 - 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 Series (TOPS)* -Volume:20 - *Optical Networks and their Applications*, R.A. Barry, editor, published by the Optical Society of America, 1998
 - 12) S.G. Finn, M. Médard, R.A. Barry, "A New Algorithm for Bi-directional Link Self-Healing for Arbitrary Redundant Networks", in *TOPS* - Volume:20 - *Optical Networks and their Applications*, R.A. Barry, editor, published by the Optical Society of America, 1998
 - 13) M. Médard, S.R. Chinn, P. Saengudomlert, "Attack Detection in All-Optical Networks", in *TOPS* - Volume:20 - *Optical Networks and their Applications*, R.A. Barry, editor, published by the

Optical Society of America, 1998 **

14) M. Médard, D. Marquis, R.A. Barry, S.G. Finn, "Security Issues in All-Optical Networks", *IEEE Network Magazine*, vol. 11, no. 3, May 1997, pp. 42-48.

Papers in final revision stages:

A.J. Goldsmith, M. Médard, "Capacity of Time-Varying Channels with Causal Channel Side Information", submitted to *IEEE Transactions on Information Theory*

- 3. Proceedings of Refereed Conferences:
 - 1) T. Ho, M. Médard, R. Koetter, "A coding view of network capacity, recovery and management", accepted to the *International Symposium on Information Theory*, July 2002 **
 - Hungjen Wang, Eytan Modiano and Muriel Medard, "Partial Path Protection for WDM Networks: End-to-End Recovery Using Local Failure Information", *ISCC*, July 2002 **
 - 3) Muriel Medard. "Optical network survivability beyond the core", invited paper to ITCOM 2002
 - 4) T. Ho, M. Médard, R. Koetter, "A coding View of Network Recovery and Management for Single Receiver Communications", *CISS*, Princeton, April 2002 **
 - 5) D.S. Lun, M. Médard, I. Abou-Faycal, "Error Exponents for Wideband Multipath Fading Channels – a Strong Coding Theorem", *CISS*, Princeton, April 2002 **
 - 6) Hungjen Wang, Eytan Modiano, and Muriel Medard, "Partial Path Protection for WDM networks", *Informs*, March 2002 **
 - 7) H. Wang, E. Modiano, , M. Médard, "Using Local Information for WDM Network Protection", accepted to *Symposium on Photonics, Networks and Computing*, March 2002 **
 - 8) R. Koetter, M. Médard. "Beyond Routing: An Algebraic Approach to Network Coding", accepted to *INFOCOM*, July 2002
 - 9) T.P. Coleman, M. Médard, "Trade-off Between Power Consumption and Delay in Wireless Packetized Systems", 39th Annual Allerton Conference on Communication, Control, and Computing, October 2001**
 - A.L. Libarikian, M. Médard, "A Robust Optical Folded Bus Architecture for Overlay Access Networks", 39th Annual Allerton Conference on Communication, Control, and Computing, October 2001**
 - 11) R. Koetter, M. Médard, "An algebraic approach to network coding and robust networks", *IEEE International Symposium on Information Theory (ISIT)*, June 2001
 - S. Lumetta, M. Médard, "Towards a Deeper Understanding of Link Restoration Algorithms for Mesh Networks", Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), April 2001
 - 13) A. Narula-Tam, S.G. Finn, M. Médard, "Analysis of Reconfiguration of IP over WDM Access Networks", *Optical Fiber Communication Conference (OFC)*, sponsored by the Optical Society of America, Paper MN4, March 2001

- S. Lumetta, M. Médard, "Classification of Two-link Failures in All-optical Networks", Optical Fiber Communication Conference (OFC), Paper TuO3, March 2001
- 15) M. Médard, R. Srikant, "The Effect on Capacity of Decoupling Slow Fades from Fast Fades in Channels with Asymmetric Channel Information", *IEEE International Symposium on Information Theory and its Applications*, November 2000
- 16) M. Médard, I. Abou- Faycal, U. Madhow, "Adaptive Coding with Pilot Signals", invited paper, 38th Annual Allerton Conference on Communication, Control, and Computing, October 2000**
- 17) P. Saengudomlert, M. Médard, "Limits of BER Guarantees in Transparent Optical Networks Using OOK Signalling", invited paper, 38th Annual Allerton Conference on Communication, Control, and Computing, October 2000**
- M. Médard, D.N.C. Tse, "Spreading in Block-Fading Channels", Asilomar Conference on Signals, Systems, and Computers, November 2000
- M. Médard, S. Lumetta, Y. Tseng, "Capacity-Efficient Restoration for Optical Networks", *Optical Fiber Communication Conference (OFC)*, paper ThO2, March 2000**
- S. S. Lumetta, M. Médard, "Robust routing for Local Area Optical Access Networks", *IEEE Lasers and Electro-Optics Society (LEOS) SummerTopical Meeting*, July 2000
- M. Médard, R. Srikant, "Capacity of Nearly-decomposable Markovian Fading Channels under Asymmetric Receiver-Sender Side Information", *IEEE International Symposium on Information Theory (ISIT)*, June 2000
- 22) M. Médard, J. Huang, S.P. Meyn, A. Goldsmith, "Capacity of Time-Slotted ALOHA Systems", IEEE International Symposium on Information Theory (ISIT), June 2000**
- 23) M. Médard, A. Goldsmith, "Capacity of Time-Slotted ALOHA Systems", Invited Paper, *IEEE Wireless Communications and Networking Conference (WCNC)*, September 1999
- 24) M. Médard, "Processing of Wireless Signals to Preserve Wireline Network Resources", Invited Paper, *IEEE Wireless Communications and Networking Conference (WCNC)*, September 1999
- 25) M. Médard, A.J. Goldsmith, "Capacity of Time-Varying Channels with Side Information at the Sender and the Receiver", *Miniconference on Information Theory,IEEE International Conference on Communications (ICC)*, June 1999
- 26) M. Médard, S.G. Finn, R.A. Barry, "WDM Loop-back in Mesh Networks", Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), March 1999
- 27) M. Médard, "Secure Optical Communications", Invited Paper, FE3, Lasers and Electro-Optics Society (LEOS) Annual Meeting, December 1998
- M. Médard, "A Coding Theorem for Multiple-Access Decorrelating Channels", *IEEE International Symposium on Information Theory (ISIT)*, August 1998
- 29) J. Yueh, A.H. Chan, M. Médard, "On the Complexity of Reconfigurable Feedback Shift Register Sequences", *IEEE International Symposium on Information Theory (ISIT)*, August 1998
- R.G. Gallager, M. Médard, R.A. Barry, S.G. Finn, "Multicast Automatic Protection Switching in Arbitrary Redundant Graphs", *IEEE International Conference on Communications (ICC)*, June 1998

- M. Médard, A.J. Goldsmith, "Capacity of Time-varying Channels with Channel Side Information", *IEEE International Symposium on Information Theory (ISIT)*, July 1998
- 32) R.A. Barry, M. Médard, "BER Analysis of Low-rate Communications Through a Single Electro-Optic R2 Nonlinear Regenerator", *IEEE Conference on Lasers and Electro-Optics (CLEO)*, May 1998
- 33) M. Médard, D. Marquis, S.R. Chinn, "Attack Detection Methods for All-Optical Networks", Internet Society Network and Distributed System Security (NDSS) Symposium, Session 3, paper 2, February 1998
- 34) R. Bergman, M. Médard, S. Chan, "Distributed Algorithms for Attack Localization in All-Optical Networks", *Internet Society Network and Distributed System Security (NDSS) Symposium*, Session 3, paper 1, February 1998
- 35) M. Médard, S.R. Chinn, P. Saengudomlert, "Attack Detection in All-optical Networks", *Optical Fiber Communication Conference (OFC)*, February 1998**
- 36) S.G. Finn, M. Médard, R.A. Barry, "A New Algorithm for Bi-directional Self Healing for Arbitrary Redundant Networks", *Optical Fiber Communication Conference (OFC)*, February 1998
- 37) M. Médard, A.H. Chan, J.D. Moores, K.A. Hall, K.R. Rauschenbach, S. Parikh, "Ultrafast Cryptography Using Optical Logic in Reconfigurable Feedback Shift Registers", *Proceedings of the International Society for Optical Engineering (SPIE)*, vol. 3228, November 1997, pp. 342-353
- 38) D. Marquis, M. Médard, R.A. Barry, S.G. Finn, "Physical Security Considerations in All-Optical Networks", invited paper, *Proceedings of the International Society for Optical Engineering* (SPIE), vol. 3228, November 1997, pp. 260-271
- M. Médard, "Bound on Mutual Information for DS-CDMA spreading over Independent Channels", invited paper, Asilomar Conference on Signals, Systems and Computers, October 1997
- 40) M. Médard, "Capacity of Correlated Jamming Channels", *Allerton Conference on Communication, Control, and Computing*, November 1997
- 41) A.H. Chan, M. Médard, "Reconfigurable Feedback Shift Registers", *IEEE International Symposium on Information Theory (ISIT)*, July 1997
- M. Médard, A.J. Goldsmith, "Capacity of Time-Varying Channels with Channel Side Information", *IEEE International Symposium on Information Theory (ISIT)*, July 1997
- 43) R.G. Gallager, M. Médard, "Bandwidth Scaling for Fading Channels", *IEEE International Symposium on Information Theory (ISIT)*, July 1997
- 44) S.G. Finn, M. Médard, R.A. Barry, "A Novel Approach to Automatic Protection Switching *IEEE International Conference on Communications (ICC)*, June 1997
- 45) M. Médard, S.G.Finn, R.A. Barry, "Automatic Protection Switching for Multicasting in Optical Mesh Networks", *Optical Fiber Communication Conference (OFC)*, February 1997
- 46) M. Médard, "Security Issues for All-Optical Networks", invited panelist statement, at the *National Information Systems Security Conference*, October 1996
- 47) M. Médard, R.G. Gallager, "The Effect of Channel Variations upon Capacity", IEEE Vehicular

Technology Conference (VTC), April 1996

- 48) M. Médard, R.G. Gallager, "The Effect of a Randomly Time-varying Channel on Mutual Information", *IEEE International Symposium on Information Theory (ISIT)*, September 1995
- 49) M. Médard, R.G. Gallager, "The Issue of Spreading in Multipath Time-Varying Channels", *IEEE Vehicular Technology Conference (VTC)*, July 1995
- 50) T.P. McGarty, M. Médard, "Wireless Architectural Alternatives: Current Economic Valuations Versus Broadband Options, The Gilder Conjecture", *Telecommunications Policy Research Conference*, October 1994
- 4. Other publications: NA
- 5. Internal Memoranda:
 - 1) Hungjen Wang, Eytan Modiano and Muriel Medard, "Partial Path Protection for WDM Networks End-to-end Recovery using Local Failure Information", L IDS report 2517, Sept. 2001.
- 6. Invited Lectures:
 - 1) Spring 1997 "Optical Network Security", Steering Committee Lecture, MIT Lincoln Laboratory
 - 2) Fall 1997 "Spreading and Recovery: topics in communications", invited seminar, University of California, Berkeley
 - 3) 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
 - 5) Spring 1998 "Security in Optical Networks", invited seminar, RPI
 - 6) Fall 1998 "Restoration in Optical Networks", Coordinated Science Laboratory (CSL) seminar, University of Illinois, Urbana-Champaign
 - 7) Fall 1998 "Spreading in Time-varying Channels", invited seminar, University of Michigan
 - 8) Spring 1999 "Capacity of Time-varying Channels with Side Information", invited seminar, University of Michigan and MIT
 - 9) Summer 1999 "Capacity of Time-varying Channels with Side Information", invited seminar, Northwestern University
 - 10) Fall 1999 "An Overview of Security for Optical Networks", Coordinated Science Laboratory (CSL) Seminar, University of Illinois Urbana-Champaign
 - 11) Fall 1999 "Capacity of Fast Time-varying Channels with Side Information", Coordinated Science Laboratory (CSL) Seminar, University of Illinois Urbana-Champaign
 - 12) Fall 2000 "Restoration in Optical Networks", invited seminar, Carnegie-Mellon University
 - February 2001,, "Optical and Wireless Communications Perspectives", presentation at Ideastream, MIT workshop

- 14) Spring 2001 M. Médard, "Robustness and Recovery in Optical Networks", invited presentation, *IEEE Gigabit Networking Workshop*, also Invited Seminar at George Washington University
- 14) May 2001 "Some different aspects of adaptive coding for wireless communications", invited seminar, Stanford University and invited seminar Lucent Bell Labs (June 2001)
- 15) June 2001, "Robust Optical Communications", invited seminar, Lucent Bell Labs
- 16) 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
- 17) October 2001 "Some New Directions in Communications and Networking", seminar to the 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
- 19) December 2001, "Optical Network Security", invited talk to the DARPA Information Assurance for Optical Networks (OpticIA) Workshop
- 20) January 2002, "Some Different Aspects of Adaptive Coding for Wireless Communications", presentation at the Hewlett Packard Wireless Center kick-off
- 21) March 2002, "When the Physical Layer Matters a perspective on networking aspects of wireless communications", invited talk to Information Science and Technology (ISAT) study group for DARPA on "Robust Networks for Critical Missions and Critical Infrastructure"
- 22) April 2002, "Some Aspects of Robustness in Wireless Networks", invited seminar to University of Massachusetts, Amherst
- 23) June 2002, "Robustness Beyond the Core", invited talk to ITcom, sponsored by SPIE (International Society for Optical Engineering)

Theses Supervised by Muriel Médard

Summary

	<u>Total</u>	Completed	In Progress
Bachelors			
Master of Engineering	2		2
Master's	11	8	3
Engineer's			
Doctoral			
As Supervisor	3		3
As Reader	4	3	1

Bachelor's Theses and other student projects

Serena Chan, "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)

Alvin Lin, "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 (Alvin will be a freshman at MIT next Fall)

Derrick Chan, "Coding for ALOHA Systems", 6.199 Advanced Undergraduate Project, FT 00 and ST 01

Vijay Divi "Heuristic Methods for Tree Selection", UROP project, ST 01

Master's of Engineering

Chang Qing Zheng proposal submitted

Pascal Rettig (6-A student)

Master's Theses

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

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

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

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

Ari Libarikian, "Robustness of Bus Overlays in Optical Networks", April 2002

Todd Coleman, "Trace-off Between Power Consumption and Delay in Wireless Packetized Systems", April 2002

Desmond Lun, proposal submitted

Guy Weichenberg, proposal expected (co-supervised with Vincent Chan)

Minkyu Kim, proposal expected

Doctoral Theses, Supervisor

Tracey Ho, started S01

Nathan Peranginangin, started S01 (co-supervised with Robert G. Gallager)

Cheng Luo, started F01

Doctoral Theses, Reader

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

Ibrahim C. Abou Faycal, "An Information Theoretic Study of Reduced Cmplexity Receivers for Intersymbol Interference Channels", January 2001, (supervised by Amos Lapidoth)

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

Sandip Ray (supervised by G. Verghese)

Professional Statement of Muriel Médard

My research interests lie in two main areas: wireless communications, particularly the information-theoretic investigation of fading channels, and high-speed networks, particularly in the areas of robustness and security. Both of these areas relate to end-to-end transmission reliability and efficient use of resources.

My contributions in the area of wireless communications have led to a better understanding of how time variations affect our ability to communicate. An example of such a contribution is the derivation that, for channels decorrelating in time and bandwidth, signals for which the second and fourth moments scale with bandwidth, such as direct-sequence code-division multiplexed signals, have capacity that goes to 0 as bandwidth increases (joint work with R. Gallager at MIT). These results have significant impact in designing ultra-wideband communication systems. My analysis of the effect of channel measurement error on the capacity of single user and multiple user systems has contributed to the understanding of the limitations imposed on communications by measurement errors. For communications at high carrier frequency, where the traditional decoupling of inter-symbol interference (ISI) 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 is in great part concerned with deepening the understanding of time variations (for instance joint work with R. Srikant at University of Illinois Urbana-Champaign (UIUC) in analyzing the effect of decoupling fast and slow fades, joint work with D. Tse at UC Berkeley in signaling over ultra-wideband channels and joint work with U. Madhow at UC Santa Barbara and I. Abou-Faycal at MIT in the area of signaling to adapt to channel error). I have been particularly active in the area of ultra-wideband channels, finding a strong coding theorem for wideband channels to relate probability of error to bandwidth (joint work with student D.S. Lun and I. Abou-Faycal), the efficiency of Frequency Shift Keying with respect to capacity achieving schemes (joint work with student C. Luo) and investigating the optimum area for direct-sequence spreading (joint work with student C.O. Zheng).

In the area of high-speed networking, my main contributions have been to the understanding of vulnerabilities of optical networks and the design of robust high-speed networks. 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. These countermeasures can be devices to detect failures (joint work with S. Chinn at MIT Lincoln Laboratory (LL), student P. Saengudomlert at MIT and D. Marquis at MIT LL), algorithms to localize failures (joint work with R. Bergman at MIT LL and 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. One of my main contributions in the area of failure recovery is in the development of robust multicast algorithms that significantly expanded the previously available solutions (joint work with R. Gallager at MIT, R. Barry of Sycamore Networks and S. Finn of MIT LL) and of the first algorithm allowing for link and node recovery without the use of rings (joint work with R. Barry of Sycamore Networks and S. Finn of MIT LL). The work in link and node recovery has led to the development of means of performing bandwidth efficient link recovery while maintaining performance with respect to several types of double failure metrics (joint work with S. Lumetta and my students Y.C. Tseng and W. He at UIUC). My recent work in the area of high-speed networking has been in the area of robust and reliable access to optical networks, such as robust optical LANs (joint work with S. Lumetta at UIUC), robust access overlay networks (joint work with student A. Libarikian), in the area of understanding how physical layer information affects recovery (joint work with E. Modiano and our student H.J. Wang) and in the application of random graph approaches to rerouting algorithms (joint work with student M. Kim).

Much of my research investigates issues which cut across traditionally separate areas. In particular, joint work with S. Meyn and student J. Huang at UIUC, A. Goldsmith at Stanford and student T. Coleman at MIT, has led to understanding how to code to achieve capacity for bursty protocols, such as ALOHA. Using this framework, we can explicitly evaluate a trade-off between throughput and delay in wireless packetized systems. I am investigating practical applications of these information theoretic schemes through emulation with student D. Chan. My work with student N. Peranginangin and R. Gallager examines the interaction between wireless and wireline resources from an information theoretic perspective.

As an educator, I carry the integrated view of communications and networks from my research into my advising and teaching. As evidenced by my research agenda, I actively involve my students in my research. In advising students, I encourage them to broaden their interests and to consider pursuing research that brings

together different sets of skills. I believe faculty involvement is important for students at all stages in their academic career. This belief motivates my involvement with students at the high school, undergraduate and graduate level. It also motivates my teaching plan. While most, but not all, of my teaching experience has been in teaching graduate courses in stochastic processes, information theory and networks, I plan to teach our undergraduate course in probability (6.041) next term and taught a similar course at UIUC. In the area of curriculum development, I am planning a course in networking for undergraduates, whose needs are not currently met by our more advanced graduate students. My long term teaching plan at MIT is to have regular rotating involvement in one undergraduate course (6.041 -probability), one undergraduate elective (the new networks course), one graduate course for 1st-2nd year graduate students (6.263 - data networks), one more advanced graduate course (say 6.003 recitation or any of the graduate courses in stochastic calculus), with other occasional assignments (say 6.003 recitation or any of the graduate courses in stochastic systems and communications).

My plans for the next five to ten years are to continue work in integrating traditional communications and information theory with the field of networking. My recent work in the area of network coding for failure recovery is bringing together the traditionally separate fields of algebraic coding and rerouting (joint work with student T. Ho at MIT and R. Koetter at UIUC). The effect of this thrust is to contribute to an integrated view of electrical engineering and networks that corresponds to the increasingly integrated curriculum chosen by our undergraduates, as evidenced by the enrollment in our 6.2 option. At the Institute level, this integration will help bring together a coordinated view of communications systems composed of jointly designed components rather than disparate parts.