Electrical Engineering

University of California
Santa Cruz

http://www.ee.ucsc.edu

Benjamin Friedlander
friedlan@ee.ucsc.edu

UC Santa Cruz

School of Engineering

Our Department

- Started in 2000, first graduates in 2001, Preliminary ABET Accreditation 2003
- Currently 12 faculty, 140 Undergraduates and 70 Graduate Students
- Strong research focus
- Research in undergraduate education

EE Faculty

Ben Friedlander	*Stanford*	*1976*	Comm./ Sig.Proc.
Claire Gu	*Caltech*	*1989*	Optics
Mike Isaacson	*Chicago*	*1971*	Bio/Nanotechn.
Steve Kang (Dean)	*Berkeley*	*1975*	VLSI / Opto-elec.
Wentai Liu	*Michigan*	*1983*	Bio/Electronics
Peyman Milanfar	*M.I.T.*	*1993*	Sig./Image Proc.
Ravi Narasimhan	*Stanford*	*2001*	Wireless Comm.
Ken Pedrotti	*Stanford*	*1985*	Optical Comm/elec
Hamid Sadjadpour	*USC*	*1995*	Communication
Holger Schmidt	*UCSB*	*1999*	Optical/Quant. Elec
Ali Shakouri	*Caltech*	*1995*	Nano Energy Conv.
John Vesecky	*Stanford*	*1967*	Remote Sensing

Friedlander Background

- Stanford 1976, Ph.D. EE, MS Statistics
- UC Davis 1989 – 1999
- UC Santa Cruz 1999 – Present
- Consulting
  - Adaptive Telecom
  - Metawave Communication
  - Bridgewave Communication
  - Kiwi Networks

Communications Research

- Ad-Hoc Networks
- Space-time Coding
- Fiber Optics Communications
- Signal processing and Channel Coding in Data Storage
- Optimum Decoding of Linear Block Codes
- Signal Processing and Coding for DSL
- OFDM

Wireless Research Group

- Multiple antennas for wireless
- Communications in shared spectrum
- Performance analysis and bounds

Multiple Antennas for Wireless

- “Smart” antennas
- MIMO
- Space-Time Coding
- Multi-user diversity

Communications in License Exempt Spectrum

- Free & plentiful spectrum
- Open architecture
- Interference

Communications in Shared Spectrum

- How to achieve reliable communications in a chaotic environment?
- Develop “rules of behavior”
- Interference mitigation techniques
- Cognitive radios

Performance of Wireless Systems

- Systems vs. point-to-point links
- Performance metrics
- Area spectral efficiency of WiFi networks
- Performance limits for multi-user multi-antenna systems

Common Wireless Fallacies

- We can get a 10X improvement
- Performance improvements accumulate
- Bounds are just theoretical

802.11 vs 802.16

	WiFi 802.11	WiMax 802.16
Speed	6 - 54 Mbps	70 Mbps
Band	Unlicensed	Both
Coverage	50 - 500 ft	3 - 10 Miles
	LOS	NLOS

Typical Response

"The thing that really grabs me though are the facts that it can go as far at 45-50km and that there is no line of sight necessary! That part just blows my mind, also the joys of about 70Mbps is awesome too."

Range and LOS

- Increasing range by x100 increases pathloss by 40 – 60 dB
- NLOS pathloss is 30 dB more than LOS
- Building penetration loss 15 – 20 dB

- Total: 70 – 90 dB (85 – 110 dB)

WiMax/WiFi Physical Layers

- Fixed communication link with WiFi TX/RX and one with WiMax TX/RX
- Use same power, antennas, data rate, frequency etc.,
- The WiMax link is a few dB better than the WiFi link