



THE WIRELESS WORLD – IT'S WAY COOL!

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EVERYONE, IT SEEMS, IS GOING WIRELESS. Wireless communications technology even shares the spotlight with celebrities and political leaders in major news media. In fact, *Newsweek* recently took a look at the wireless revolution in a cover story that reported the enthusiasm of kids the world over for “way cool smart phones” in addition to presenting more measured assessments from industry experts. And wireless has become much more than a way to talk to each other.

Packing greater digital power than a mid-1990s PC, the phone or PDA (personal digital assistant) in your hand makes it possible to exchange text messages, photos and video while on the move. Wireless enabled laptop computers and proliferating

“hot spots” have also untethered access to the Internet, and to the office and classroom. (See sidebar, “Speaking Wireless.”)

NJIT researchers and alumni are at the forefront of this massive migration to wireless. The significance of their work for the world at large, and for NJIT, is evidenced by the special emphasis on wireless communications technology in the university’s new strategic plan. Along with applied mathematics and architecture, the plan identifies wireless technology as an area where expertise and results to date offer a solid foundation for building an even higher profile in education, research and commercial development.

Billions and billions

Statistics from the wireless world verge on challenging believability for those of us not working in the field — like the billion cell phones shipped in the past two years and the explosive growth in the number of laptop computers equipped for wireless Internet sessions. (See sidebar, “Some Unwired Statistics.”) But viewed in the overall context of global communications, it’s not surprising that wireless has become so prominent. For millions of people in developing nations who can’t be served by wireline networks, wireless promises to give them their first phones. It’s also a way to bring broadband Internet connectivity even to developed regions where providers do not offer high-speed access via phone lines or cable.

At NJIT, the Center for Communications and Signal Processing Research (CCSPR) is a focal point of wireless work. Faculty affiliated with the center, which has been the backbone of communications research in the Department of Electrical and Computer Engineering for two decades, have received funding for projects from many sources. Among these are the National Science Foundation, the U.S. Army and Air Force, and companies that include AT&T, ITT, InterDigital, Nokia, Mitsubishi, Panasonic, Samsung and Telcordia.

Yeheskel Bar-Ness, distinguished professor, Foundation Chair and CCSPR director, points out that the growing level of funding for NJIT’s wireless initiatives reflects the international recognition that the university has achieved in wireless research and development, and for preparing students to enter the field. This recognition also encompasses the number of issued and pending patents — a dozen in just the past few years.

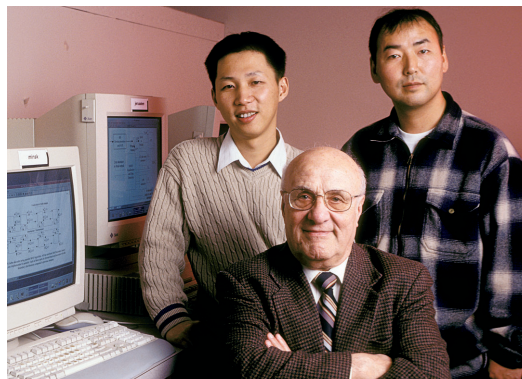
Finding MIMO at NJIT

The work that NJIT is carrying out in cooperation with industry, government and other universities addresses numerous aspects of wireless technology.

An especially notable achievement according to Bar-Ness is the set of algorithms developed by NJIT researchers that has become an industry standard facilitating CDMA — code division multiple access. This is one of the most widely used digital cell phone technologies. Also notable are the solutions to problems involving OFDM — orthogonal frequency division multiplexing — which can greatly increase the amount of digital data sent over wireless networks with minimal signal degradation.

Professor of electrical engineering and CCSPR member Alex Haimovich, who has directed various wireless projects at the university, says that “pressure just keeps building to expand the wireless envelope when it comes to transmission speed, user mobility, and transparent transitions across equipment, carriers and services.” Other members of the Department of Electrical and Computer Engineering affiliated with the CCSPR include Assistant Professor Ali Abdi, Professor Nirwan Ansari, Assistant Professor Hongya Ge and Assistant Professor Roy You.

In addition to theoretical analyses aimed at increasing basic knowledge about wireless communications, Haimovich and his colleagues are working to develop technologies that the industry needs to realize these objectives. MIMO is one such technology. MIMO, which stands for multiple input/multiple output, uses antenna arrays to increase the bit rate of wireless communications. “Antennas are a multiplier for bandwidth,” Haimovich says, “and bandwidth to support the services that a growing number of people want is a very valuable resource.”



Yeheskel Bar-Ness (seated), distinguished professor and director of the Center for Communications and Signal Processing Research, with graduate students Songping Wu (left) and Seokhyun Yoon.

SPEAKING WIRELESS

Wireless technology is spawning abbreviations, acronyms and other descriptors as rapidly as new hardware and ads for service providers. Here's a sample of the wireless world's burgeoning vocabulary:

Bluetooth®: Technology for short-range wireless connections, such as eliminating the wires between a computer and printer, or between a combination earpiece-mike and cell phone. Think Bluetooth the next time you see someone in the supermarket who appears to be having an intense conversation with a can of soup.

GPS: The Global Positioning System that uses 24 satellites to transmit data that can be tapped by hand-held devices or built-in systems in automobiles to help you find your way to the best steak restaurant in an unfamiliar city — or to provide an alternate route around a serious accident.

Hot spot: The wireless place to be in a building or outdoors. Hot spots provide access to local area networks and the Internet, typically via a wireless-enabled laptop or handheld device that combines voice and data communications capabilities.

SMS: The Short Message System that supports emailing with cell phones. In Europe, it's often referred to as "texting."

2G, 3G, 4G: The generations of wireless technology. Third generation, or 3G, standards and techniques go beyond 2G by providing better capabilities for roaming and data transmission. 3G marks the transition from mobile service focused primarily on voice to multimedia services. 3G is also a way to accommodate different cellular standards such as Global System for Mobile (GSM), Code Division Multiple Access (CDMA) and Time Division Multiple Access (TDMA). While still primarily a gleam in the collective eye of service providers, hardware companies and researchers, 4G promises to expand the wireless envelope still further in terms of data transport and what can be done with handheld wireless devices.

VoIP: Voice over Internet Protocol is a way to shift telephone traffic to the Internet from conventional networks. The mobile phone in your hand may eventually allow you to place VoIP calls worldwide at no other cost than that of your broadband Internet access.

Wi-Fi: Wireless Fidelity, or Wi-Fi, is the set of industry standards that allows connecting with local area networks and the Internet through laptop computers and other devices, usually at a range of several hundred feet from a Wi-Fi base station.

Wi-Max: Short for Worldwide Interoperability for Microwave Access, Wi-Max technology greatly extends the range at which you could use mobile devices for broadband services.

BLASTing into the wireless future

Not a few NJIT graduates are working to shape the wireless future. For one of them, Gerard Foschini '61, advancing this technology has been a real BLAST (See sidebar, "The BLAST Solution.") In recent years, the CCSPR has helped an increasing number of alumni head in the same professional direction. For example, 7 of the 10 students who received PhDs at the university's May 2004 commencement earned their degrees for work under the auspices of the CCSPR.

Other grads are bringing considerable telecom industry experience to bear on the technical challenges of the wireless world. A 1970 graduate with a BS in electrical engineering, Brian Kiernan is chief strategic standards officer at InterDigital Communications Corporation, where he's been "in the middle of the wireless revolution" for 20 years. InterDigital has been a pioneer in the design and delivery of advanced wireless platforms, with a current focus on 3G and wireless LAN (local area network) technologies and products.

Kiernan says that while "voice is still the killer app" there is fast-growing interest in multimedia services. He explains that the implementation of 3G technologies has significant import for all of the services that providers now offer and those they plan to roll out in the near future. The rate of data transmission could be substantially increased, for instance. But that's just part of the 3G story. Providers will potentially be able to serve more customers with less infrastructure, and at the same time improve the quality of service.

Further ahead, over the next 10 years, Kiernan sees an increasingly seamless handoff from one wireless environment to another. Using the same communications device, we should be able to "keep a session going" from a local area network in the office or at home, to a Wi-Fi or Wi-Max network on the street, to a cellular network while traveling on the highway.

"Given the bandwidth, they will fill it," Kiernan says, "and we may be surprised by the applications that will excite consumers. Enthusiasm for feeding a parking meter or buying a can of soda from a vending machine on credit through your cell phone might seem far-fetched. But who would have thought that downloading customized ring tones would be as popular as it is?"

In 2003, U.S. cell phone users spent \$80 million to download such ring tones, with individual downloads of tones that include snippets of music costing between 99 cents and about \$2.50. This is a four-fold increase over 2002. Worldwide, people spent around \$3.5 billion for ring-tone downloads, which adds up to 10 percent of the global music industry's total revenue.

Echoing Kiernan, My Chung says that people want to be reachable at one number any time, any place, and they want to do much more than just talk to someone. Chung, who received a BS in electrical engineering from NJIT in 1974, is group president for Spirent Communications. Spirent is a large international firm specializing in performance analysis and service-assurance solutions for emerging network technologies, including wireless broadband.

Chung says that the convergence of Wi-Fi and 3G technologies in the same handset presents the possibility of moving seamlessly from a home wireless environment to other locations at will. But a provider's network has to be able to deliver the quality of service that users will demand for applications such as text messaging and video. "Not too long ago, we were working with handset manufacturers primarily to assess signal strength. Now we've

moved on to evaluating network infrastructure for the ability to support multiple applications."

The very serious side

Undeniably, efforts to improve wireless communications for personal convenience, productivity and entertainment are of major economic and social significance. But wireless technology is also integral to homeland security and the capabilities of the nation's armed forces.

Isidore Venetos, who has an MS in electrical engineering from NJIT and is a PhD candidate at the university, is involved in one very serious aspect of wireless. Venetos is SIGINT (signals intelligence) technology branch chief with the U.S. Army Communications-Electronics Research, Development and Engineering Center's Intelligence and Information Warfare Directorate at Fort Monmouth in New Jersey.

Venetos is working on new ways to gather intelligence based on analyzing signals from the electronic equipment that an adversary has deployed to determine the type and location of that equipment. The basic goal of this initiative, he says, is to help commanders formulate the most effective response possible by arming them with even more informa-





Professor Alex Haimovich (left) of the Center for Communications and Signal Processing Research and Professor Atam Dhawan, director of the New Jersey Center for Wireless Networking and Internet Security

tion about the capabilities of their opponents in a hostile environment.

Work in the wireless security arena at NJIT is coordinated by the New Jersey Center for Wireless Networking and Internet Security (NJWINS). This cooperative venture, which receives advisory input from industry, includes Princeton University and Stevens Institute of Technology. Headed by Professor Atam Dhawan, who also chairs the Department of Electrical and Computer Engineering, NJWINS is dedicated to research and commercial development involving a host of issues related to network operation.

“The implementation of our plan to build the ECE department’s strength in wireless communications, networking and security has been very timely in view of society’s needs,” says Dhawan. “We are proud that these efforts will receive additional support as a key part of NJIT’s strategic plan. The faculty and students who have worked so hard over the years to establish the foundations of this program deserve special congratulations.”

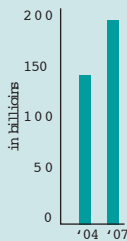
Dhawan and his colleagues have an extensive, well-funded R&D agenda. Some areas of investigation are resource allocation in wireless networks, secure management of ad-hoc networks, intrusion detection, multi-level network and data security, techniques to protect information such as data hiding and watermarking, transaction authentication, and post-attack analysis that includes tracing IP addresses back to the origin of a security breach.

“It’s only natural for us to want to use innovative communications technologies to share information in new and exciting ways,” Dhawan says, “but this makes network security a fast-moving target. No matter how you protect a network, someone will find a way to circumvent that protection, and the good guys must take the next step.”

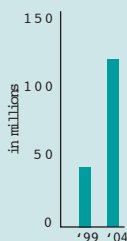
As an example of the complexity of providing security for communications these days, Dhawan

SOME UNWIRED STATISTICS

Gleaned from the Telecommunications Industry Association, CTIA (the international wireless industry organization), and other comparable sources:



- The U.S. market for all wireless products and services is expected to be \$190 billion in 2007, up from an estimated \$145 billion in 2004



- Cell phone users in Latin America rose from about 40 million in 1999 to 118 million today

- AT&T’s first cellular network, brought online in Chicago in 1977, served 2000 customers
- As of July 2004, there were some 167 million wireless subscribers in the U.S.
- Almost a billion cell phones have been sold in the past two years alone
- Virtually all major wireless providers — Verizon, AT&T, Cingular, T-Mobile — are planning to roll out broadband video and music services
- China, where the number of cell phone users increased at the rate of two each second, overtook the U.S. as the world’s largest cell phone market by number of customers in 2001



- By the end of 2004, half of all laptops shipped will be Wi-Fi ready

- Some 1.5 billion cell phones are now in use around the world, outnumbering PCs three to one

3 TO 1

points to the emergence of ad-hoc networks, which can consist of people on the move using a variety of communications devices and applications. In such an environment, making sure that authorized users have access to service and unauthorized users do not can be especially challenging.

While NJWINS was on the organizational drawing board before 9/11, its planned work gained new urgency after the center opened for business on January 1, 2002. As we all come to rely more and more on wireless, Dhawan says, it's imperative that responding individuals and agencies in a local or national emergency be able to depend on the networks and equipment involved.

"Critical message and data traffic must not only get through, but it must be handled without delay on a priority basis," he says. "This can present significant challenges given the bursts of traffic generated by all those trying to communicate in an emergency. It's also vital to be on guard against electronic attacks against the communications infrastructure in such a situation."

For Dhawan, while these and other security issues loom large, the positive economic and social potential of wireless is equally important. Increasingly, he says, decision makers in the public and private sectors are conducting business on the move, with the expectation of reliable high-speed access to essential information in any location, at any time. In essence, this is the expectation of everyone who enters the wireless world. Wireless technology does allow some people to inflict inane conversations on those nearby in a restaurant or theater. But there's also the physician who can respond immediately to an emergency, or the parent who knows that a child is safe and only delayed in coming home by a late-night flat tire. ■

For more information on the Web, visit the Center for Communications and Signal Processing Research and the New Jersey Center for Wireless Networking and Internet Security by clicking on "Centers & Labs" on the NJIT homepage (www.njit.edu) and then the links for the individual centers under "Computing, Mathematics and Telecommunications." Visit the Department of Electrical and Computer Engineering at www.njit.edu/ece.

THE BLAST SOLUTION

Its full name is Bell Labs Layered Space Time — BLAST for short — and in large measure it's the work of Gerard Foschini, a 1961 graduate of Newark College of Engineering. In the mix of innovations energizing the wireless revolution, BLAST technology is one of the most promising. Using a multiple antenna configuration for both transmitting and receiving systems, BLAST technology could increase the capacity of a wireless network enormously. It is also an especially effective way to facilitate wireless communications in obstacle-cluttered environments ranging from cities to forests.

In 2002, MIT's *Technology Review* magazine included the patent for BLAST that bears Foschini's name in its annual tally of "patents to watch," with the significance of this advance underscored by the fact that just five patents were accorded such recognition. That same year his contribution to developing BLAST earned Foschini the Thomas Alva Edison Patent Award. This award is sponsored by the Research and Development Council of New Jersey, and it honors men and women whose inventions have especially significant implications for technological and social progress.

Foschini has been with Bell Labs since graduating from NCE some 43 years ago. He is a Bell Labs Fellow and Distinguished Member of Technical Staff in the Wireless Communication Research Laboratory. Of the education that prepared him for this career, he says that he was a mediocre student until he entered NCE to study electrical engineering. "For the first time, I worked hard in school, and to my surprise I enjoyed it immensely. The courses really sparked my interest, and it was great to be on campus with students and faculty who were just as enthusiastic as I was. I will always appreciate how NCE changed my life."

BLAST