WINLAB
WIRELESS INFORMATION NETWORK LABORATORY

Packets

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BREAKING NEWS!!!

FOCUS '99
ON
HOME RF

Hosted By
UC Berkeley Center for
Wireless Communications
and
WINLAB

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New Brunswick, New Jersey
USA

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What's Inside

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WINLAB - Then and Now

by David J. Goodman, Director

When WINLAB opened for business in July 1989, analog cellular phones were ramping up in the marketplace, and second generation systems were on the drawing board. Then, as now, WINLAB research fell into two overlapping categories: and ***technology creation***. To evaluate wireless technologies, WINLAB produces mathematical and simulation tools for predicting system performance. Technology creation focused initially on third generation systems, then a distant speck on the time horizon. Both activities produced a host of significant achievements. Performance analysis has produced the first mathematical techniques for evaluating the interrelated effects of power control and coding in CDMA systems and the first techniques for quantifying the amount of work a mobile communications system has to do to track the locations of subscribers. Technology created at WINLAB has often related to packet transmission and switching in wireless systems. While wireless packet communications is a hot topic today, it seemed exotic in the early 1990s. Another theme of the early research was distributed network control. This thrust led to breakthroughs in radio resource management, including new techniques for power control, handoff, and channel allocation. Many of the early WINLAB innovations by now have been absorbed into the products, practices, and research programs of our sponsor companies and by the wireless communications community in general.

Because wireless communication has come so far in the past nine years, it is a good idea to take stock of where we are now and to articulate the viewpoint which is shaping WINLAB research today. One way to summarize the present situation is to update the first sentence of this article. Now, ***digital*** cellular systems are ramping up in the marketplace and ***third*** generation systems are on the drawing board. I think that the autumn of 1998 is an especially exciting time for us. With cellular telephones commonplace consumer items on every continent and mobile satellite systems entering commercial operation, the vision of anytime, anywhere communications is now a reality, at least with respect to telephone calls and short messages. By contrast, wireless delivery of other information services (most of them in the category of wireless data services) has so far failed to meet expectations. This situation poses a major challenge to the technical community.

Industry's responses to this challenge are embodied in the dozen or so third generation (3G) systems under consideration by the IMT-2000 project of the International Telecommunications Union. To place the 3G systems in perspective, we should ask why wireless data has not yet caught on in a big way. In my mind, there are four principal reasons: tranmission rates are two slow; services are too expensive; power budgets are excessive; and the user interface is not matched to the needs of people moving around with small terminals. The 3G systems explicitly address the first issue by aiming for speeds on the order of hundreds of kilobits per second and higher. However, they fail to address the other three issues significantly.

In this environment, WINLAB research in 1998 parallels our early days. Among the 35 present projects, many evaluate and optimize new systems while others create enabling technologies for the distant future. Sponsors will have an opportunity to examine all of them at the Fall Research Review on October 20 and 21, 1998. In the remainder of this article, I will focus on a theme of a cluster (continued on page 4)

FOCUS 98 IS A CLEAR SUCCESS

UNIQUE CONFERENCE "FOCUSES" ON U-NII

In June, WINLAB unveiled a new format for its longstanding Workshop— one which "focuses" on a topic of broad interest from a variety of directions, including technology, market, economics and regulation. The topic of Focus '98 was the Unlicensed National Information Infrastructure, a mouthful of words which is better known by its acronym—U-NII.

At 5 GigaHertz, the U-NII is a more difficult band to use than cellular or PCS, but since it offers 300 MHz (in three 100 MHz bands) with almost no rules, the industry must try to decide whether it represents gold or that other stuff. Focus '98 looked at that question from a variety of directions, and while it raised many more questions than could be answered, attendees enjoyed both the topic and the format.

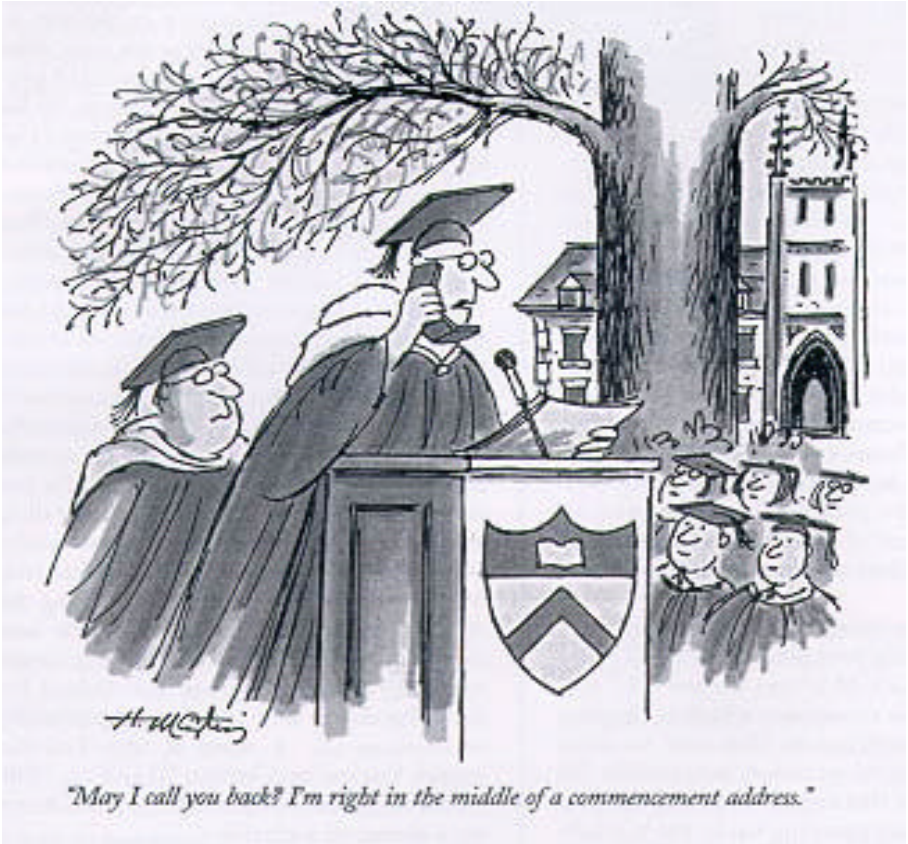
A BAND FOR ALL REASONS

The original petition that led to the U-NII proposal envisioned a wireless superhighway over which schools and other institutions could satisfy their vast need for information. This vision was immediately questioned by some speakers, who felt that both costs and power limitations would be a problem, and that the use of fixed Internet access points would drive schools toward copper and fiber.

As the vision for U-NII expanded to include other applications, viewpoints aligned along two different axes, with one group focused on high-speed point-to-point or point-to-multipoint communications that might cover several miles and the other on short-range networks with the potential for mobility. This was partly due to the different power limitations in the 100 MHz sub-bands, but it also illustrated the uncertainties and conflicting viewpoints that surround and confound the subject of wireless data.

From community networks, to LANs in hospitals, to "home systems", a variety of potential uses were aired—and to keep attendees from flying too high DeWayne Hendricks of COM21 argued most emphatically that ***no*** existing applications seem to require the huge allocation represented by this band. Thus, while ideas abound, the uncertainties of market appear to overshadow issues of technology in the U-NII.

CARTOON CORNER



"May I call you back? I'm right in the middle of a commencement address."

A STANDARD BY ANY OTHER NAME ...

One of the most spirited discussions involved the regulations (or lack thereof) which would allow this new band to grow and prosper. Are channels required? What is an "etiquette", anyway? Are the Europeans on the right track with their greater emphasis on standards, or is "Freedom Road" the path we should take?

There is conflicting evidence that having no rules can help innovation, and can throttle it as well! The unlicensed ISM (Industry, Science and Medical) bands have almost no governmental rules and have spawned a variety of products and services, from cordless phones to internet access, toll collection and vehicle location. Amateur radio has a long positive tradition of operational etiquette. The European HIPERLAN, on the other hand, was pointed to as an unlicensed system that isn't working as well as had been hoped.

It was felt by many that some form of regulation was needed to reduce the risk of investment in technology and infrastructure, while others pointed out that regulation has the potential to delay and handcuff innovation. Attendees agreed to disagree, and Mike Marcus of the FCC cautioned the industry to "be careful what you wish for— you could get it". He went on to say that if the industry wanted rules in this open bandwidth, the FCC would probably comply but that changing the rules afterward would be a Herculean task.

SETTING THE RESEARCH AGENDA

Invigorated by two days of multidisciplinary interaction, attendees met to shape a research agenda for U-NII. From antennas to etiquettes, the range of proposals was as broad as the backgrounds of the participants. Whatever the uncertainties, all agreed that this is a good area for research, with important potential payoffs. In particular, attendees want to study the implications of dissimilar applications sharing the band, and the extent to which interference can be mitigated by etiquettes, smart antennas, spreading, coding and the other tools of the design engineer. Underneath it all remains the fundamental questions of markets and services—what will the user need and be willing to buy—and of course the need to address the all-important issue of COST!

(Continued on next page)

SUMMING UP

Participants agreed overwhelmingly that FOCUS '98 chose a timely topic and supported the continuation of this novel format in future years. In the words of participants: "Good conference." "Well organized." "Lots of time to talk, relax the mind and think." "Small group [led to] good interactions." "Good topic." "I absorbed more and thought more than at a 'typical' conference with papers." "I enjoyed the format immensely because it encourages networking and it addresses the most important issues ."

Gang Wu

WINLAB Visiting Scholar

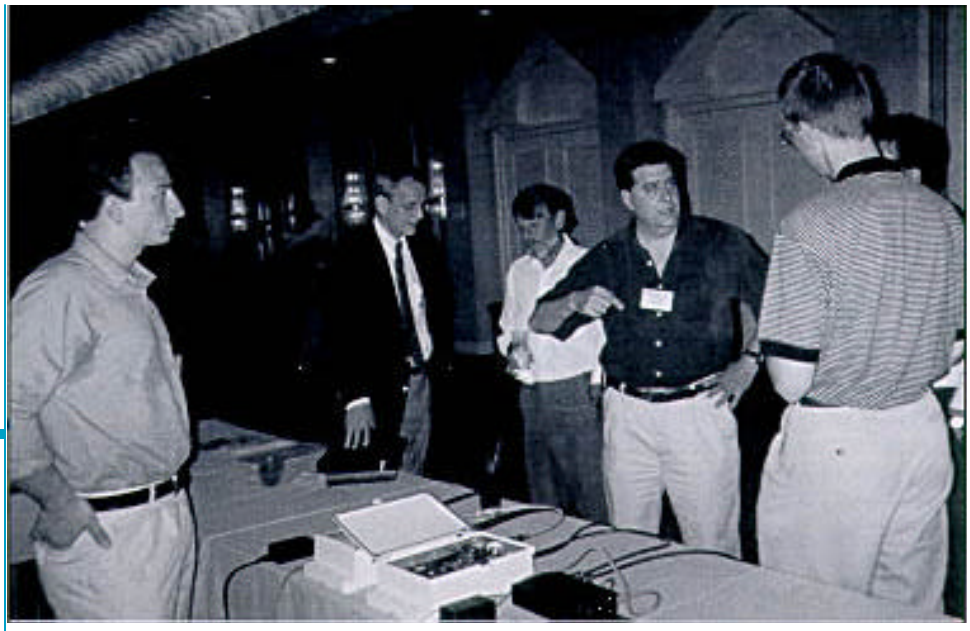
Since his arrival at WINLAB as a Visiting Scholar in March 1998, Dr. Gang Wu has played a lively role in many different activities. In addition to his work on the WINMAC protocol for Infostations which he presented at the June Research Review, Dr. Wu participates in the WIPPET simulation project and is an active mentor to WINLAB students.

In his "day job" in Japan, Dr. Wu is a Senior Researcher at the Communications Research Laboratory, Ministry of Posts and Telecommunications. Since his days as a Ph.D. student at Shizuoka University, there has been a strong tie between his research and WINLAB interests, so it was no accident that Dr. Wu approached WINLAB when he planned his current sabbatical. His most recent assignment before leaving CRL was to design the MAC protocol for a 50 Mb/s LAN. At WINLAB, his primary research is focused on finding ways to download data rapidly to a mobile terminal, even when that terminal is a car that is moving rapidly through the coverage area of an Infostation.

Dr. Wu has also brought with him a dedication to mentoring, and many WINLAB students have benefited from his presence at WINLAB. In the words of WINLAB professor Jim Evans, "Gang Wu possesses great breadth and depth in radio communications and communication protocols. His mentoring is of great help to the students and to the WINLAB faculty." It seems that Dr. Wu is right at home at WINLAB.

Dr. Wu says he is enjoying the opportunity at WINLAB to do some "hands on" research, and to interact with well known researchers in his field.

In addition to the new research ideas Dr. Wu will take home, he will also take home a new baby girl due in October. We all wish him, his wife and daughter the best of luck! Yes, he already knows "It's A Girl".



Lively discussions were an integral part of Focus '98.

Sponsors Review WINLAB Research

Many FOCUS '98 participants stayed an extra day to attend the semi-annual WINLAB Research Review and Advisory Board meeting. At these sessions, WINLAB Sponsors receive an update on the projects going on at WINLAB and help to shape the directions of future research.

The June meeting had three segments. In the first segment, Professor David Goodman presented an updated vision of the focus and goals of WINLAB, expanding on a dinner speech delivered at FOCUS '98 (see page 1 for more on this subject).

In the second segment, several students and faculty members presented the results of their work. Among the highlight talks, Manish Vachharajani discussed publicly for the first time the student-developed NaviDATor, a location-based service for wireless Internet. This two-semester undergraduate class project involved the creation from scratch of a prototype PDA plus a business plan for a Net service that delivers information such as maps and points of interest, based upon the users' location and in a less expensive way than current wireless services. (See Spring PACKETS for a full story).

Visiting scholar Gang Wu of Communication Research Lab, Japan discussed WINMAC, a transmission protocol for Infostations. WINMAC features variable rates based on channel conditions, asymmetric uplink and downlink transmission structures, support of "fairness" and preemptive services, and selective retransmission of data. This initial implementation is based on a Harris Prism radio designed for 2.4 GHz wireless LANs.

Postdoctoral Fellow Pascalis Ligdas brought mathematical game theory into a study of power control in wireless data transmission. He described a non-cooperative game in which each transmitter aims to maximize its own utility.

Dr. Ligdas showed that this game produces optimum results for speech transmission but not for data. In data systems, the situation improves when each transmitter aims for the maximum difference between utiltiy and "price". In this context price is measured not in terms of money but in terms of the negative effect each transmitter has on the utility of other transmissions.

The third segment was a roundtable discussion of WINLAB research and directions. Dr. George Walters of the NSF opened the discussion and summarized the interests of the conference attendees using the feedback forms collected after each talk. High interest was noted in the topics of wireless Internet, WINMAC, mobile location estimation and interference cancellers.

In general, WINLAB Sponsors approved the current focus of the WINLAB research program. They encouraged WINLAB to get more deeply involved in issues related to software defined radios and new protocols for wireless data, especially GPRS, the General Packet Radio System. The meeting concluded with a lively discussion of FOCUS '98, and potential subjects for FOCUS '99.

Then and Now (cont'd)

of new projects. Their aim is to go beyond 3G and simultaneously break the cost, power, and speed bottlenecks of wireless data systems. In addition to the 3G applications of email and web browsing, the new research anticipates a future of greatly expanded computer communications. The vision maps the history of personal computing into the future of wireless communications. Ten years ago, most PCs were desktop computers with communication links confined to printer cables. Today, virtually every PC is also a communications terminal, connected through networks to an array of other devices and information services. If we look beyond PCs at our present world we see computers everywhere - on our wrists, in our cars, in our home appliances, in our power meters, our thermostats... the list is endless. Imagine that one day in the future most of these computers will be able to communicate through wireless networks.

How will this be possible? As yet no one knows. To begin supplying answers I suggest that we reverse four dimensions of the cellular communications paradigm. Cellphones communicate in licensed frequency bands; their transmissions conform to published standards; they rely on a fixed network infrastructure; and they provide seamless (anytime, anywhere) coverage. WINLAB has begun to examine a new paradigm that reverses all four attributes. In this paradigm, computers communicate in unlicensed radio bands, using arbitrary waveforms, forming ad hoc networks that operate in isolated coverage areas. These characteristics can overcome the speed, cost, and power bottlenecks of today's wireless data networks. However, a large array of problems has to be addressed in order to achieve practical results.

In exploring this new paradigm, we are embarking on a voyage of discovery. Will we find valuable treasures or will we return empty-handed? It is far too soon to know. We may have to wait until 2007 to find out if the new paradigm becomes conventional wisdom or a dimly remembered, abandoned folly. That's what makes the quest exciting.

WINSPEAK

The newest WINLAB sponsors are Daimler-Benz, Motorola, and Sprint. WINLAB will play an active role in the New Jersey Center for Wireless Telecommunications, recently established by the New Jersey Commission on Science and Technology. Professors Narayan Mandayam and David Goodman will perform research on "Multimodal Collaboration Across Wired and Wireless Networks" under a major "Knowledge and Distributed Intelligence" grant recently awarded to Rutgers by the National Science Foundation. Congratulations to Sennur Ulukus who recently defended her Ph.D. thesis, "Power Control, Multiuser Detection and Interference Avoidance in CDMA Systems", and Kabir Kasargod, who recently defended his Master of Science thesis on "Optimal Routing Schemes for a Simplified Packet Radio Network Architecture". Special congratulations also to WINLAB graduates Jian Cai and Greg Pollini on their recent marriage.

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