

## The Argument for Wireless LANs

Colleges and universities cite many reasons for their decision to delay installing wireless networks:

- Wireless bandwidth is too limited for effective use by an entire class.
- Security for 802.11b is too weak.
- The industry is too unsettled to commit to wireless technology.
- Students with networked laptops in class will be too busy e-mailing each other to listen to the lecture.

Some of these reasons may sound remarkably familiar. But as persuasive as these arguments can be, wireless local-area networks (WLANs) continue to appear. So let's acknowledge the shortcomings and move on: wireless networks can support a very respectable, but not unlimited, number of users, and bandwidth will improve; security needs to be better, but encryption at the application layer minimizes risk; waiting for technology to stabilize is tantamount to refuting Moore's law; regardless of technology, if a lecture doesn't captivate students' attention, they will find something else that does.

In comparison, consider where we've come with two other technologies that have reduced location dependence—laptops and cell phones. Clearly the early days for these technologies were also filled with a myriad of arguments about their limitations. The phones were too bulky; the laptops (then portables) were too heavy and not nearly powerful enough; and neither had sufficient range (be it cellular coverage or battery life). Nonetheless, each technology is now unquestionably accepted, despite remaining shortcomings.

Since a commitment to deploy wireless should be based on more than the fact that others are doing it and also on more than rosy thinking about the pace of technology adoption, I'd like to relate some experiences with wireless at two different institutions—Carnegie Mellon University and Duke University. Carnegie Mellon was one of the first higher education institutions (if not the first institution) to deploy wireless campus-wide, beginning in the mid-1990s. In about 1995, an initial wireless network of one hundred access points was deployed in support of faculty research. By the time the IEEE 802.11 standard was ratified in 1997, the central computing organization had sufficient wireless expertise and confidence to commit to supporting wireless as a production network. By 1999 every academic and administrative building was covered (along with associated outdoor spaces), and by 2001 the addition of residence hall coverage completed the comprehensive campus wireless network. Adoption rates for the network were quite high, even though there was no student laptop-ownership requirement. By the end of 2001, about one-third of the campus population was using wireless. Moreover, surveys of incoming students showed that nearly 50 percent of students owned laptops in 2001, up from just 19 percent in 1999.

More striking than the extent to which individuals voluntarily embraced the technology for general and classroom uses was its success in supporting existing and in facilitating new areas of research and collaboration. At least in part because of the pervasive wireless network, Carnegie Mellon was successful in getting several grants of handheld computers. Innovative faculty

and student research efforts followed, including significant work in location-based and context-aware computing. The result was that the wireless network facilitated research using wireless networks, regardless of whether that research was related to wireless networks. This is an important subtlety to recognize, since many people brush off Carnegie Mellon's experience as being uniquely tied to the university's technology focus. Although that focus may have partially influenced the earliest research network deployment, in the end there was as much—if not more—research *using* wireless as research *in* wireless.

My second example is Duke University, which is currently deploying wireless in many of its campus buildings. Today that wireless network does not reach every room in each campus building, but the extent of coverage is already facilitating innovative projects with applications in health care, engineering, geographic information systems, computer science, and elsewhere. Though the emphasis of a few of those projects is on wireless networking, the vast majority simply use wireless as a tool, both in research and in the classroom. At the end of the day, wireless is a liberating technology that reduces the constraints of where we compute. And whereas the trend a few years ago was to talk about ubiquitous computing in the sense that every student should have a laptop, the reality in the networked world we live in today is that talking about ubiquitous computing without a pervasive network is a contradiction.

So if we accept not only that the momentum of wireless will continue but also that there are valid reasons to believe wireless will become an increasingly important network medium, the question becomes

how we prepare for that future. The logical answer is that convenient, high-speed wireless data access must become pervasive. This does not necessarily mean that 802.11 networks will exist everywhere, but there must eventually be seamless coverage provided through transparent handoff across different networks. Just as a cell phone roams the country and the various service providers grant and charge for access accordingly, the time will come when WLAN and cellular data networks behave in the same way. This will make it possible to sustain a network connection independent of geographic location, with the key difference being only the bandwidth (and perhaps cost) of the connection in different locations. So in the future, when I'm on Duke's campus, my device is communicating on a shared 11 Mbps connection. But as I get in my car and begin driving to an off-campus meeting, the device moves out of the 802.11 network range and is handed off to the local cellular data network. When I reach my destination, the device's connection is handed off to yet another network, this time the 802.11 WLAN on the campus I'm visiting.

Today one might downplay the value of a constantly connected device, but I believe the continuity of the connection will become increasingly important as new applications rely on location and context information—and especially as small devices become more popular and more powerful. My palm device is of limited value if its data are only as up-to-date as the last time I synchronized with the enterprise calendar or e-mail server. In a world of constant connectivity, if I'm across campus and my next meeting has been relocated, I should be automatically alerted to that change as soon as my assistant updates the enterprise calendar system. Moreover, because the connection is always available and because my location can be determined, my calendar alert should be aware of my context and notify me accordingly. That means that if my next meeting is in the same building, I want to be alerted just a few minutes in advance. But if the meeting is across campus or across town, the alert should notify me accordingly, perhaps also offering directions on the shortest route.

One might argue that existing cellular wireless provides the foundation for that broad network coverage. But that is less

than half of the story. On the one hand, the need for high bandwidth in the locations where we do most of our computing—on campus and at home—drives the need for 802.11 in those environments. On the other hand, the need for constant connectivity in the many places where we spend lesser amounts of time throughout the day drives the need for seamless compatibility and handoff of connections between 802.11 and cellular networks.

Exactly what applications will ride on top of the pervasive wireless networks and take advantage of handheld computing devices is yet to be seen. But location-based computing and context-aware computing are certainly going to play a role in defining the future technology environment. And if we look at how much innovation has grown out of college and university environments over the years, we can see that the sooner campuses embrace WLANs, the more likely it is that students and faculty will be helping to shape that future environment by using technologies such as wireless and handhelds to identify unmet needs and to apply innovative solutions.

I began this column by listing several popular reasons that colleges and universities cite for not deploying wireless net-

works, but I hope that I have now provided a persuasive argument for the importance of the role that wireless is likely to play on campuses in the future. For those who still question whether it's time to start thinking about deploying a WLAN, I'll make the following prediction: If within the next year a campus is not completing or at the very least in the midst of *some* level of wireless deployment, that campus is likely to be viewed, by incoming students and future faculty, as being behind the technology curve, in the same way that campuses without networked residence halls were considered to be at a disadvantage five years ago. So for those colleges and universities seeking to prepare for the emerging reality of WLANs, it's never too soon to begin experimenting with 802.11 networks and exploring potential applications.

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**Tracy Futhey is Vice President for Information Technology and Chief Information Officer at Duke University. Before her move to Duke in February 2002, she spent seventeen years at Carnegie Mellon University, most recently as Vice Provost for Computing Services and CIO. Sightings of her on either campus without her handheld wireless device have been few and far between.**

