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Wireless Technologies in Education: Prospects for Improving and Extending K-12 School Services

By Emilio Gonzalez

Foreward by
Dr. Arthur Sheekey, The CNA Corporation
Dr. Laurence Peters, Temple University

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The ATEC at CNAC, 4825 Mark Center Drive, Alexandria, VA 22311

APPALACHIAN TECHNOLOGY IN EDUCATION CONSORTIUM

The Appalachian Technology in Education Consortium (ATEC) is one of ten regional consortia funded by the U.S. Department of Education to promote effective use of technology in K-12 education. For more information, go to www.The-ATEC.org, or contact Dr. Arthur Sheekey at *SheekeyA@CNA.org*.

FOREWORD

Open up any technology magazine and you are almost certain to find an article about how wireless technologies are enabling more people to access the same kind of computing power while mobile as when working at their desktop. This "wireless revolution" is having a profound effect on schools. In a recent survey, 62 percent of respondents indicated that they are currently implementing some form of wireless technology in their schools or school districts, while 29 percent are in the piloting stage and 35 percent are evaluating and reviewing wireless (*Heller Reports*, October 2002). During the 2001–2 school year, close to half a billion dollars are being spent on wireless technologies, and that amount is expected to rise to $776 million next year, a 57 percent increase. Clearly, this increase reflects the fact that wireless broadband access is often relatively fast, economical, and easy to install, offering the mobility that wired connections cannot and providing new levels of reliability and scalability. Not surprisingly, a survey by the Peak Group (2002) found that education investments in wireless technologies are projected to grow dramatically over the next several years.

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Although no one technology or telecommunications service can respond to the needs of all schools and school districts, this type of service does appear to offer special advantages for rural areas. Recent studies by the U.S. Department of Commerce and the Appalachian Regional Commission confirm the fact that most rural areas in our nation have little access to broadband or high-capacity electronic information services. Cable and telecommunications companies have delayed investments in broadband networks that would pass through the nation's poorest and rural areas. In this regard, our contacts in the states have reminded us that state and federal regulators need to act to resolve this dilemma.

If federal and state agencies fail to collaborate in their efforts to reform existing regulation, many communities will not receive the full benefits from the universal services fund. Several studies have identified a number of policy and regulatory barriers that inhibit the wider uses of wireless technology. A study conducted by the University of North Florida concludes that schools in these areas "desperately need more bandwidth." Although wireless technologies will not change these dynamics overnight, they offer the best hope of slowing the growing technological gulf separating urban and suburban America from their rural counterparts.

We were able to confirm the findings of others (most notably the Peak survey cited above) that many of those responsible for technology in schools did not know enough about the advantages and disadvantages of wireless systems and services. Nevertheless, we did come across several success stories in regard to use of E-Rate funding. Three counties in Virginia—Charlotte, Lunenburg, and Prince Edward—have received E-rate funding for wireless wide-area networks (WANs) to serve schools at a bandwidth of 10 MB/s. The E-rate program provided discounts for central office equipment and wireless transmitters and antennas at each school. Unfortunately, too many small and independent schools do not participate in the E-Rate program because of the difficult application process. Our review of the program suggests that schools that rely on statewide applications and technical support—schools in West Virginia, Tennessee, Missouri, and Florida, for example—seem to have a better chance of receiving the funding they deserve.

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In addition, we were intrigued by the potential of wireless technologies to transform the process of teaching and learning when every teacher and learner has his or her own computer. Specifically, the work of Elliott Soloway (University of Michigan) and Saul Rockman (Rockman et al.) and the report, *Can Handheld Computers Improve Education?* (WestEd, October 2002), have enabled many educators to better understand how ubiquitous computing (that wireless now renders more feasible) advances opportunities for learning.

Wireless LANS for Extending School and Community Services

Our review gave us the opportunity to examine a number of models that should interest the education community. Some of the most interesting pioneers deploying wireless services are community and campus based. We note the "Athens Georgia Zone," which involves a "wireless cloud" that covers 12 blocks in the heart of the college town. Nine boxes that transmit and receive data are mounted on light poles and traffic lights. Anyone with a PDA (personal digital assistant) or laptop computer equipped with a wireless (Wi-Fi) card can log on to the Internet, free, when they are under that "cloud." We also cite the Digital Bridge Project in San Diego that involves a state-of-the-art "smart community technology center," linking to six new mini-labs that will be built in public housing complexes and community technology centers in schools, libraries, and non-profit organizations throughout the county. The center features wireless laptops and modular furniture that enable multiple groups to use the space at the same time, in different configurations. The project has created collaboration and efficiencies by including school and non-profit community groups operating in the San Diego area.

ATEC/MARTEC Workshop

Our workshop on *Wireless Technologies and Schools* (October 2002) convened to discuss these and many other practical questions from our two respective regions. During our discussions, a number of participants who are recognized experts in this field indicated that wireless broadband technology has become the technology of choice for many urban and rural schools that needed affordable and efficient access to the Internet. With wireless technologies, school officials are claiming that they are able to offer new and alternative educational services within their schools, and services beyond their school campuses that would not otherwise be available to students and the local community.

The workshop participants laid out an exciting vision for the way educational technology can be used. Our two regional technology consortia plan to document our progress in pursuit of this vision, and to that end, we are planning an interactive website that will feature transcripts from the workshop and other related reference materials as well as an electronic bulletin board which will allow for feedback on plans for a subsequent workshop.

We thank all the individuals who participated in the ATEC/MARTEC forum, and especially those participants who followed up with additional advice and recommendations during the preparation of this report. We give special thanks to Emilio Gonzalez who wrote the bulk of this report. In addition, we received a number of helpful comments from Greg Weisiger from the Virginia State Department of Education, and from Ricardo Tostado from the Illinois State Department of Education. Both are among a cadre of highly qualified and dedicated officials whose efforts indicate the impact that state officials can have in ensuring that all schools and school-age students receive the benefits of advanced technologies.

Arthur Sheekey, The CNA Corporation
Laurence Peters, Temple University

BACKGROUND

Representatives from the ATEC and MARTEC projects that sponsored the forum entitled *Wireless Technologies in Education: Prospects for Improving Schools* agreed to initiate a two-year initiative to determine how wireless technologies can help schools, particularly schools in low-income and rural areas, to leverage advanced communications and computing technologies.[1] The forum relates to the sponsors' continuing effort to identify innovative teaching practices and new technologies that have the potential to improve education and upgrade the technology literacy skills of today's students. The sponsoring institutions and their counterparts that make up the national Regional Technology in Education Consortia (R*TEC) are especially interested in assisting states in their efforts to equalize access to advanced technologies that support and extend public education.

In this report, we offer a broad overview and preliminary examination on how wireless technologies, such as wireless communications, networking, and hand-held computers, can help schools, and especially rural schools, overcome barriers to accessing affordable and advanced telecommunication services. The report also highlights proven strategies for success.

Following a brief assessment of wireless technologies, we highlight key policy issues and market trends that can facilitate or hinder how rural schools integrate technology, and especially advanced telecommunications, into the classroom. These issues were often a focus of discussion during the workshop. The workshop participants identified these specific concerns:

- The lack of affordable advanced telecommunications services in rural areas
- The need for strategic partnerships that aggregate demand for services and foster economies of scale
- A general concern regarding telecommunications policies that ignore rural needs for affordable and advanced communication services
- The need for stable funding sources to help offset the high costs of telecommunications service, infrastructure, training, and maintenance.

In particular, rural schools will benefit from thinking and acting strategically. Rural schools, working in partnerships with other local institutions, can aggregate demand and talent. For example, partnering rural schools with other community-based institutions can help offset costs by aggregating

1. A list of participants attending the Wireless and Education Forum, October 29, 2002, can be found at the end of this document.

demand, and they can minimize risks by working with various technology experts available as a result of aggregating talent in the partnership. Although such partnerships can be difficult to arrange, they are well worth the effort. We believe that the prospects for improving rural schools with wireless technologies have never been better.

INTRODUCTION

Technologies for teaching and learning, such as computers in the classroom and the Internet, are important resources in the educational reform movement and in helping students acquire the 21st century skills necessary for success in today's technology-intensive global economy. Historically, rural schools have understood the power of technology for teaching and learning, and they have been among the first to adopt such educational technologies as distance learning and satellite-based instructional television services. From the start, rural schools have recognized that these technologies would enable them to overcome barriers of distance and geography.

Over the past year, the demands associated with the *No Child Left Behind* Act have raised new anxieties about the capacity of rural schools to provide *adequate educational services*. The mandates in the Act include, for example, the requirement that all schools have "highly qualified" teachers in all classrooms—teachers that are certified in the subject areas they teach—and that schools provide equitable access to learning technologies. Although rural schools are getting a substantial share of E-rate funding, students in rural schools still do not have sufficient access to advanced information technologies. For example, in 2001, only 72 percent of schools with fewer than 300 students were using broadband Internet connections compared to 96 percent of schools with more than 1000 students. Eighty-two percent of rural schools had broadband, compared to 88 percent of urban and suburban schools.

Access to advanced telecommunications is increasingly important in the educational arena because it supports many of the newest technology-driven tools that foster collaborative and interactive learning among students. Unfortunately, despite massive federal investments in technology (roughly $3 billion per year for K–12 schools), most rural schools lag behind their urban counterparts when it comes to accessing broadband or advanced telecommunications services at affordable rates.[2] In addition, recent upheavals in the telecommunications industry, such as increased consolidation among wire line service providers and massive corporate bankruptcies in the long distance sector, have dimmed the

[2] The Federal Communications Commission defines "advanced telecommunications" as the availability of high-speed, switched, broadband telecommunications that enable users to originate and receive high-quality voice, data, graphics, and video using any technology.

outlook for speedy deployment of advanced telecommunications in rural areas.

Fortunately, there are alternatives. Wireless technologies are providing cost-competitive alternatives to wired technologies in many areas as suggested by their impressive rate of market growth.[3] In addition, many wireless innovations are offering improved functionality and greater compatibility with other devices.

Although federal funding is available to help offset the high costs associated with communications and infrastructure (networking devices, hardware, software, installation, and training), these funds cover only a fraction of the costs required to transform rural schools into world-class 21st century schools. Funding limitations emphasize the importance of strategic partnerships and aggregation of demand that rural schools can leverage throughout the process of integrating technology into their classrooms.

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As one would expect, there are advantages and disadvantages to wireless vis-à-vis wired technologies. A brief examination of pluses and minuses (see the section on Advantages and Disadvantages of Wireless) indicates that, increasingly, wireless technologies are an effective, and often preferable, alternative to wired technologies. Understanding such tradeoffs is important because educators and administrators will need to prepare plans and policies that guide schools through the expensive and complex process of deploying technology in the classroom.

Besides considering the pros and cons of wireless technologies, it is equally important to assess the functionality of new wireless products and services. The wireless devices and services that are available today offer a glimpse of what the rural classroom of tomorrow would be like with high-speed, high-bandwidth wireless networks supporting wireless hand-held computers.[4]

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[3] In the education sector, wireless technologies account for over $775 million, which is 15 percent of total yearly expenditures on educational technologies nationwide. Most likely, spending on wireless technologies for education will continue to grow for the foreseeable future as wireless devices become more sophisticated and functional as well as less expensive.

[4] See: *Schools Using Wireless Applications*.

Federal Policy and Rural Telecommunications

The 104th Congress revamped communication law and deregulated significant aspects of the business when it enacted the Telecommunications Act of 1996 (Act) in an effort to foster competition and growth in the field of communications and information technology. It was the first time in 60 years that Congress had significantly revised communications law.[5]

Although rural access was not a main thrust of the Act, most members of Congress understood that there are benefits for rural areas that can access advanced telecommunications applications, such as distance learning, tele-medicine, and e-commerce. Members heard stories and testimony about rural towns such as Abingdon, Virginia, a small town of 8,000 near the Tennessee border. Abington is home to a ten-square block fiber-optic network that links business, schools, and government agencies at very high speeds of up to 10 megabytes per second. The results have been improved delivery of government services, enhanced educational and life-long learning opportunities, and revitalized economic development. This example is not unique, but it is not common either, and rural areas continue to lag behind in terms of access to affordable and advanced telecommunications.

Economics, geography, and telecommunications policy all play important roles in determining how fast and at what price advanced telecommunications services will be offered in rural areas. The telecommunications industry has undergone significant changes in the last five years that have led to greater cross-ownership and consolidation, and although it is too early to assess what the full impact has been, many are concerned about higher rates and fewer service options. For example, prior to the Act, there were seven Regional Bell operating companies (RBOCS); today only three remain, and long distance service providers appear to be headed in a similar direction.

Universal Service and Advanced Services for Rural Areas: Sections 254 and 706

Without universal service support, many rural residents, schools, and small businesses could not afford telephone service at all. Fortunately, the Act provides promise as well as immediate relief for rural areas in the form of universal service. In the immediate sense, the Act specifically requires a revision of the universal service system and the support mechanisms that fund its operations. The revision "must expand both the base of companies that contribute to offset communications service rates and the category of customers who benefit from discounts and subsidies. Schools, libraries, and

[5] The Communications Act of 1934 was the last major piece of communications law not counting the court-mandated breakup of AT&T.

health care providers, as well as residential and rural customers, will be the primary universal service beneficiaries."[6] Section 254 addresses universal service for schools, libraries, and rural health care providers. Section 706 also supports calls for expanded universal service and instructs the Federal Communications Commission (FCC) to ensure periodic review of universal service and to assess the state of deployment of advanced services in rural areas.

Section 254. This section revises and expands the concept of universal service to include K–12 schools (public and private), public libraries, and rural health care providers as eligible entities for universal service support. It also authorizes the FCC to establish the necessary funding mechanisms for the creation of a program called Universal Service for Schools and Libraries. With funding of $2.5 billion a year, this program has become the largest single federal investment in educational technology ever.

The E-rate program offers K-12 … discounts … for such items as telecommunications services, Internet access, and internal connections.

Universal Service for Schools and Libraries, commonly referred to as the E-rate program, offers K–12 schools the opportunity to modernize their technology infrastructure by providing discounts of up to 90 percent for such items as telecommunications services, Internet access, and internal connections. In developing the fund, the FCC recognized that one size does not fit all; thus, the E-rate program is designed to be technology neutral, allowing schools to purchase either wired, wireless, or hybrid infrastructure.

Section 706. This section charges the FCC with monitoring the deployment of broadband, or advanced telecommunications, into rural areas. Section 706 requires that the FCC consider how universal service will evolve and how it should be defined over time. Today, universal service for residential customers is defined as plain old telephone, but that is likely to change with time as advanced telecommunications services become more ubiquitous. Although E-rate funds offer an immediate opportunity for rural schools, Section 706 provides a more subtle, but equally important, set of policy tools because it can foster the deployment of meaningful resources to support the rollout of advanced telecommunications into rural areas.

Unique Barriers and Challenges in Rural Areas

Despite investments generated by the E-rate program and funding from the U.S. Department of Education for a host of technology-related programs, rural schools still face significant hurdles and disparities in accessing advanced telecommunication services. We can summarize the general state of

[6] Federal Communications Commission, Proceedings on Universal Service.

E-Rate Regulatory Constraint¾ Most Wireless Providers Are Not Common Carriers

State E-Rate coordinators have been urging the FCC to adopt "competitively neutral technology purchasing policies" that could encourage wireless applications. In its response to an FCC notice relating to universal service support, the state of Illinois indicated that leasing technological solutions from a common-carrier offers greater assurances that the service will be eligible for discount, regardless of whether the services offered are the best, most effective, or most efficient choices for the applicant. In contrast, developing a wireless solution by leasing similar services from a non-common carrier is virtually guaranteed to not offer a discount for the majority of schools unless the services are exclusively for Internet use—a very inefficient use of resources that would require duplicate networks. Illinois argued that schools should have the maximum flexibility to choose between competing carriers and technologies in order to best fit their educational needs. The current system heavily favors funding traditional, leased, wired services and equipment through an eligible telecommunications carrier.

rural telecommunications in this way: *The available services are less advanced than those in urban areas, and when services are available, they typically cost much more.*[7]

The high cost of advanced telecommunications in rural communities is generally attributable to three economic factors:

- The high cost of deploying telecommunications infrastructure in rural areas
- The trend toward minimizing cross-subsidies to offset the high cost of service
- The lack of aggregation of demand for advanced telecommunication services.

The high cost of deploying infrastructure in rural areas. The deployment of telecommunications infrastructure has always been both capital and labor intensive. From the start, labor costs and the expense of buying copper telephone lines and securing public right-of-ways combined to make the deployment of the public switched telephone network one of the most expensive infrastructure investments in American history.

[7] Rural schools have the greatest incentive to use technology, but they don't have the same resources (museums, AP qualified teachers, etc.) that many urban and suburban school have. "These deficiencies," according to Illinois' E-Rate coordinator Rocardo Tostado, "can be bridged through technology. We are finding that the real need among our rural schools is to have enough bandwidth to do video, including distance learning, AP courses, etc."

The trend toward minimizing cross-subsidies to offset the high cost of service. The use of cross-subsidies, the practice of setting rates for telecommunication services above the costs of providing services in order to generate subsidies to reduce rates for residential and rural customers, is not used as often today as it was in the past because the Act requires subsidies to be transparent to the consumer. Cross-subsidization has been a valuable tool in fostering infrastructure rollout into rural areas, but now carriers must balance the benefits of cross-subsidies with the possible consequences of consumer dissatisfaction over what could be perceived as "excessive" taxes and tariffs.

Lack of aggregation of demand for advanced telecommunication services. Rural areas suffer from a lack of access to affordable and advanced telecommunication services because they usually have small populations that are spread over large geographic areas. In fact, "the physical footprint of a typical rural telephone switch—the number of square miles served—is twice as large as that of a typical urban switch."[8]

Most likely, rural areas will continue to encounter barriers and challenges in accessing affordable advanced telecommunication services because rural market forces cannot compete with the high population density of urban centers. Recent reports by the FCC and the Appalachian Regional Commission (ARC) document the fact that high-speed telecommunications services are not readily available in rural and low-income areas.[9]

A recent U.S. Commerce Department report on broadband telecommunications notes that the "demand for broadband is robust, although as with most new technologies, broadband supply currently exceeds demand."[10] Recently, many telecommunication companies have made massive investments in fiber optics and such broadband technologies as the Digital Subscriber Line (DSL), but most of these ventures have yet to turn a profit. Low return on investment, especially in urban markets, delays the deployment of advanced services to rural areas.

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[8] TVA Rural Studies Program/Staff Paper, 1999.

[9] Report on the Availability of High-Speed and Advanced Telecommunications Services (FCC, 2000), and Links to the Future: The Role of Information and Telecommunications Technology in Appalachian Area (ARC, June 2002).

[10] U.S. Commerce Department, Office of Technology Policy, Understanding Broadband Demand: A Review of Critical Issues, 2000.

An Overview of Wireless

In 1880, Alexander Graham Bell invented the first wireless communications system, using reflected sunlight and photoelectric selenium receivers. Using this technique, however impractical, he was able to transmit intelligible speech at a distance of up to 700 feet. A decade later, a German scientist named Heinrich Hertz discovered the phenomenon of invisible force waves emanating for several meters around an electric spark of sufficient intensity. Shortly thereafter, Guglielmo Marconi was able to transmit these "waves" over several kilometers, thus creating a new technology called radio. In 1890, Reginald Fessenden developed wireless voice communications. Although many revolutionary developments and innovations have occurred since, these individuals and their "inventions" created the foundations of what are now commonly called wireless technologies.[11]

Wireless … refers to communications without wires or physical connections.

Wireless, quite simply, refers to communications without wires or physical connections. Wireless communications have come a long way from the early days of bulky phone handsets and expensive and unreliable service. Today, there are an estimated 100 million cellular telephone users worldwide, and wireless technologies are no longer outside the mainstream because they are offering lower prices, increased functionality, and mobility.

There are several types of models for establishing wireless networks and communications infrastructure for schools and for classrooms. Below is a brief account of some of the most important technologies, services, and devices that are particularly applicable for rural schools.

Wireless Communications

Wireless communications include the use of cellular, infrared, microwave, and satellite-based transmission systems. Microwave and satellite communications are generally high-speed transmission and network backbones systems that do much of the heavy lifting in terms of transporting large amounts of voice and data. Infrared technology requires a direct line-of-sight for transmission of data and is commonly used to allow PDA devices to "beam" data to one another or to a local area network, but its limitations are obvious. The most widely used wireless medium is cellular; the vast majority of commercial and educational users use this medium for their long distance and voice communications needs.

[11] Communications Systems and Networks: Voice, Data & Broadband Technologies, Ray Horak and Mark Miller, Consulting Editor, M&T Books, 1997, p. 331.

Cellular technology is based on radio technology and the concept of radio cells, which dates back to the 1940s. Today, cell phones are common in most countries, and cellular technology is rapidly moving toward digitally based standards, using Time Division Multiple Access (TDMA) or Code Division Multiple Access (CDMA) techniques such as those employed by Sprint for its PCS system.[12]

Licensed Spectrum

Spectrum is a designated electro-magnetic frequency in which a radio signal can travel and operate. Spectrum is licensed, allocated, and managed by the federal government through the National Telecommunications and Information Administration (NTIA) and the FCC. Spectrum availability is typically categorized as licensed and unlicensed spectrum, with the majority of it being licensed. Experts note that "most wireless frequency bands are licensed, meaning that the government gives an entity such as a radio broadcaster or the military the exclusive right to transmit on those frequencies. The license comes with restrictions on geography, power output, technical characteristics, and/or service offerings."[13] Radio and television broadcasts, emergency communication systems, and cellular telecommunications are all examples of licensed uses of spectrum.

Recent innovations in digital communications technologies are making spectrum use more efficient. These new digital technologies are designed to distinguish between signals within similar frequencies and thus allow more users to share the same airwaves without having to pay, or wait, for expensive licenses.

Unlicensed Wireless Networking LANs and Wi-Fi (Wireless Fidelity)

Wireless local area networks (LANs) are enjoying modest success in terms of growth in the United States. Wireless LANs use spread spectrum technology developed during World War II and refined since. Wireless LANs operate in four distinct radio frequency ranges: 902 MHz to 928 MHz, 2.4 GHz to 2.5 GHz, 5.8 GHz to 5.9 GHz, and 18 GHz to 19 GHz, or they can use infrared technology that is very limited in bandwidth and requires a direct line-of-sight.

Wireless LANs offer the obvious advantage of not having to deploy wires within a building or classroom to connect multiple devices and users. In many older schools where asbestos remains a problem, wireless LANs are an effective networking solution offering significant costs savings.

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[12] Ibid.
[13] Werbach, Kevin. *Open Spectrum the New Wireless Paradigm*, Spectrum Series Working Paper #6, New American Foundation, October 2002, p. 3.

As with many consumer electronics, wireless LANs are continuously becoming less expensive while providing more functionality in terms of the bandwidth needed to support multimedia applications. Because of the high costs and disruptions involved in wiring a school and/or classrooms, wireless LANs have gained significant acceptance in the education market as a viable alternative for use in networking classrooms.

Unlicensed Wireless and the Advent of Wi-Fi

The FCC had designated a limited set of spectrum frequencies for use with unlicensed consumer devices such as baby monitors, wireless phones, and local area networks. Many of the designated unlicensed frequencies operate in the 2.4 GHz and 5 GHz bands. These bands, or ranges, are commonly referred to as "junk bands," yet it is in these "junk bands" where exciting and cost-effective wireless applications, such as "Wi-Fi" and Bluetooth personal area network technologies, are flourishing.

Wi-Fi is short for wireless fidelity and is based on the 802.11 protocols established by the Institute for Electrical and Electronic Engineers (IEEE). Wi-Fi was developed for unlicensed wireless local area networking, allowing for high-speed data connections within a few hundred feet of an access point or "hot spot." Wi-Fi is a wireless technology like a cell phone. Wi-Fi signals enable computers to send and receive data indoors and outdoors anywhere within the range of a base station. An advantage of Wi-Fi is that it is several times faster than the fastest cable modem connection. Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, with an 11 Mbps (802.11b) or 54 Mbps (802.11a) data rate or with products that contain dual band. Wi-Fi can provide real-world performance similar to the basic 10BaseT wired Ethernet networks.

Wi-Fi's offer great potential for helping schools, especially rural schools, establish high-speed wireless local area networks and possibly lower cost connections to the Internet. Users can expect more innovations and applications from Wi-Fi because the technology and the demand for it has captured the attention of many leading-edge high tech companies. According to the Yankee Group, "a coalition that includes Intel and IBM is discussing a hotspot [Wi-Fi] plan called Project Rainbow." According to the Wi-Fi Alliance, "worldwide sales of Wi-Fi related hardware are estimated to total $2.1 billion this year and more than $3 billion next year."

Wireless Computing and Three Generations of PDAs

Many educators have been quick to realize the potential of personal digital assistants (PDAs) not only for teaching but also for managing administrative tasks and communicating with students, parents, and other teachers. Most students are comfortable with PDAs because they have grown up using handheld video games such as the Nintendo Gameboy. PDAs may not soon replace PCs and laptops in schools, but the use of PDAs is growing, and software developers are beginning to offer innovative packages for incorporating educational curriculum, assessment, and administrative functions.

PDAs are multifunctional wireless devices that first appeared on the market in the mid 1990s. These lightweight devices can typically store and transmit data via infrared or designated radio frequencies.

The first generation of PDAs consisted mainly of electronic date and address books that allowed users to store and manipulate data in new ways because the information was stored in digital format. The second generation of these devices incorporated, on a limited basis, wireless Internet access and other functions made possible by improvements in software and operating systems.

The third generation devices that are starting to reach the market offer promise for educators and students because of their increased functionality and ease of use. For example, a new multimedia-capable PDA called the Sidekick offers a totally wireless way to make calls, send email, surf the Web, and take and transmit digital pictures. The device has a full keyboard and high-resolution LCD swivel-screen as well as built-in speakers. Incredibly, this 5-ounce multimedia handheld computer costs only $200.

PDAs can currently operate in one of two basic systems, Microsoft's version of Windows for PDAs and the Palm OS. Protocol and standards issues with PDAs are improving, and experts note that the new 802.11g protocol will help ease much of the incompatibility experienced among PDA users today.

Current developers and manufacturers of PDAs include Palm (the Palm Pilot), Texas Instruments, Sony, Hewlett Packard/Compaq, and several others. New PDAs offer color screens, keyboards, Internet access, large memories, and a growing list of available software applications, most of which can be downloaded from the Internet.

Third Generation Systems (3G)

A major set of developments with catalytic potential for wireless communications is the impending availability of Third Generation Systems (3G). The FCC is currently regulating the deployment of these promising new communications systems that will offer high-speed access and multimedia functionality. The FCC Wireless Bureau describes the capabilities of 3G systems and the functions that they can support in circuit and packet data at very high bit rates of: 144 kilobits/second or higher in high-mobility (vehicular) traffic, 384 kilobits/second for pedestrian traffic, and Megabits/second or higher for indoor traffic.[14]

Implications of Digital Television

Digital television (DTV) is the new form of broadcast television. All of the familiar television stations around the country have or soon will begin broadcasting digital signals at 19.4 Mbps. Stations can broadcast high definition (movie quality) video as well as providing datacast services.

Datacasting refers to what is officially called by the FCC "ancillary and supplementary" uses of DTV spectrum. It combines data transmission with broadcasting. DTV uses a standards-based (MPEG2) transport protocol that allows IP packets to be encapsulated. In other words, IP data packets can be placed into DTV transmissions to be broadcast to the station's coverage area. DTV datacasting is a cost-effective solution for one-to-many multicasting delivery of data streams.

To receive DTV datacasts you will need a PC with a DTV data receiver card, and the ability to receive the over-the-air TV signal. In many cases, a $20 antenna beside your PC will work; however, a rooftop antenna will provide better reception. The PC DTV Data Cards are available for as little as $150. If your PC is on a LAN, only one PC on the LAN needs to be connected to the TV antenna. Received IP packets can then be multicast locally on the LAN to all PC clients.

Like regular TV, DTV is a one-way broadcast service. The advantage of DTV is in providing broadband, last-mile, wireless data delivery. However, any PC connected to a dial-up ISP or LAN already has Internet access. DTV can be the downstream, and ISP or LAN connectivity can be the interactive link for full functionality.

[14] See: *www.fcc.gov/* for a more complete discussion of 3G technology.

3G systems are already entering the market, offering color screens, email, built-in digital cameras, and a host of other functions. In the next two to three years, a variety of education-related software tools are likely to appear on the market and further stimulate demand for 3G systems.

Advantages and Disadvantages of Wireless

Implementing any technology in the classroom has its advantages and disadvantages. It is no different with wireless and wired technologies. Tradeoffs are especially important to understand because they affect costs and functionality, factors that must be carefully considered when making decisions about the procurement and deployment of technology. Despite the disadvantages, demand for wireless technologies continues to grow as consumers demand greater mobility from their communication and computing devices.

Assessing the advantages and disadvantages of wireless vis-à-vis wired technology should be done with care because technology is a moving target. Regardless, there are generic tradeoffs to consider when considering whether to implement a wireless or wired technology platform for the classroom. Such tradeoffs include:

- *Cost of voice and data communications.* The cost of voice communications continues to drop, especially for long distance service that is a vital link for rural users. Recurring charges for telecommunications is a critical variable because often it is the single largest on-going expense.
- *Installation costs (asbestos, electrical outlets, labor, disruptions, etc….)*. It costs much less to deploy and install wireless networks. In fact, "tremendous costs can be saved by eliminating requirements to secure terrestrial right-of-way, dig trenches and plant poles, place conduits and hang crossarms, place repeaters, and so on."[15]
- *Bandwidth/capacity.* Because the availability of spectrum is a finite resource, there exist within each slice of allocated spectrum only so much bandwidth. Wireless technologies, at present, do not provide bandwidth comparable to what is available with wired telecommunications such as T-1 lines. However, new spectrum allocation and improved technologies are making it possible to transmit significant amounts of data over wireless networks in a cost-effective manner when all factors are considered. *Demand for spectrum in rural areas is relatively low because of lower population density. Therefore, sufficient bandwidth is available in most rural areas for broadband deployment.*

[15] Ray Horak, *Systems and Networks*, M&T Books, 1997, p334.

- *Quality of service*. Typically, wireless communications lacked the quality of uninterrupted service and low error performance that the public switched network offers. However, as wireless communications continue moving toward digital systems and as more money is invested in expanding their infrastructure, these problems will likely abate, unless investment lags and infrastructure deployment fails to keep up with demand.
- *Security and privacy*. Wireless technologies typically offer less security in terms of data transmission, but with new developments in digital transmission and encryption algorithms, these weaknesses are rapidly diminishing. A concern for educators and administrators is that wireless technologies are mobile and thus are subject to loss and/or theft, but that is a minor concern that can be addressed with appropriate use policies and basic training about care and transportation of devices.
- *Compatibility and interoperability among wireless devices*. Like wired technologies, wireless devices are limited by a lack of compatibility and interoperability. Fortunately, this counterproductive trend is changing for the better as manufacturers and software developers continue to work on common standards and interchangeable software that will allow a broad array of wireless devices to communicate with one another.
- *Vendors*. School system and school building clients need to be especially vigilant to ensure that vendors and manufactures of wireless telecom equipment are willing to offer a stable, long-term relationship.

Overview of Policy Issues

Several important policy and regulatory issues, ranging from spectrum management to the E-rate program, will affect how and when advanced technologies reach rural areas and how these technologies will be used for teaching and learning.

The FCC's current proceeding regarding the Third Generation Wireless System (3G) will have an impact on future use of wireless. The spectrum that has been made available to support 3G can support many of the most advanced wireless applications and thus benefit rural schools by making available a wireless communications system that is comparable to the public switched network. According to the FCC, "3G systems will provide access, by means of one or more radio links, to a wide range of telecommunication services supported by the fixed telecommunication networks and to other services that are specific to mobile users. A range of mobile terminal types will be encompassed, linking to terrestrial and/or satellite-based networks, and the terminals may be designed for mobile or fixed use."[16]

[16] See *www.fcc.gov*.

Wireless Growth in the Education Market

The growing acceptance of wireless technologies in the education sector is exemplified by a recent informal poll of 184 schools and school districts, conducted by Peat Group LLC. According to the poll, 62 percent of respondents are implementing wireless and 12 percent are considering doing so in the near future.

The poll highlighted issues, or tradeoffs, that concern these educators and administrators. Ranked in order of importance given by respondents, they are:

- Standards and interoperability
- Implementation costs and recurring charges
- The availability of education-related applications
- Concerns about ease of use
- Bandwidth capacity.

Proven Strategies for Success in Using Telecommunications for Education

Below are six proven strategies to help rural schools:

- Conduct a technology needs assessment and develop a 5-year strategic plan—a plan that is consistent with a compatible emerging statewide network—with federal (NCLB Act, Title 2.0) funds
- Conduct pilot projects of new technologies and applications
- Partner within the local community to aggregate demand and talent
- Work with your Regional Technology in Education Consortia (*www.rtec.org*)
- Take full advantage of the E-rate program (*www.e-ratecentral.org*)
- Exploit other funding sources such as corporations and foundations

The FCC has also requested and received public comment regarding the E-rate program and has requested comments on how to streamline the application and reporting requirements of the program. Anticipated orders in response to recent Notices of Proposed Rulemaking relating to the Universal Service support program could affect the types of services that will be considered eligible, and the role of states in aggregating demands and in coordinating statewide networks.

Policy and Regulator Issues in 2003 and Beyond

The new Congress and the Bush Administration have work to do on a number of other important policy issues that will affect costs and use of technology for teaching and learning. Some of the key unresolved policy issues include:

- FCC actions regarding the use of spectrum (licensed and unlicensed)
- Standards for fostering interoperability among wireless devices
- Privacy versus security laws and regulations
- The evolving definition of universal service
- Limited E-rate funds for internal connections
- The deployment of advanced communications in rural areas
- The impact of the No Child Left Behind Act on educational technology and rural schools.
- How can school officials be assisted in assessing the quality of technologies and the quality of vendors and vendor support services?

Suggested List of Concerns and Issues for State Educational Technology Directors, School Administrators, and Technology Coordinators

Educators and technologists alike must consider what technologies are best suited for today's needs and environment: For example, is wireless best suited for broadband access? Can wireless provide a viable solution for the last mile barrier? Is wireless the appropriate vehicle for inter-building communication? Is wireless well suited for the small classroom and school? Can wireless provide the necessary flexibility for network growth since adding a node doesn't require much work?

Concerns and Key Questions Remain

Other questions and concerns worth noting include:

- The current lack of standards—it is unclear whether cellular, microwave, or radio frequencies such as 802.11b would dominate.
- The need to aggregate demand for wireless services to be economically viable—to do this, schools will need to work far more closely than they have in the past with their communities and possibly with higher education institutions.
- In aggregating demand in this manner, the use of the E-rate program that has provided much help to rural America could still subsidize programs if the school or library is not the only beneficiary.
- The current dearth of models that could provide rural school districts with a blueprint or roadmap to where they need to go.
- What is the cost/benefit analysis of wireless versus wired?
- Are there "quality of service" (QOS) limitations and concerns?
- Are there security and privacy issues that need to be addressed?
- Are there issues regarding interoperability (wireless with wireless and wireless with wired) or compatibility (today with tomorrow, today with yesterday)?
- What are the simplest/most important issues to be understood: Signal range (how far can it go?) Bandwidth (how much information can it carry?), etc.

Examples of Schools Using Wireless Applications

Below is a brief listing, including limited contact information, of schools that are currently employing and piloting innovative uses of wireless technology for teaching and learning. These projects may have valuable lessons to offer in terms of best practices and potential pitfalls.

Beaufort County Schools
School District Central Office
Beaufort, South Carolina 29901
843-322-2300

This school district implemented the "Learning with Laptops" program to give students and teachers the opportunity to interact using wireless technology.

Bernardston Elementary School
Massachusetts 01337
Phone: (413) 648-9356

This school integrated handheld technology into its science classrooms.

Colchester Middle School
Colchester, Vermont
Phone: (802) 655-1772
www.vita-learn.org/cms/

This school provides wireless handheld devices for students to check out.

Consolidated High School
Orland Park, Illinois
Phone: (708) 361-4600 Ext. 197

This high school has equipped 1,700 of 2,200 students and 65 teachers with handheld computers.

Lessenger Elementary
30150 Campbell Rd.
Madison Heights, Mississippi
Phone: (248) 589-0556
www.lamphere.k12.mi.us

This school received a Palm Educational Career Grant and was given 50 Palm handheld pilots. Fifth graders use the pilots for interactive learning including fieldwork for the science curriculum.

River Hill High School
Clarksville, Maryland
(410) 313-7120
www.howard.k12.md.us

Classes are conducted using wireless technology. Teachers are provided with laptops and students use Compaq iPAQ Pocket PCs.

Resources for Learning More

To learn more about educational technology in general, wireless technologies, the E-rate and other funding programs, examples of schools using wireless technologies, or pertinent government policy and regulation, visit:

Industry/Private sector-sponsored wireless technology sites

AT&T Wireless Services
www.attws.com/

Funds for Learning
An education technology consulting firm with considerable experience in helping schools to submit successful E-Rate applications.
www.fundsforlearning.com

Intel Education: Wireless Technologies
This site provides a newsletter and information service about schools that have implemented wireless technologies to improve learning environments. ...
www.intel.com/education/teachtech/learning/casestudies/wireless.htm

Verizon Wireless
This site provides national wireless network news and information.
www.verizonwireless.com/

WirelessWeek
A wireless-industry site with in-depth coverage and breaking news on mobile business, technology, regulations, and information.
www.wirelessweek.com/

Non-profit and academic institutions sites

Bay Area Wireless Users Group
www.bawug.org

E-RateCentral
A resource website sponsored by the State Education Telecommunications Alliance (SETA), which is affiliated with the Council of Chief State School Officers. This activity is partly supported by a grant from the AT&T Foundation.
www.e-ratecentral.org

"Grayslake High School's Infrastructure Goes Wireless to Cope With Growth." T.H.E. Journal Online. October 1995. [Online] Available: *www.thejournal.com/journal/magazine/95/oct/app2.html*

Hughes, David R. " The Connected Schools of Belen, New Mexico—A Wireless Success Story." National Science Foundation (May 1996) [Online] Available: *http://192.160.122.20/belen1.txt*

Kongshem, Lars. "Colorado's 'cursor cowboy' helps schools go wireless and save money." Electronic School Online [Online] Available: *www.electronic-school.com/0197f1.html*

Marin Community Wi-Fi Network
www.digiville.com/wifi-marin/index.htm

National Centre for Technology in Education
http://www.ncte.ie/ICTAdviceSupport/AdviceSheets/WirelessNetworks/

Wi-Fi Alliance
The Alliance is a non-profit association of wireless member companies.
www.weca.net

Wireless Networks in Education, George D. Stetten, Duke University
www.dcet.k12.de.us/teach/reynolds/wired1.html

"Wireless LAN Allows Remote Alaskan Schools To Communicate with the Rest of the World." T.H.E. Journal Online. January 1998 [Online] Available: *www.thejournal.com/magazine/98/jan/198apps.asp#504*

Government-sponsored sites

Federal Communications Commission
www.fcc.gov

Regional Technology in Education Consortia
www.rtec.org

Appalachian Technology in Education Consortium
www.the-atec.org

Mid-Atlantic Technology in Education Consortium
www.temple.edu/MARTEC

Universal Service Administrative Company/Schools and Libraries Division
www.universalservice.org

National Telecommunications Information Administration
U. S. Department of Commerce
www.ntia.doc.gov

U.S. Department of Education—education technology
www.ed.gov/Technology

Author

Emilio Gonzalez, Washington, DC

Emilio Gonzalez is a Washington consultant and proprietor of EG & Associates. Prior to this, he was Vice President of Strategy Group International (SGI), where he served as Chief U.S. lobbyist for the Dominican Republic, representing his client before Congress, the Administration, and the Overseas Private Investment Corporation. Prior to joining SGI, Mr. Gonzalez was a Senior Associate at Cartwright & Riley, a bi-partisan public affairs company based in Washington, DC, with offices in Sacramento. As a senior staff member of Cartwright & Riley, Mr. Gonzalez represented domestic and international clients involved in aviation, telecommunications, resort development, and electrical utility projects. Clients included American Airlines, Lucent Technologies, the Canary Islands, Nova Southeastern University, and the Commonwealth of Kentucky.

From 1997 to 1998, Mr. Gonzalez was a Senior Policy Advisor in the Office of the Deputy Secretary at the U.S. Department of Education. Besides providing day-to-day advice on a range of technology policy issues, Mr. Gonzalez's responsibilities also included implementing key parts of the Telecommunications Act of 1996, which included developing implementation plans, communication strategies, and managing congressional relations. Before joining the Department of Education, Mr. Gonzalez was a policy Advisor at the National Telecommunications and Information Administration (NTIA), U.S. Department of Commerce. At NTIA, he was responsible for developing domestic and international policy positions as well as developing and overseeing $100 million a year in domestic grant programs for fostering the development of communications infrastructure.

From 1990–1993, Mr. Gonzalez was a Policy Analyst with the U.S. Congressional Office of Technology Assessment. As a member of the Telecommunications and Information Technology staff, he acted as a policy advisor to various committees of Congress, including the Senate Commerce Committee and the House Committee on Science & Technology. He has also testified before the U.S. Senate as an expert witness on telecommunications policy and e-government. Mr. Gonzalez authored *Connecting the Nation: Schools, Libraries and Healthcare Providers in the Information Age* and is a co-author of *Making Government Work: Electronic Delivery of Federal Services*. He holds a Bachelors and a Masters Degree from Harvard University.

Forum on the Status of Wireless Technologies for Schools
October 29, 2002

Individuals invited to participate in the forum: *Wireless Technologies in Education: Prospects for Improving Schools* were asked to identify the critical issues relating to wireless technologies that needed to be addressed and understood by educators. At the outset of our discussions, a number of questions were raised. Basically, we wanted to know: "What are the educational benefits supported by wireless technologies, and what is wireless best suited for today?" Other important and technical questions dealt with broadband access, last mile solutions, and quality of services, and with interoperability and compatibility concerns (wireless with wireless and wireless with wired). ATEC and MARTEC discussion leaders also expressed an overall policy interest that related to ensuring affordable access to telecommunications services in rural schools and in rural community settings.

Participants:

Arthur D. Sheekey
Appalachian Technology
Education Regional Consortium
The CNA Corporation
4825 Mark Center Drive
Alexandria, VA 22311
(703) 824-2751
sheekeya@cna.org

Laurence Peters
Mid Atlantic Technology
Education Consortium
Temple University
1301 Cecil B. Moore Avenue
Philadelphia, PA 19122
(215) 204-3000
lpeters@temple.edu

David Diggs
Vice President and Executive Director
The Wireless Foundation
1250 Connecticut Avenue, NW, Suite 800
Washington, DC 20036
(202) 785-0081
DDiggs@ctia.org

Richard V. Ducey
President, SpectraRep, Inc.
15120 Enterprise Court
Chantilly, VA 20151
(703) 802-2995
rducey@spectrarep.com
www.spectrarep.com

Christopher Fennig
BBN Technologies
1300 North 17th Street
Arlington, VA 22209
(703) 304-9561
cfennig@bbn.org

Phil Gieseler
Universal Service Administrative Company
2120 L Street, NW
Washington, DC 20037
pgieseler@universalservice.org

Emilio Gonzalez
Consultant
612 Constitution Avenue, NE
Washington, DC
(202) 907-8460
egonzalez@mybluelight.com

Orin R. Heend
President
Funds for Learning
2111 Wilson Boulevard, Suite 700
Arlington, VA 22201
oheend@fundsforlearning.com

Mike Hernon
Hemingway Group
907 6th Street, SW
Washington, DC 20024-3875
(202) 554-5106
Mike@HemingwayGroup.com
mtHernon@erols.com

Aleck Johnson
Aleck Johnson Consulting
514 West Street
Alexandria, VA 22314
(703) 582-7420
aleck@speakeasy.org

Eric Jensen
Educause
1150 18th Street, NW, Suite 1010
Washington, DC 20036
(703) 868-8325
eljensen@comcast.net

Steve Jones
Director of Technology
Town of Blacksburg
300 South Main Street
Post Office Box 90003
Blacksburg, VA 24062-9003
(540) 558-0726
sjones@blacksburg.gov

Stephen Kohn
Director of Strategic Alliances
and Education and Disabilities Initiatives
Verizon
79 Lexington Street
Westbury, NY 11590
(212) 395 2255
Stephen.Kohn@Verizon.com

Arlene Krebs
Director Technology Development
Office of the CIO
California State Univ. Monterey Bay
100 Campus Center
Seaside, CA 93955
(831) 582-5025
arlene_krebs@csumb.edu

Neal McNeil
Office of Engineering and Technology
Federal Communication Commission
445 12th Street, SW
Washington, DC 20554
nmcneil@fcc.gov

Mark G. Seifert
Common Carrier Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554
(202) 418-1548
mseifert@fcc.gov

Linda Schatz
Education and Telecommunications Consultant
Washington, DC
(202) 251-4097
lschatz@earthlink.net

ATEC

Appalachian Technology
In Education Consortium

The ATEC at CNAC
4825 Mark Center Drive
Alexandria, VA 22311