Mobile & Wireless Technology

FEATURE

Wireless Nirvana

By Peter Rysavy

It all seems so sexy on TV--the image of a luscious plate of pasta on their buddy's cell phone gets the other guys drooling. You know you want it. Now you can have it--if not the spaghetti, the data service.

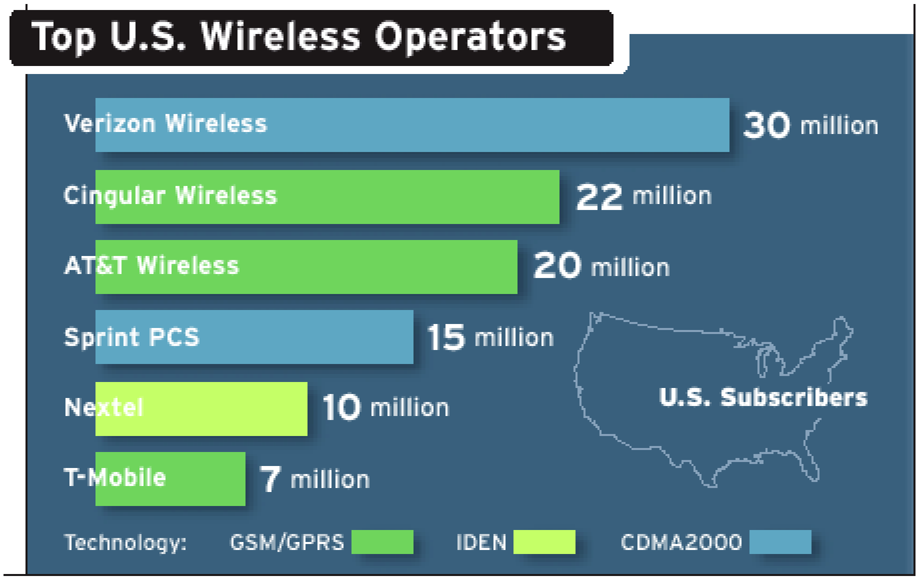
After years of anticipation, next-generation cellular-data services are being deployed worldwide. In the United States, AT&T Wireless, Cingular Wireless and T-Mobile (formerly VoiceStream) are deploying GPRS (General Packet Radio Service) data technology in their GSM (Global System for Mobile Communications) networks, while Alltel, Sprint PCS, U.S. Cellular and Verizon Wireless are deploying CDMA2000 1XRTT. These new services give a big boost to networking options for remote-access solutions.

Both IP packet networking technologies offer substantial speed improvements over previous cellular technologies, including CDPD or circuit-switched data services. Is this wireless heaven? Yes and no. GPRS and 1XRTT (which stands for "one-carrier radio-transmission technology") are a huge step forward and will enable a broad range of new wireless applications, but in terms of performance, they are more like dial-up than broadband and require some care to fully exploit their capabilities. In particular, you'll need to consider throughput, latency, security, usage costs, service coverage, IP-address and data-session management, and intranet interconnections.

Network Details

Although they're different in almost every other detail, both GPRS and 1XRTT are packet-switched--the most important improvement over earlier technologies. Data services for GSM and CDMA were circuit-switched and emulated modem connections. With packet switching, a user's modem (whether a data-capable mobile telephone, PC Card modem or PDA with integrated modem) uses only the radio channel when sending and receiving packets. Thus, packet switching uses scarce radio resources more efficiently than does GSM or CDMA circuit-switched data services, and theoretically provides users with an always-on, always-virtually-connected experience. Because cellular networks, even digital ones, were designed for circuit-switched voice communications, packet switching requires new a infrastructure to handle authentication for data services, IP-address management and network interconnections.

To the user or IT manager, GPRS and 1XRTT provide very similar services, namely the transport of IP packets to and from mobile terminals. The connection to the packet data service is functionally equivalent to a connection to an ISP. The connection begins at the mobile terminal, such as a notebook computer. A mobile application interfaces to a TCP/IP protocol stack, which interfaces to the wireless modem, which is inserted in the computer or, in the case of a data-capable cell phone, connected by a serial cable, USB cable, infrared or Bluetooth. The modem presents a PPP interface or NDIS interface. NDIS, normally used by Ethernet devices in a Microsoft Windows environment, offers better plug-and-play capabilities and is typical for PC Card devices; PPP suits tethered devices, such as mobile telephones. In the case of GPRS, the PPP connection terminates in the device; in 1XRTT, the PPP connection terminates in the network. Although this difference illustrates CDMA's greater use of IP protocols within its infrastructure, it hardly matters to users.



Across the air, GPRS and 1XRTT use different approaches, though end users probably will never know the difference. GPRS takes the GSM time-division approach: Each 200-KHz radio channel is divided into eight time slots. Normally, one time slot supports one voice user, but for packet data, GPRS can combine up to four time slots for effective throughputs of about 40 Kbps. 1XRTT, in comparison, is a DSSS (direct-sequence spread-spectrum) system that uses a much wider, 1.25-MHz radio channel and different codes to designate channels. Compared to prior CDMA versions, 1XRTT introduces high-speed supplemental channels that can operate at 16 times the fundamental voice-call channel rate. This technology allows burst rates of 144 Kbps, though typical user rates are generally 40 Kbps to 60 Kbps. In both GPRS and 1XRTT, a medium-access protocol controls which user gets to send packets at what time; data users must contend for radio resources with other data users and voice users. Operators can specify how much of their system capacity to allocate to data and to voice. Both technologies can take advantage of idle voice capacity to boost data capacity, though the converse also holds true--in a cell busy with voice traffic, only a small amount of capacity may be left for data.

Unlike Ethernet network nodes, which can monitor network activity directly and instantly detect collisions, cellular networks' mobile terminals listen to and communicate only with the base station, not with one another. This increases latency relative to wireline networks as the network must coordinate all communications. For packet communications, the mechanism to transmit data packets occurs in two stages. First, the mobile terminal uses a control channel to request a traffic channel. The control channel is a random-access channel and collisions can occur from other terminals, in which case the terminal must repeat the request. The network responds by assigning a traffic channel (specified time slots in the case of GPRS and a specified code in the case of 1XRTT) for data transmission. The complexity of managing radio access results in wireless-network latencies higher than those of a wireline network. Round-trip times of .5 seconds to 1.5 seconds are typical. Latency can slow down some applications more than throughput, especially if the application shuttles a lot of messages. Delays also can restrict what applications are feasible. Some applications, such as packetized voice, are highly sensitive to delay. On the other hand, streaming applications that are not interactive should not have a latency problem.

With both GPRS and 1XRTT, the network separates packet data from circuit data at the base-station controller and connects it to a separate packet infrastructure. The core packet nodes in GPRS are SGSN (Serving GPRS Support Node), which tracks user locations, and GGSN (Gateway GPRS Support Node), which handles IP-address management and gateways to external networks, such as the Internet. In the case of 1XRTT, the core packet node is PDSN (Packet Data Serving Node); it performs much of the same functions the SGSN and GGSN do. This internal architecture is of little consequence to users, other than the fact that server-side connections are via packet networks, and not telephone networks.

IP Packet Architecture

To control data sessions, modem vendors (or operators) provide a software utility that reports connection status and handles management. When the user invokes a data session, the network dynamically assigns an IP address to a mobile terminal--by the GGSN in GPRS and by the PDSN in 1XRTT. From a usage point of view, the cellular network looks like an ISP, with IP packets routing to and from the mobile user. Like an ISP, the operator may also provide an e-mail address but is less likely to provide other services such as Web hosting.

GPRS and 1XRTT are steps in an evolution of capability. The next step for GPRS will be EDGE (Enhanced Data Rates for GSM Evolution), a radio upgrade that promises to triple throughputs. EDGE retains the same core infrastructure and uses the same spectrum and same time-division approach, but adds sophisticated radio mechanisms to alter modulation and error correction dynamically based on the instantaneous radio environment, thus increasing spectral efficiency and user throughputs. EDGE networks will become available in 2003, with nearly all North American carriers committed to that technology's deployment. Beyond that, GSM carriers will deploy wideband CDMA (WCDMA)--also referred to as UMTS (Universal Mobile Telecommunications System)--a version of CDMA different from CDMA2000 that initially will boost peak data throughputs to 2 Mbps. That throughput eventually will jump to 10 Mbps, with a technology called High Speed Downlink Packet Access.

For CDMA2000, the evolution path includes a technology called 1XEVDO (1X Evolution Data Only), which boasts peak throughputs of 2.4 Mbps and 1XEVDV (1X Evolution Data and Voice), which will have peak downlink speeds of 5 Mbps.

Keep in mind these factors when you consider the future of wireless data:

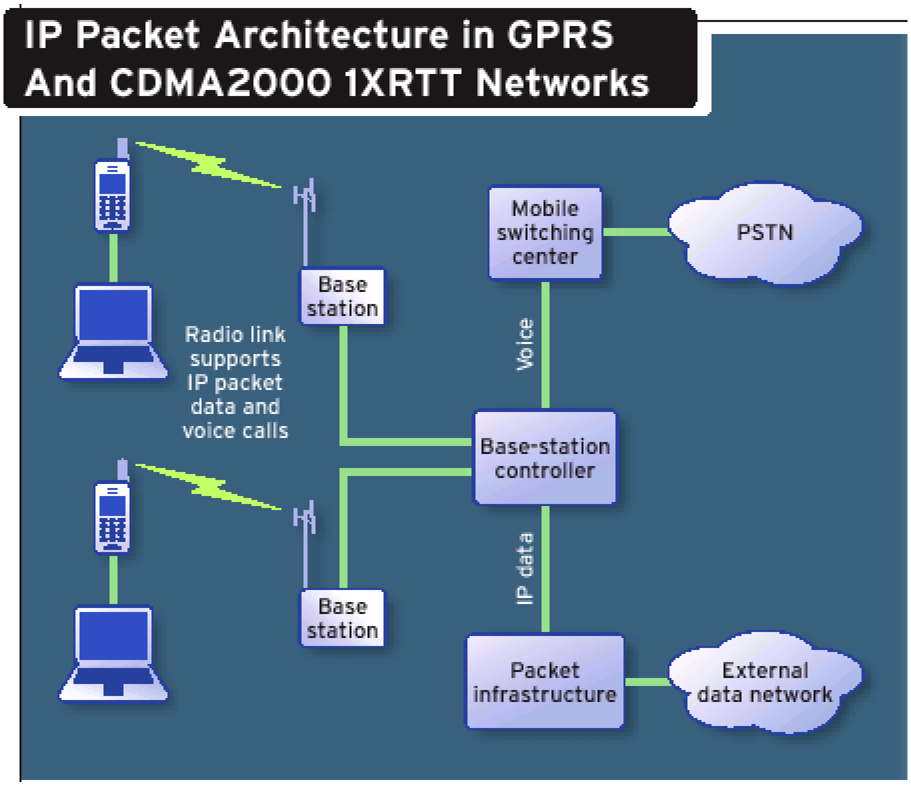
• **Peak speeds are not the same as average speeds.** For instance, though WCDMA tops out at 2 Mbps, this represents the total cell capacity; typical users will likely get 200 Kbps to 300 Kbps throughput on a loaded network.

• **These deployments will take time.** Though EDGE, essentially a network-software upgrade, is almost here, WCDMA and 1XEV deployments could take several years. These technologies will be more expensive and complicated and will require a new radio-access network.

• **Business plans for 3G networks are up in the air,** with demand for wireless data services uncertain and the rapid deployment of public WLANs possibly channeling user-data subscriptions away from cellular networks. Following the overall telecom meltdown, many operators are delaying their 3G deployment plans.

• **Spectrum is an issue.** Operators can deploy EDGE and CDMA2000 easily in existing spectrum, but WCDMA uses 5-MHz radio channels--it's not called wideband for nothing. Finding room for these channels won't be easy. Most countries in Europe and Asia have auctioned new 3G spectrum for 3G service. The United States is a little further behind, having just recently identified which bands might be feasible.

Meantime, GPRS and 1XRTT are real. Which is the better service? 1XRTT has a throughput advantage for the moment, but GPRS is available in more countries. And the upgrade to EDGE should more than match 1XRTT, though users will need new equipment to take advantage of the service. From all other perspectives, the offerings are largely equivalent. The table on page 78, "Wireless Technology Time Line," compares capabilities and deployments of the different cellular technologies. \



Using the Networks

Getting started with these networks is easy, but getting full satisfaction requires attention to detail. Establishing connections is straightforward, IP-based applications work immediately, and you can almost instantly realize the convenience of anywhere, anytime communications. But you must consider where service is available, which platforms to use, performance variations, security, usage costs and networking idiosyncrasies. Fortunately, these are manageable once you understand them.

Service availability is the best place to start because if you don't have service, the rest of the points are moot. All the operators are planning nationwide service, and if you can get voice service, you will be able to have higher-speed data service, a significant improvement over networks such as CDPD, in which service coverage does not match the voice footprint. But this won't happen overnight. T-Mobile offers GPRS everywhere it offers GSM voice service, but AT&T Wireless and Cingular Wireless use TIA/EIA-136 TDMA technology for their voice networks and are rolling out new GSM/GPRS networks. AT&T Wireless expects to have most of its network deployed by the end of this year; Cingular Wireless, by the end of 2003.

On the CDMA side, the two largest operators are upgrading their existing networks to 1XRTT and both will offer broad coverage by the end of this year. Sprint PCS has upgraded most of its network, and Verizon Wireless says it expects to cover 90 percent of its 30 million subscribers by year's end. Check with the operators. Most show coverage maps on their Web sites for these services.

Increasingly, customers are asking about global coverage, and here GPRS has the advantage of availability in 64 countries. However, make sure your provider has a roaming agreement with a foreign operator in the country of interest. In addition, GSM operates in different radio bands in different locations, so your device must be able to tune to the appropriate frequencies. Fortunately, multiple-band GPRS phones and modems are available.

Throughput Versus Latency

Because Packet-Switched data networks don't deliver a dedicated circuit, they can't promise consistent throughputs either. This is the new services' most significant caveat. With traditional modems, users have a dedicated circuit and can expect a consistent performance level. This is also true with circuit-switched data for cellular. In the case of the new packet networks, the medium is shared, just like Ethernet, but the total available bandwidth per cell site is much lower than Ethernet's. Although CDMA2000 carriers quote their networks as having peak speeds of 144 Kbps, and say users can expect 40 Kbps to 60 Kbps, they fail to mention that at peak times under heavy voice loading, data throughput may drop to 10 Kbps. GPRS can suffer from this effect too. Also, once the number of data users increases, the available data channels will be shared, and average throughput will go down. How much? It depends to what extent the operators manage QoS (quality of service) for data. As with voice capacity, they can increase data capacity by allocating more radio channels (assuming they have spectrum available) or by adding base stations (a costly endeavor). So take the figures quoted by operators as a starting point, but do your own testing to determine how well your applications operate. Furthermore, keep in mind that any testing you do today may not capture how the networks will perform once popularity increases. Given the historical low data usage on cellular networks, this is a problem operators would love to have. Furthermore, operators have had similar voice-capacity challenges in some markets, but have managed to keep up with demand. In the case of Web access, most operators provide optional Web acceleration servers that work quite well. The accelerators increase Web throughput significantly by reducing the file size of images, compressing text and reducing the number of TCP connections used to download pages. Some operators include specialized e-mail gateways that let smart phones access conventional e-mail services.

Latency--the amount of time it takes packets to traverse the network--is as important as throughput. Wireless networks have higher latency than wireline networks. In CDMA2000 1XRTT networks, round-trip times for small packets can be 500 milliseconds to 600 ms, and with GPRS can be closer to 800 ms. High latency will take a toll on applications that require many small data transactions. Keep in mind, however, that operators are still tuning their networks for optimal performance. Do the available data rates and latencies support existing enterprise applications, such as VPNs, Microsoft Outlook, Lotus Notes, Web-based applications and database access? Yes, but you still will want to be careful how much data you download, for performance and cost reasons.

Pricing It Out

AlThough Verizon Wireless offers a flat-rate business plan at $99 per month, most plans are usage-based, and charge between $1 and $10 per megabyte, depending on the size of the monthly commitment, with $4 per megabyte being typical. It is quite easy in an interactive data session over an hour to transfer more than a megabyte of data. So costs can add up quickly. Moreover, most users, including experienced ones, have no idea what volume of data different transactions consume. You will want to characterize your applications for data volume before you commit to a pricing plan. Pricing may also influence the application architecture you choose--a thin-client approach transmits less data than a fat-client setup. See "Wireless Data Service Pricing" chart for costs for different data plans. Note that these are changing on a regular basis, and the trend will be downward as competition increases.

Platforms raise another interesting question. In the past, laptop users would attach a data-capable cell phone or plug in a PC Card modem, but the number of options is increasing quickly. First are phones with ever-increasing data capability. Although for some time phones have had microbrowsers for viewing specially formatted Web content, the newest ones can actually execute programs, enabled by both Sun Microsystems' Java 2 Micro Edition and Qualcomm's Binary Runtime Environment for Wireless. New smart phones also incorporate PDA capabilities, using either proprietary platforms or platforms supplied by Microsoft, Palm or Symbian. These slightly heavier and larger phones make sense for users who want voice and data on one device, but who favor voice.

For those who favor data, the platform of interest may be the phone-enabled PDA, which looks like a

PDA rather than a phone. Palm OS, Pocket PC and RIM Blackberry represent the leading platforms, and devices are available for both GPRS and 1XRTT networks. Wireless-enabled PDAs might just become the platform of choice for GPRS and 1XRTT, while notebooks may gravitate to wireless hotspots based on 802.11 technology that have the higher bandwidth preferred by communications-intensive applications.

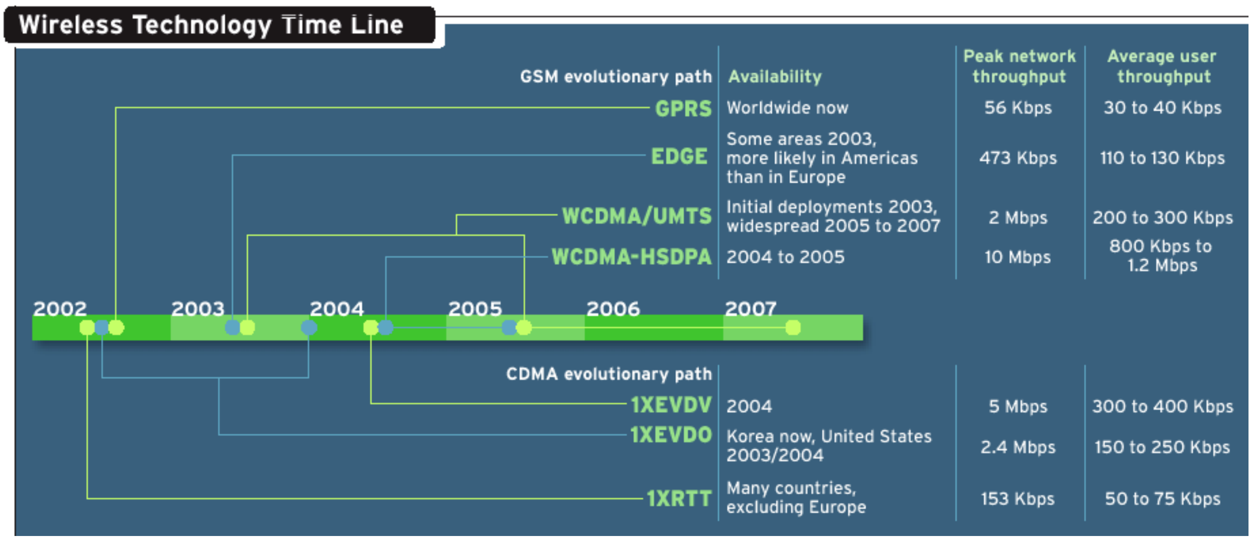
But Is It Secure?

WLAN security, or lack thereof, has received a huge amount of attention, but cellular networks are a different story. First, operators employ rigorous authentication mechanisms to protect against fraud. As for encryption, CDMA networks do not encrypt data traffic, but it is inherently difficult to eavesdrop because CDMA's spread-spectrum signal is intended to look like low-level noise. However, it is not impossible. GPRS, meanwhile, has a reasonably effective encryption option, but only some operators use it. Both 1XRTT and GPRS would require sophisticated equipment that's not yet readily available to try and monitor user traffic, but most corporations are likely to employ their remote-access VPNs with these networks anyway. Even if the wireless link is protected, the data traffic may still pass across the Internet, and the VPN is probably required to access the corporate network. Traditional VPNs work fine over GPRS and 1XRTT, but are not as efficient as some new wireless-optimized VPNs from companies such as NetMotion Wireless and Ecutel.

Although these new networks support IP, you need to read the fine print. One item to watch is session maintenance. To conserve networking resources, such as IP addresses, operators time out inactive sessions. With Verizon Wireless, time-outs occur in as few as five minutes. A user who has just spent a couple of minutes establishing a VPN connection won't be happy to lose that connection five minutes later just because he or she ponders over an e-mail. You may need to adjust keep-alive timers in the VPN accordingly. In contrast, AT&T Wireless (GPRS) has its time-out set at one hour. You will need to ask about this or test it directly. When your session times out, you lose the IP address you had, which can also complicate server-initiated communications, such as for dispatch or other forms of notifications. Also, there simply aren't enough IP addresses for the new world of mobile users. Most operators employ NAT (Network Address Translation) in their networks and issue users private (nonroutable) IP addresses. This lets multiple private addresses map to a single public IP address. Because this does not work with all applications, including most VPNs unless they are configured appropriately, operators also offer public IP addresses as a service option.

Once you sort out networking on the mobile side, you'll have to consider the fixed-end side--that is, how to establish a communications channel between the operator's network and fixed-end services. Since all the wireless networks provide Internet connectivity, mobile access of public sites is a breeze. However, if you are accessing services on your intranet, you'll have to consider several options. If your company allows remote access via the Internet and VPNs, one alternative is to do the same with these wireless networks, and to use the Internet as your back-end connection. However, if you need a more secure and more reliable back-end connection, you may want to negotiate with the operator for a frame-relay circuit between your intranet and the operator network, or possibly a dedicated server-to-server VPN connection across the Internet. However, these options, which vary by operator, typically are made for large commitments only.

These data services are as new for the operators as for users, and the average customer service or phone store representative may have no idea what you are talking about when you ask about data services, or even worse, about a technical matter such as private versus public IP addresses. However, most have a customer-care group that specializes in data, so try to reach that group if you run into any technical difficulties, or be prepared to investigate on your own. Fortunately, the products and services are well-designed, and with a small time investment, you will be dispatching bits into the ether.



Peter Rysavy is president of Rysavy Research, a communications technology consulting firm.

Executive Summary

Next-generation cellular data services are enabling a wide variety of wireless networking apps, from databases to e-mail access. View images on a cell phone's screen; make phone calls on a PDA--it's all possible in the new world of packet-switched, wireless IP transport.

The major wireless carriers have employed two key technologies. AT&T Wireless, Cingular Wireless and T-Mobile use GPRS, while Verizon Wireless and Sprint PCS have chosen CDMA2000 1XRTT. Both perform similar functions, about equally well, though the details are different for each. Users can expect to get about 30 Kbps to 40 Kbps throughput with GPRS, and roughly 50 Kbps to 75 Kbps with 1XRTT--both slow compared to wireline connections. Latency will also be an issue--500 to 600 milliseconds for 1XRTT, and about 800 ms for GPRS--though these figures primarily will affect applications that require many short transactions, such as database access.

Pricing changes frequently, but at press time, we found rates that ranged from Cingular Wireless' $14.99 to transfer up to 3 MB of data to $99.99 per month for Verizon Wireless' unlimited data plan.

We also ran tests on a 1XRTT network in Syracuse, N.Y., and a GPRS network in Portland, Ore. Both did their jobs respectably, with comparable throughputs and decent connection capabilities. Regardless of which wireless network you select, you'll get adequate service--much slower than wired, but much more convenient as well, since you can take your cell phone, PDA or notebook computer just about anywhere.

GPRS: Problem-Free Connections

As part of the research FOR this article, we obtained a GPRS-capable handset and GSM/GPRS service from AT&T Wireless, and conducted tests in Portland, Ore., and Bellevue, Wash. Our overall experience was positive.

AT&T Wireless supplied us with an Ericsson T68, an extremely popular new model globally, featuring data capabilities, color display, WAP browser and Bluetooth connectivity. We created a model based on a user who uses the phone primarily for voice, but occasionally connects it to a notebook computer to transmit data. In this configuration, Microsoft Windows sees the phone as a modem, through which it can establish a dial-up networking session. The first choice was whether to connect using Bluetooth or a cable. We took the easy route and used the cable, but after connecting and disconnecting the cable dozens of times, we decided Bluetooth would be much more convenient, especially if it were integrated into the notebook as it is on some new notebook models. The cable comes in a connectivity package that also includes software.

If you are technically inclined, you can use the modem information file for the phone and create a dial-up networking icon in Windows with the appropriate parameters. However, this would defeat most users. Fortunately, AT&T Wireless provides a connection utility that installs all the right drivers and configures the computer appropriately for immediate access. The utility then provides a small window in which you can connect, disconnect, and monitor your connection status. When you press the connect button, the network authenticates the device and assigns it an IP address. At that point you can send and receive data. Being connected does not result in any usage charges; you are charged only when you communicate data. This may not be obvious to the average user. The utility does not keep track of how much data you send and receive, but if you click on the Windows dial-up-networking icon in the system tray, you can monitor data usage.

In actual usage, we learned that we needed a certain level of signal strength--at least two bars, and preferably three (out of five)--for reliable operation. Although GPRS employs extensive error correction, a poor signal throttles throughput due to retransmissions that cause TCP and application time-outs. You can obtain a numerical indication of signal strength from the connection utility, but only when you are in a disconnected state. With PC Card modems, you can view signal strength while online, which is much more convenient.

For actual data transmissions, we were very pleased. Throughput tests measured between 31 Kbps and 36 Kbps. We did not notice any differences in throughput based on time of day, but this is probably because the network is not yet heavily loaded. Using ping, we consistently measured round-trip time latency of about 750 ms. Web browsing, file transfers and e-mail applications worked perfectly, and were put solidly to the test during a business trip where we used GPRS for all business communications, both in a hotel room and in a conference room where access to e-mail during the day proved extremely convenient. For Web browsing, we experienced a significant boost in speed when we enabled Web compression, an option in the connection manager. --Peter Rysavy

Verizon Wireless' 1XRTT: Safe At Almost Any Speed

We tested Verizon wireless' Express Network (CDMA 1XRTT) in and around Syracuse, N.Y. Although our tests may seem extreme--not too many people try to download e-mail while driving--we're happy to report the worst-case scenarios we encountered weren't too bad. We experienced latency everywhere, but the service's speed was adequate when we had a strong signal. When the signal is weak, though, you might as well use carrier pigeons for wireless transfers.

Verizon supplied us with a Sierra Wireless AirCard 555, a Type II PCMCIA-based cell modem, which we installed on a Dell Latitude CPx laptop running Microsoft Windows 2000. This dual-band wireless PC Card provides network, voice and two-way messaging capabilities. It has a plug for a headphone jack and can be used as a normal cell phone. An on-screen interface mimics a cell-phone screen, for making and receiving calls. The interface shows voice-mail status, signal strength and dialing buttons. Beyond providing caller-ID information, however, the computer does little more than answer, dial and deal with SMS text.

The Sierra card's antenna looked flimsy and breakable. It is not retractable nor is it permanently attached to the card. We've broken enough PCMCIA Ethernet card dongles to know this is not a good thing. You must install the Windows-only software to use the card; however, the process is straightforward. The software automatically loads a driver for the card, sets up a PPP script and loads a custom user interface for dialing and status information. We were running in about five minutes.

The card supports 1XRTT and circuit-switched CDMA connections, and is backward-compatible (albeit at 14.4 Kbps) if 1XRTT service isn't available in your area. Connecting to the 1XRTT network and obtaining an IP address took 1 to 5 seconds, depending on signal strength. You are given a three-day lease, but it's virtually useless. If you are IP idle for five minutes, you will be disconnected. And reconnecting does not guarantee the same IP address; we went through several during our tests.

For our main test, we drove about 40 miles, taking measurements in downtown Syracuse, the suburbs and on Interstate 90 going 65 mph in our Nissan Sentra. We had connectivity all the time, but in some places the throughput was so poor it was barely usable. We measured from 3 p.m. to 4 p.m., and then again from 11 p.m. to midnight. Latency was terrible all the time. Pings to www.yahoo.com usually took between 300 ms and 450 ms, and peaked at more than 800 ms. The average rate for even our best connection was 375 ms. Latency did not increase or decrease with signal strength, but throughput did. We used bandwidthplace.com/ speedtest as our speed gauge.

Verizon Wireless claims the network is capable of data speed bursts up to 144 Kbps, with average speeds of 40 Kbps to 60 Kbps. At worst we got 11 Kbps and at best almost 104.7 Kbps, the latter at night. We were surprised to see a respectable 66.4 Kbps while traveling down the highway during the day. In areas with lower signal strength, lost packets occurred frequently. In general the system was quite fast and usable. If you're in a good coverage area, the speed is better than dial-up but slower than broadband. When reception is bad, you'll likely get better results with an acoustic coupler attached to a bullhorn. --Michael J. DeMaria