If you want to see the future, watch a teenager in Japan. For young Japanese, the cell phone call--that phenomenon of modern living--is already going the way of 45-rpm vinyl.

Phones aren't just for calling; they're for sending e-mail. Since its introduction in February 1999 the Internet-ready iMode phone has been taken up by some 10 million Japanese. It has proved so popular that the carrier, NTT DoCoMo, is now Japan's largest Internet service provider. "All my friends have them," says 18-year-old Aya Shimizu. "We use them all the time to stay in touch."

In the U.S. the acceptance of Web phones is growing rather more slowly. Cell companies have built "microbrowsers" into their latest phones, allowing their customers to send e-mail and check news headlines. Those technophiles who use Web phones swear by them. W Edward Learned, marketing director for an Internet service provider in Minneapolis, get lost, he simply enters his location and the phone gives him directions. Thumb twiddling is thing of his past. When he's standing in line, he checks his e-mail, looks up movie times, and tracks his portfolio. "I can even pull up a stock chart," he marvels.

But it's still not clear
that Americans will embrace Web phones with the same enthusiasm as the Japanese or the Scandinavians. Industry analysts are divided over the long-term viability of the Wireless Application Protocol, in particular. Typing out e-mails using the keypad code is a real chore; newer phones are incorporating ways to make it easier, such as guessing the word you're trying to spell, but it's still much slower than a full keyboard. Worse, custom quickly find that small screens and meager services can cost big bucks.

"The truth is, what you're getting isn't worth what it costs," says Simon Buckingham of Mobile Lifestreams LLP, a British consulting group. "The real problem with the technolo right now is that it doesn't reflect the rhetoric. There is a huge gap between what people have been promised and what you can actually do today."

For many customers, the first hurdle is simply the idea that you can navigate a Web site on that teensy cell-phone screen. Unconvinced? You can try it yourself using your desktop computer to simulate the Web phone experience. Of course, of the vast ocean of information available on the Internet, only a trickle is available through a Web phone. The sites you use most often when sitting at your desk will, as likely as not, overwhelm a phone.

The ones that do work must be specially tailored. Although a few companies such as Google have developed technology that converts a standard Web page into a Web phone page on the fly, most sites prefer to build a kind of parallel Web site that Web phone users can access. The number of such sites is increasing by the week. Pinpoint.com in Durham, N.C., runs an Internet search engine that seeks out and tracks phone-friendly Web pages. This past April it found 150,000 of them; by June, 2.4 million. Company president Jud Bowman estimates that 25,000 of the five million Internet domains—each of which corresponds to an individual Web site—offer Web-phone-optimized pages. The vast majority are in Europe and Japan.

In short, a Web phone is no surfboard. It can be used to get snippets of information from certain sites such as MapQuest, Amazon and CNN, but it is not a general-purpose browser. Almost all carriers restrict users to a small subset of the phone-optimized Web pages. Is that enough? For many consumers, yes. Those who want bigger screens, easie text entry and broader access, at the price of carrying an extra device, can turn to handheld or laptop computers. The Palm VII model comes equipped with wireless Internet access and radio modems such as OmniSky's Minstrel can be clipped onto other handhelds. For laptops, Metricom has just rolled out a new version of its Ricochet wireless modem, promising speeds twice as fast as the best ordinary modems and eight times faster than c phone modems.

But even the most patient early adopters get frustrated with the spotty coverage, glacial spe and long latency. If anything, the service in mar areas has been deteriorating over time. "Some the services [that] people have set up are not robust, not scalable," Buckingham explains. "They work for a few dozen people, but if a few
hundred people try to use them they break or work very slowly." The much-touted third-
generation networks may also run into such difficulties [see "The Third-Generation Gap"

When delay strikes, the mismatch of cost and capability becomes seriously irksome. U.S.
carriers charge as much as 39 cents per minute, and European carriers are similarly pricey. The
clock ticks even when your fingers cramp up or the World Wide Web turns into the World Wide Wait. It's disconcertingly easy to lose track of how much money you're spending. "We've been hearing stories about bill shock Buckingham says. "Somebody looks up a sports score and checks the headlines and the

In Japan the pricing model is less punitive. Making a brief call on a cell phone runs about
cents; sending an e-mail message, about a penny. NTT DoCoMo makes its money in other ways. The company estimates that the average iMode user spends an average of about a month on Internet-related services in addition to telephone time. The most popular feature is a monthly download of cartoon characters from a company called Bandai. The files cost about $1 apiece and are used as screen savers. But even in Japan, open-ended costs frighten some consumers away. "I think it would be very useful, but I'm worried about how much using all those features would cost," says Ida Kohei, a former television executive who is, admittedly, 72 years old.

To be sure, these are probably just the early teething pains of the industry. Businesses
everywhere see the potential of the technology; connected consumers will be big, mobile wallets. The plan is that you'll use your phone to spend money everywhere, all the time. Riding the elevator and hear a song you love? Whip out the phone and order the album. Found the perfect sweater but not sure about the price? Use your phone to see if you can get a better deal across the street or on the Internet. Thirsty? Access a list of nearby coffeehouses. But until cell phone companies get their act together, the dream will remain just a dream.

The Author

DAVID WILSON, who writes for the San Jose Mercury News, has covered the Internet since 1991. His motto: He who laughs last thinks slowest.
Every great journey begins with a first step. Many leaders in the telecommunications industry are convinced that the first step toward a wireless Web is a set of technical specifications called the Wireless Application Protocol, or WAP.

In recent years the leading wireless companies have introduced data networks that allow cell phone users to pull information from the World Wide Web and display it on the phones’ tiny screens. The WAP specifications would essentially standardize how these networks transmit Web documents to cell phones, pagers and other handheld devices. Wireless carriers in Europe are currently implementing the WAP standards in their data networks, and some U.S. carriers—including Sprint PCS and Nextel—promise to do so in the near future. WAP’s proponents say that the transition will accelerate the growth of the wireless Web. But critics counter that the WAP specifications are inadequate because they severely limit the user’s access to the Internet. It is still unclear whether WAP will truly usher in a golden age of wireless data or turn out to be just a false start.
The Wireless Application Protocol evolved from technologies developed by Phone.com software company based in Redwood City, Calif. The great obstacle to wireless Web access is the fact that cellular phones and their networks are not robust enough to handle HyperText Markup Language (HTML), the lingua franca of the Internet. The publishers of Web sites use HTML to weave text and graphics into simple, easy-to-navigate documents. Current cell phone networks, however, have a low bandwidth: they relay data much more slowly than fixed-line networks do, making it difficult if not impossible to transmit Web pictures wirelessly. And today’s cell phones do not have the processing power or the display screens needed to show complex images.

To get around these problems, the software engineers at Phone.com created Handheld Device Markup Language (HDML), which was specifically designed for wireless networks. HDML allows the text portions of Web pages to be transmitted to cell phones and other mobile devices. Many of the wireless data networks in the U.S. incorporated Phone.com software into their phones and network servers. What is more, Phone.com allied with three cell phone manufacturers—Motorola, Nokia and Ericsson—to devise a standardized language based on HDML. The result was Wireless Markup Language (WML), which became the core of the WAP specifications. The companies also formed an industry group called the WAP Forum to promote the new standards. The group now has more than 530 members.

Here’s how a WAP network taps into the Web: first, the owner of a WAP-enabled phone uses the device’s microbrowser—a pared-down version of the browser software used by PCs to navigate the Internet—to request a specific Web page [see illustration on opposite page]. The request goes over the airwaves to a cellular transmission tower and is then routed to a server operated by the wireless carrier. Running on the server is the WAP gateway: software that serves as a filter between the wireless network and the Internet. The gateway finds the Web page requested by the cell phone user. If the page is written in HTML (as most Web pages are), coding software converts the document to WML, stripping away the page’s graphics and any specialized formatting of the text, such as elegant fonts. The WAP gateway encodes the WML translation so that it can be transmitted wirelessly, and then the document is sent to the user’s cell phone, where it appears on the device’s small screen.

Conversion from HTML to WML, however, is usually not trouble-free. If a Web page uses pictures as links to other pages, for example, the page has to be rewritten to provide text links instead. In practice, this conversion frequently limits the amount of accessible information and occasionally makes the Web page completely unreadable. For this reason, many Web publishers have created separate versions of their pages written in WML and expressly tailored for WAP devices. For example, MapQuest, MSNBC.com and Go2Online.com have created WAP versions of their sites. WAP users can find a list of more than 5,000 WAP-friendly sites by visiting www.cellmania.com.

With the help of these portals, cell phone users can call up sports scores, airline flight schedules or the latest book bargains from Amazon.com. But the range of services and information that can be accessed by cellular phones is only a small fraction of the wealth of data available on the Internet. Some analysts believe that the WAP standards will swiftly
become obsolete as cell phone technology advances. “WAP was designed for the low-bandwidth cellular networks of the 1990s,” says Rich Luhr, an analyst with Herschel Shostech, a technology consulting firm in Wheaton, Md. “And it was designed for phones that had no graphics capabilities and screens with only two to four lines of text.” Accord to Luhr, as wireless networks and devices improve, WAP’s raison d’être will disappear.

The companies that are supporting WAP, however, say that the specifications can be revised to suit future technologies such as the high-bandwidth third-generation network now being developed [see “The Third Generation Gap”]. Furthermore, they emphasize that WAP-compatible phones are not intended as substitutes for Web-browsing PCs.

“WAP isn’t about browsing the Internet,” says Skip Speaks, general manager of Ericsson’s Network Operators Group. “It’s about delivering unique content that’s optimized for wireless devices.” Adds Scott Goldman, the chief executive officer of the WAP Forum: “Using or accessing the Internet from a wireless device is a different experience than accessing it from a PC. I use an analogy that access the Internet from a PC is like going to an all-you-can-eat buffet. You see a broad range of foods, pick and choose what you want, and move quickly from one food to another, putting as much as you want on your plate. WAP is more like room service. You see a menu, order what you want, and it’s delivered to you.”

Spurring Internet companies to produce more content for WAP phones is a high priority for the WAP Forum. But according to some analysts, creating a WAP-compatible Web page is more difficult than setting up a typical Internet page, because WML is harder to learn than HTML. The WAP Forum’s Goldman says that WML developer tools similar to those used for HTML will become more prevalent as WAP gains in popularity. Even so, the doubts about WAP’s future have made many Web developers leery: they do not want to invest the effort in creating separate pages for cell phone users if the standards are likely become outdated. “No one wants to jump in and commit to anything until things settle down,” says Herb Williams of Spyglass, a software company based in Naperville, Ill. “There’s a lot of negativism about WAP, and that limits the amount of content available.”

WAP’s Weak Point

WAP has another hurdle to overcome: security. The current version of the standards includes a set of provisions called Wireless Transport Layer Security (WTLS), which specifies how to encrypt wireless data while they are in transit from the cell phone to the network operator. The WTLS techniques require less power and memory than the Secure Sockets Layer technology that is used to protect credit-card numbers and other sensitive information on the Internet. The system’s weak point, however, is the server that runs the network’s WAP gateway, where the data must be decrypted.
from the wireless coding and reencrypted using Internet coding. For a fraction of a second (the exact time depends on a network’s latency and speed) the cell phone user’s private information is unencrypted. Granted, this moment of vulnerability occurs on servers that are closely guarded by the wireless carriers. But critics insist that even a split second of exposure is too much. Goldman asserts that WAP’s security problem is a nonissue. “It’s like a one-inch hole in a 100-foot wall,” he says.

As if all these problems were not enough, a patent dispute also clouds WAP’s prospects. Geoworks, a company based in Alameda, Calif., that develops software for wireless communications, holds a patent for the user interface incorporated into WAP phones and is seeking a $20,000 annual licensing fee from any large company that uses the technology. Phone.com filed a suit against Geoworks this past April, challenging the validity of the patent. Two months later Geoworks filed a countersuit, saying that Phone.com’s activities infringe on Geoworks’s patent. Although the dispute may seem like mere posturing from two rival companies, the lawsuits and the uncertainty over licensing fees may have a chilling effect, says Eddie Hold of Current Analysis, a technology research firm in Sterling, Va. “The development of WAP at the same stage as the development of the Internet in the early 1990s,” Hold says. “If the companies that developed content for the Internet had been required to pay a licensing fee it’s quite possible there would not be an Internet today.”

Furthermore, WAP is not the only game in town. Some wireless networks in the U.S. may decide to stick with their current HDML-based microbrowsers and gateways rather than switch to the standardized WAP software. Technologically, there is not much difference between WAP and HDML. WAP’s advantage is that it is an open standard rather than a proprietary system; the operator of a WAP network can buy its microbrowsers and gateways from a variety of vendors instead of relying solely on Phone.com. Switching from HDML to WAP, however, has its costs. A network operator must replace any equipment that is not compatible with the WAP standards, including older cell phones that work only with HDML.

Some analysts are certain that U.S. carriers will eventually rally around WAP as the European carriers have done. But the bigger question is whether wireless customers will actually use the data services that WAP provides [see "The Future Is Here. Or Is It?" on page 50]. Many observers believe that WAP networks will not become popular unless wireless carriers charge no more for data services than they do for voice communications. “WAP content should be used as a point of leverage to garner and retain voice customers,” Luhr says.

In the end, WAP’s future may hinge on the attitudes of its promoters. The current wireless networks are not as open as the Internet; the carriers and hardware manufacturers are controlling, to a large degree, the kinds of data available on their phones. But the explosive growth of the Internet was a direct result of its openness. The medium became so popular because any business could create its own site on the Web with a minimum of effort and expense. Many analysts believe that the wireless data networks must follow this model to succeed. Says Luhr: “Today’s WAP is about control, so the wireless industry can tell people what to do and what to look at. WAP must evolve beyond that.”
The Author

KAREN J. BANNAN is a freelancer who writes and edits for the *New York Times*, *Wall Street Journal*, *Internet World* and *PC World*, among other publications.
The Internet has been the subject of more self-parodying hype than anything since 500-channel cable. "The new economy offers synergies of disintermediation for the enterprise in the fast-paced B2B market." Whatever. Teasing out the truth can be tough. And it is getting tougher as the marketing machines gear up for the latest and greatest technomarvel, the wireless Web.

As this special report describes, the basic concept is simple enough: allow people to access the Internet from cellular phones, handheld computers and other portable gadgets. But it is neither an especially new idea—even in the U.S., which has been slower than other nations to catch on, such devices have been available since the mid-1990s—nor a sure sell. The data networks have been hobbled by incompatible standards, awkward user interfaces, punishingly high service charges and problems with spectrum allocation. They could yet go the way of, say, satellite telephone networks, the most famous of which, Iridium, has begun to fall to earth (literally).

That said, even a skeptic would give the wireless Web a good chance of success. Overheated sales rhetoric should not detract from the real engineering achievements. Spraying data through the airwaves isn't easy. Morse code used to be the basis of radio communication for good reason: sometimes only the simplest of signals can wade through sea of static. Over the decades, partly through the efforts of amateur radio hobbyists, the reliability and speed of data transmissions have slowly but steadily improved. Current wireless networks send data at a rate of about 10 kilobits per second, about the speed of regular modem circa 1990, and carriers are promising a 100-fold improvement in the next few years.

In the meantime, wireless enthusiasts (including a few *Scientific American* editors) can attest to the usefulness of checking movie times from the local bar and reading e-mail in airport waiting areas. Whether or not the breathless predictions come to pass, the wireless
Web is slowly weaving itself into everyday life.
Imagine it's the year 2005, and you're in New York City on a business trip. Strolling past the garish stores on Fifth Avenue, you suddenly hear the distinctive beep of your digital companion. When you remove the device from the pocket of your coat, you find a distressing sight on its video screen: a news bulletin reporting a plunge in your company's stock price. Standing there on the sidewalk, you bark the words "Access personal finances!" into the digital companion's microphone. The gadget instantly calls up the Web page of your favorite on-line stock-trading site. As the other pedestrians stare at you curiously, you start selling shares to reduce your exposure. Then you instruct the digital companion to access an airline reservation service and buy a ticket on the next flight back to the company headquarters.

You use the same device to call your wife and tell her about your change of plans. Finally, you order the machine to give you directions to the nearest bar. You're going to need a stiff drink before you head for the airport.

Although this scenario may seem fanciful, many of the biggest telecommunications companies are spending billions of dollars to make it real. What's motivating them is the
The infrastructure for a wireless Web is already being constructed, although progress has been more rapid in Europe and Japan than in the U.S. In Finland, cell phone users can send text messages to their friends, pay the bills, get traffic reports and buy a cup of coffee at a Helsinki café simply by dialing the right numbers. In Japan, hip teenagers have gone wild for the Internet-connected iMode phone which has attracted more than 10 million users. American companies have been slow to offer such services, primarily because the competing wireless networks in the U.S. employ different technologies for transmitting their signals. But in the past year, wireless carriers have launched aggressive campaigns to convince their customers to buy cell phones that can access the World Wide Web. In addition, new handheld computers such as the Palm VII have built-in antennas for wirelessly accessing the Web, and other models can do so by attaching to a mobile phone or a modem with an antenna.

Currently all these devices are restrained by the slow speeds of wireless data transmissions which average about 10 kilobits per second—less than one fifth the data rate of a typical modem over a fixed telephone line. These sluggish speeds may be fine for simple requests such as sending text messages, but they can make surfing the Web a frustrating experience and they practically rule out the wireless downloading of video, audio and other data-intensive files into a handheld device. What is more, many of the wireless data networks now limited to major cities, making it impossible for users to go on the Internet when they travel outside the coverage area.

New wireless technologies, however, promise to remove some of these stumbling block.

Here, Or Is It?

The Third-Generation Gap

enormous number of cell phone customers. In the U.S., some 95 million people use mobile phones, or about 34 percent of the population. In many countries in western Europe, the penetration of cell phones is above 50 percent; in Finland, the most cell phone–crazed nation on the planet, it is 71 percent. Even if just a small portion of these customers also subscribed to data services, it would represent a tremendous market.

SUBTOPICS:

Super Phones
Software Struggles

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New wireless technologies, however, promise to remove some of these stumbling block.

The first generation of cellular phones were analog devices that transmitted radio waves modulated to match the sound waves of the users’ voices. Today's digital cell phones are the second generation: they convert the sound information into bits of data carried by modulated radio or microwaves. Telecommunications companies are now working on third generation (3G) wireless networks that could increase the data rates of mobile devices to much as two megabits per second—high enough to allow users to download songs and movies from the Web. In particular, mobile phone operators across the globe are developing a technology called Wideband Code Division Multiple Access, which raises transmission rates by spreading each wireless signal over a wide band of frequencies /[see "The Third-Generation Gap."]/.

Licenses to use the sections of the radio spectrum necessary for 3G networks have already been allotted in the U.K., where the auction for the frequency bands raised nearly $35 billion for the government. The U.S. government is working on plans for a similar allocat:
In the U.K., wireless carriers such as British Telecommunications, Vodafone and France Telecom are promising that 3G networks will be in place as early as 2002, but it is difficult to predict when the speedy data services will actually become widespread. People in rural communities may have to wait a longer time than big-city dwellers will. Forrester Research, a consulting firm in Cambridge, Mass., forecasts that 3G services will not be available outside major metropolitan areas before 2010.

In the meantime, some wireless carriers will roll out a variety of intermediate technologies, the so-called 2.5G networks. In the U.S., for example, Sprint PCS plans to raise the top speed of its Web applications to 144 kilobits per second by implementing packet-switching techniques. Almost all of today's wireless networks are based on circuit switching; when you make a connection, you are assigned a specific frequency channel until the end of the call. With packet switching, though, the signal is chopped into packets of data. Each packet is tagged with the address of the destination and then sent swirling through the network to find its own way on any available channel. At the receiving end, the packets are reassembled in the correct order. This system yields higher transmission rates than circuit switching systems because data from many different sources can be intermingled on a single channel. Customers of packet-switched networks could talk on their cell phones and access the Internet at the same time. And because the signals would occupy a network's channels only when the phones are sending or receiving data, customers would pay for the volume of data that they downloaded rather than the time they spent on the network.

Unfortunately, this approach has a big drawback. Gathering and reassembling the data packets at their destination points takes a little time, and some packets get lost and have to be resent. This time lag is known as latency. It is not an issue with most data transmissions, where a delay of a few seconds can be tolerated, but losing bits of someone's voice can make conversation rather tiresome. Telecommunications companies have tried to minimize the problem with methods such as silence suppression, which removes the noiseless moments of voice communications. (About 30 percent of any phone conversation is silence.) The packets of data that do not contain voices are simply not sent, reducing traffic on the network and thus decreasing latency.

Super Phones

Cell phone manufacturers are experimenting with several different designs for the handheld devices that will be linked to the enhanced wireless networks of the future. If these machines are really destined to become digital companions, they will have to be versatile, adaptable and fashionable. At the high end of the product line, companies such as Nokia, Ericsson and Motorola are working on 3G "super phones" that will look nothing like existing cell phones. In fact, calling them phones seems absurd. They will have color screens, several inches square, for the presentation of high-resolution graphics and video. Some will have keyboards and miniature mice for data input, but most will use touch-sensitive screens and styluses, like those employed now by the Palm machines and other handheld computers.

In addition to carrying voice communications, the super phones will also be able to...
play music files that are circulated on the Web in the popular **MP3 format** (or in whatever format may replace it). Indeed, this application could open up a huge new market for the devices. "I believe music will be the killer application for the mobile Internet," says Robe Madge, founder of **Madge Networks**, a British networking and Internet services firm. "The next generation of mobile appliances will take over from the Walkman." PC users who spent hours trying to download music from the Web may scoff at this prediction. But a high-speed access service that is solely dedicated to music distribution could conceivably send highly compressed audio files to mobile devices when they are not being otherwise used (at night, say). The music files would then be stored in memory, perhaps on cards like **Sony Memory Sticks**, until the user wanted them.

For customers who are inclined more toward the written word, there will be handheld devices with bigger screens for reading electronic books. Some companies have even developed prototypes equipped with tiny video cameras and projectors for showing movies downloaded from the Web. "If you're on a train with one of these, you could project a film on a fellow passenger who's wearing a white shirt," quips Lars Bergendahl, a program director for Ericsson. "After asking permission, of course."

Almost all the prototypes have earpieces that are separate from the body of the device, and many have headsets that hold both the earpiece and a microphone, so that users can speak, listen and see the device's screen at the same time. To eliminate the need for wires, many prototypes use low-power radio waves to transmit signals between the headset and the body of the device. Several companies have already incorporated short-range radio-wave devices--based on an industry standard called **Bluetooth**--into their existing product lines. This same technology could also transmit data between the digital companion and any nearby device, including cash registers at supermarkets and other stores, thus making it possible for users to conduct transactions without cash, checks or credit cards.

But for all the millions of dollars that are being poured into designing these super phones, a prototype can cost $2.5 million to build--analysts predict that the top-of-the-line devices will occupy only a small niche of the market. "Most people will not need full-motion video on the move," observes Lars Godell, an analyst at Forrester Research. He believes that simpler "smart phones" will be much more common. These devices will look more like today's cell phones but with slightly larger screens and better input options than today's alphanumeric keys. The capabilities of smart phones will most likely be limited to sending and receiving e-mail, accessing the Internet (probably through specially adapted portals like those used by today's Web-browsing cell phones) and perhaps playing downloaded music.

Phone companies are not the only ones eyeing the market. The makers of handheld computers, which have until now been used primarily for scheduling appointments and compiling address lists, are also introducing devices that can access the Internet. Some manufacturers are planning to add voice communications to the machines as well so they can compete directly with the super phones. Even the makers of video-game consoles--Nintendo and Sony are expected to equip their **GameBoy** and **Playstation** consoles with Internet access in a year or two, according to Godell. And as more and more consumers get their music from the Web rather than from tapes or CDs, manufacturers of portable music players will start to build models that can wirelessly download the MP3 files on the Internet.

Another interesting idea is the Internet watch. Hewlett-Packard has formed a **collaboration with Swatch**, the world's biggest manufacturer of watch components, to create a wireles
device that will appeal to the fashion-conscious. Although it will look like a normal
timepiece, the watch will contain a tiny radio transmitter that will enable the wearer to
download sports scores, e-mail and music from the Web.

**Software Struggles**

While the hardware manufacturers battle it out, a similar competition will focus on the
software that will control all these devices. One popular contender is the operating syste
developed by Palm for its handheld computers and also used in Handspring's Visor
machines. Another is the EPOC operating system created by Psion, the British
manufacturer of handheld computers, and also used in Web-browsing cell phones made
Nokia and Ericsson. The third player is Microsoft, which has realized the importance of
portable platforms as shipments of desktop PCs have flattened out. In 1996 the compan
invented Windows CE, a pared-down version of its operating system for PCs, which is
used in handheld computers made by Hewlett-Packard, Compaq and Casio. Microsoft
now developing software specifically designed for smart phones and has joined with
manufacturers such as Ericsson to create mobile devices that will be customized for use i
particular businesses—for instance, digital companions with special applications for lawy
doctors or children. Because of the diversity of devices, most industry watchers agree th
there is unlikely to be a single winner in this software war, in contrast with Microsoft's
domination of PC operating systems.

As technological advances continue to miniaturize
batteries and electronics, the size of handheld device
will come to depend primarily on their screens and in
systems, which must be large enough to be seen and
manipulated by users. But what if the user could
interface with the device by voice command instead of
by screen or keyboard? To make this possible, the
machines would need software that could understand
and replicate human speech. Microsoft has set a goal
developing an operating system that can cope with vo
commands, and IBM and Philips are pursuing similar projects. Lernout & Hauspie, a
Belgian voice-recognition software company, recently acquired two rival firms, Dragon
Dictaphone, to accelerate its own development efforts.

Unfortunately, progress in this area has been disappointingly slow. Although the quality of
dictation software has climbed impressively--some systems can accurately transcribe
between 95 and 99 percent of the words dictated to them--even the most advanced
computers still struggle with basic language tasks. The problem is that the software for vo
command is not yet sophisticated enough to catch the nuances of human speech [see
"Talking with Your Computer," by Victor Zue; Scientific American, August 1999].

Lernout & Hauspie, however, has developed an intermediate technology that could allow
limited number of voice commands. The software is code-named NAK (the name come
from the Hawaiian word nakulu, meaning "echo"), and it is designed for mobile devices
running on Intel's StrongARM chips, a class of powerful and energy-efficient
microprocessors. A NAK device would use a speech synthesizer to read the text of an
incoming e-mail aloud. The user could then dictate a response into the device's microphone
and ship it off with a voice command such as "Send e-mail." Lernout & Hauspie claims t
NAK will have a vocabulary of more than 30,000 words, a wide range of possible
commands and the capability of understanding more than one language. Products based on the technology are expected to cost about $500 and will ship in volume early next year.

It is becoming clear that today's panoply of portable electronics gadgets will eventually give way to a new order of mobile devices that will combine the functions of their forerunners. Deluxe all-in-one digital companions will provide full access to all the resources on the Web, including graphics, video and music. Other wireless devices will be more specialized, such as Walkman-like music players that can download songs from the Internet. The most generally useful functions—accessing the Web, probably through customized portals, and sending e-mails—will be built into most portable devices, because it will be cheap, easy and expedient to do so. Otherwise, users would have to carry a Walkman and a mobile phone. And in the near future that will seem as quaint as wearing a monocle.

Related Links:

Third Generation Partnership Project

The Author

FIONA HARVEY, a journalist based in London, frequently writes about wireless technologies and the telecommunications industry.
Just wait until cell phone networks go high-speed. It will start to happen later this year, as carriers in Japan begin to deploy so-called 3G, or third-generation wireless cell phone systems. Spreading from east to west, the nimble networks should arrive in Europe in 2002 and the U.S. in 2003. Unlike the previous two generations of cellular networks, 3G systems have been designed from the get-go to carry data as well as voice. Carriers promise downloads approaching 2.4 megabits per second (Mbps)—twice as fast as wired broadband services, and fast enough to bombard cell phones, handhelds and laptops with video, music and games.

Or so they say. But there is a growing chorus warning that 3G will not be all it’s cracked to be.

3G is not a single standard or technology but an umbrella term for a variety of approaches to bringing high-speed Internet services to cell phone networks. In most cases, 3G will come from updates and upgrades to current systems, which differ from continent to continent and from country to country. Most 3G networks will start off as hybrids, with new capabilities added gradually as demand dictates.
The result is an alphabet soup worthy of a convocation of rocket scientists. In general, Europe and Asia will convert from GSM (Global Standard for Mobile communications), whose widespread adoption has given them the lead in wireless technology, to W-CDMA (Wideband Code Division Multiple Access). In North America, CDMA (Code Division Multiple Access) networks, such as Sprint's and GTE's, will also migrate to W-CDMA. But TDMA (Time Division Multiple Access) systems, such as AT&T's and Southwestern Bell's, plan to go to EDGE (Enhanced Data rates for Global Evolution).

These systems are still mostly in an experimental or testing stage, and each has its advantages and disadvantages. EDGE requires relatively minor infrastructure upgrades, its theoretical maximum data rate of 384 kilobits per second (kbps) pales when compared with W-CDMA's much faster 2 Mbps.

W-CDMA and CDMA are based on a technology known as spread spectrum. Older cellular technologies such as GSM and TDMA use a variant of the approach taken by ordinary radio stations--namely, they divide the radio spectrum into narrow frequency bands. To add capacity, these networks can interleave several phone calls on each frequency channel, but there is a tight limit to how many users can share a channel before the signal quality suffers. CDMA, on the other hand, assigns each phone call a particular code. Multiple radio signals can then share a fairly wide range of radio frequencies. Each phone will pick up the transmissions intended for it by watching for its code. In some implementations of spread spectrum, the transmitter and receiver hopscotch among frequencies in a prearranged sequence [see "Spread-Spectrum Radio," by David R. Hughes and Dewayne Hendricks; Scientific American, April 1998].

Although spread-spectrum systems have their inefficiencies--with all the overhead to determine which messages are going to which phone, they tend to use a lot more bandwidth than the signals alone require--they are very tolerant of noise and are difficult to intercept or interfere with. CDMA uses channels 1.25 megahertz (MHz) wide in the 800-MHz or 1.9-gigahertz (Ghz) bands. W-CDMA channels are 5, 10, 15 or 20 MHz wide in several bands located around 2 GHz, which allows for faster data rates and more users.
Mbps per user: the bandwidth will be shared among everyone in a particular cell (the geographical area covered by a single cell tower), which could be dozens of people at a time on each channel. Cooper says users should expect 64 kbps from 3G networks at best, a privilege for which they will pay a handsome premium. Although quite an improvement over current wireless networks, it is only marginally faster than an ordinary modem and hardly enough to justify all the futuristic claims made for the networks.

For Cooper, 3G is a baby step toward real high-speed, inexpensive wireless communications. He is now at ArrayComm, a San Jose, Calif., start-up working on "smart antennas," which, he claims, could provide 1 Mbps for each of up to 40 concurrent users. The technology makes better use of the arrays of antennas found in cellular base stations. As you may have noticed when driving by a cell tower, each station contains a forest of up to a dozen antennas. Currently they are used to broadcast omnidirectionally—that is, with equal strength in all directions.

But many communications and radar systems have long used similar arrays to aim their signals in particular directions. The transmissions from individual antennas interact with one another, preventing the signals from going in some directions and amplifying them in others. Cooper proposes retrofitting cellular base stations to the same end.

His system is based on digital signal processors originally developed by the U.S. military for spying on foreign radio broadcasts. Such signal processors, when attached to an antenna array, can beam radio signals precisely at individual users. As each user moves around, the smart antennas track them. The result is a kind of cloud of radio signals that follows each user around like the cloud of dust around Pigpen. The system can reuse the same radio frequencies for different users in the same vicinity, without worrying that the transmissions will interfere with one another. The result is very efficient use of the carrier's spectrum, which affords the high data rates.

The antennas are already in place, and most cellular base stations have signal processors with the necessary computational power. So in most cases a software upgrade is all that is required to turn them into smart antennas. The drawback is that high data rates come at the expense of movement. Although the system is able to track a walking subject, it currently can't keep pace with a fast-moving vehicle. ArrayComm plans to begin wide-scale tests soon and has teamed up with Sony to deliver video, music and games over the airwaves in San Diego.

A radically different approach is being taken by inventor Larry W. Fullerton, who has spent the past two decades working in obscurity on a potentially revolutionary technology known as UWB (ultrawideband). Most radio transmissions have two components: a carrier wave and a signal. The carrier wave is the vehicle; it is the frequency to which you tune a radio. The signal is the passenger; it comes from a microphone, TV camera or Internet connection and is imprinted onto the carrier wave in a process known as modulation. The most common style of modulation, FM (frequency modulation), causes the carrier to spread by an amount roughly equal to the data rate of the signal. A 10,000-bps message, for instance, causes the carrier to "smear" by 10 kHz on each side. This is why radio station
have to be spaced apart in frequency.

Spread-spectrum radio, used in the most advanced cell networks today, essentially switches among many different carriers for a given transmission. But UWB, first devised in the 1960s, dispenses with the carrier altogether. It is pure signal, essence, a switch attached to the antenna turns on and off, which produces a pulse of electromagnet energy—rather like the pop you hear on the radio when turning on a lamp. In Fullerton’s systems, the pulses last less than a billionth of a second and occur up to 40 million times per second. Like an ultrafast Morse code, the pulses occur in a very particular pattern, which can encode the desired information.

One implication of UWB sounds utterly crazy: rather than take up a small slice of the radio spectrum, as other technologies do, it uses the whole thing. Typically the pulses carry energy from 1 to 3 GHz. Fortunately, that doesn’t lock out other radio systems. To most radio receivers, the UWB signals sound like random static and can be filtered out as long as their power remains low. Only receivers that know the pattern of pulses can recognize and decode the signals. Different UWB transmitters can use different patterns, allowing many to operate once without interfering with one another.

Fullerton is now chief technology officer of Time Domain, a Huntsville, Ala., firm created to commercialize the technology. The firm hopes to push the data rates even higher. “Our engineers—with a straight face—tell me we can get a gigabit per second,” says Ralph Petroff, the company’s president. Several other firms, such as Multispectral Solutions in Gaithersburg, Md., have also been working on the technology. Until this spring the Federal Communications Commission (FCC) had licensed UWB only for limited experiments, but in May it gave the go-ahead for much wider tests.

UWB has a wide variety of potential uses, from personal radar systems for detecting collisions to imaging devices that can see through walls. But will it ever provide high-bandwidth wireless communication? To keep the signals from interfering with other radio devices, UWB broadcasts at extraordinarily low power—50 millionths of a watt. Trouble low power means low range—just a few meters. The more power, the farther it could reach, but the greater the chance it would interfere with radios, televisions and Global Positioning Satellite receivers. Petroff says UWB will initially be confined to indoor local area networks, a kind of Bluetooth on steroids, but may one day be used for neighborhoodwide networks.

“I think there’s going to be some kind of power restriction from the FCC that will restrict
range," comments Bob Scholtz, a professor of electrical engineering at the University of Southern California. "But we don't know what that will be. It could be hundreds of yards.

Multiple Channels

Yet another approach--one that has been around in one form or another since the 1950s--is based on a communications technique known as multiplexing, which involves the transmission of more than one signal over the same channel. Multiplexing is commonly used in fiber optics, in which a big packet of data is chopped into smaller pieces, transmitted simultaneously on different wavelengths of light and stitched back together at the other end. Exactly the same principle applies in a wireless system, except that the wavelengths used are in the radio part of the electromagnetic spectrum.

To date, wireless multiplexing hasn't been exploited for cellular systems because digital signal processors fast enough to track and combine the different signals have not been available. That may change soon. A Calgary, Alberta--based company called Wi-LAN holds a number of key patents for a multiplexing technology known as wideband orthogonal frequency division multiplexing, or W-OFDM.

According to the company's CEO, Hatim Zaghloul, W-OFDM can deliver very high data rates across a limited range of radio spectrum--approximately 10 MHz in the unlicensed industrial-scientific-medical (ISM) bands at 900 MHz, 2.4 GHz and 5 GHz. The 10 MHz is divided into 10 evenly spaced channels, each of which can carry 1 Mbps of data.

So what, you might ask? After all, those 10 MHz could just be lumped into a single 10-Mbps channel. Multiplexing can't deliver something for nothing: it may divide a high-speed data stream into several low-speed data streams, but the total capacity of the radio spectrum, which is fixed by the laws of physics, must remain the same.

The key is that fast signals are more easily degraded by noise, interference and so-called multipath effects, which are caused by radio signals' bouncing off buildings or other landmarks. Slow signals, on the other hand, can slink through the static. By subdividing the spectrum, then, W-OFDM uses it more efficiently.

In one configuration, Wi-LAN has achieved 32 Mbps. In tests conducted earlier this year, technicians broadcast a stream of video to a car traveling at 70 miles per hour. Zaghloul says that he expects a whopping 155 Mbps by the end of next year as improved signal processors allow for more channels. The technology could be deployed in fixed wireless systems early next year and in mobile systems by 2003. The downside is that W-OFDM would require significant reworking of current cellular networks. Its adoption may have to wait until carriers look past 3G systems to 4G.

Because so many technologies--spread spectrum, antenna arrays, UWB, multiplexing and others--are in the works, many analysts are coming to realize that the biggest obstacle to wireless communications is not the engineering but the business model. What resources...
carriers willing to put into their systems? What trade-offs will they make between the available bandwidth and the number of users forced to share it? "Deployment is the big issue," says Craig Mathias, an affiliate analyst with market research firm MobileInsights. "3G depends on the carriers. If they want to deliver high-speed data networks, they'll do it. But the business today is voice. The big question is the business plan, not the technology.

Cooper says that today's wireless industry is dominated by telecom monopolies that think in terms of a one-size-fits-all network. Instead, he says, he would like to see a multitude of different networks for different purposes. He predicts that nationwide voice networks will coexist with local data networks, and that low-cost, low-speed networks will rub shoulders with pricier high-speed ones. As for speed, Cooper says that wireless networks will eventually deliver the performance of wired ones.

In many ways, it's only an accident of history that we have wired, rather than unwired, telecommunications. If Guglielmo Marconi and Nikola Tesla had been a few years ahead of Alexander Graham Bell, instead of the other way around, we might have had a very different telecom landscape today.

The Author

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haald Bluetooth was a fierce Viking king who made history by uniting Denmark and Norway by force of arms in the 10th century. The king has now lent his name to a technology that may make history in the world of electronics: a short-range wireless system that spells a long-overdue death for computer wires and cables.

Created by a consortium of mobile-phone manufacturers and silicon chipmakers, Bluetooth is a "wireless wire" that allows computers and telecommunication devices to be connected without cables. It was originally conceived as a way of making wireless headsets for cell phones but has been rapidly adapted across the electronics industry. Although the first Bluetooth devices are only just appearing, it is already becoming the de facto standard, with more than 1,000 manufacturers committed to making Bluetooth-enabled devices, from laptops and cell phones to toys and refrigerators.

The technology has a maximum range of about 10 meters (30 feet) and operates in the 2.4- to 2.5-gigahertz industrial, scientific, and medical (ISM) band, in which low-power radio transmitters are allowed to operate without first getting a government license. To avoid interfering with other devices, Bluetooth hovers around frequencies at a rate of 1.6 times per second.

As well as replacing cables, Bluetooth will make it easy to set up wireless networks at home or in the office and public places such as airports and cafes. Bluetooth will also allow devices to swap information with one another whenever they come into range, allowing conference attendees to trade business cards or traders to synchronize handheld organizers as they walk into the office. Many cell phones, handsets, and laptops have infrared ports for these purposes, but their range is typically limited to one meter or so.

The industry expects Bluetooth to replace ubiquitous, but its rate of adoption will depend on how often devices are replaced. Although people may buy new cell phones and computers every year or two, washers, machines, and microwaves are on a much longer replacement cycle. — I

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Cellular Usage vs. Prices

Cellular Phone Penetration
(ownership as percentage of population)

17/09/2000
SOURCES: International Telecommunications Union, European Commission, eMarketer and national telecom agencies and carriers

Back to Article (The Future Is Here. Or Is It?)
Standard vs. Multiplexing

### Standard Technology
1. If you send data as a single big chunk...
2. ...it gets battered by static interference...
3. ...and may not reach the other end intact.

### Multiplexing Technology
4. But if you subdivide it...
5. ...each part evades interference better...
6. ...and can be reassembled into a complete package.