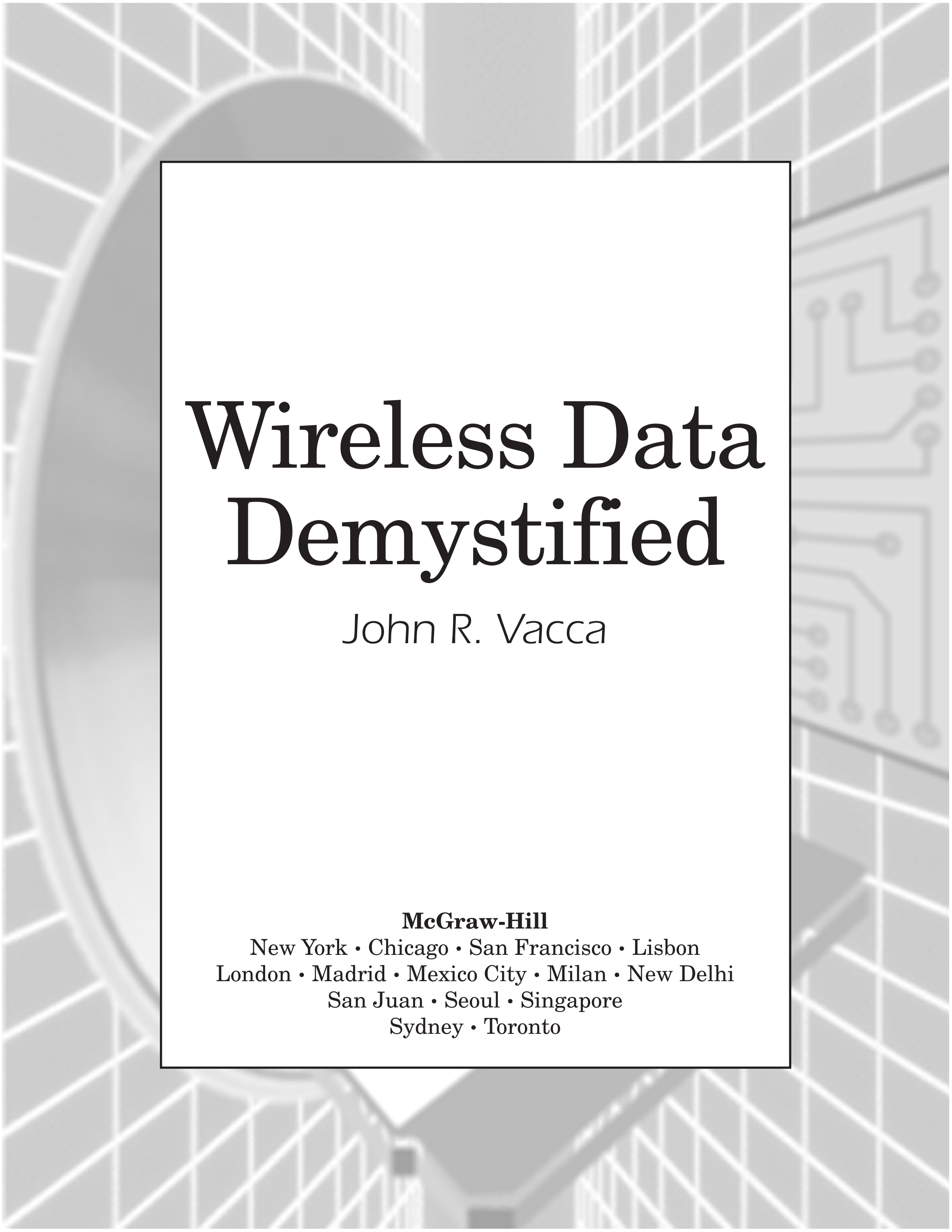

Wireless Data Demystified

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To Dennis Pleticha, the network guy.

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PART 1

Overview of Wireless High-Speed Data Technology

CHAPTER 1

Wireless Data Network Fundamentals

Wireless data is a recent and valuable addition to the arsenal of corporate mobile computing tools, and has been the subject of much recent attention. It needs to be considered within the context of the business problems being solved and the existing corporate mobile infrastructure, with a realistic eye toward the capabilities of the public wireless networks of today and tomorrow.

Based on this author's extensive hands-on experience, this chapter, as well as the rest of the book, has been written to address popular misconceptions, minimize the hype, and provide insight to wireless data networks. Each of the chapters serves to help further the understanding of the wireless data world and to offer practical hands-on recommendations and perspectives.

The book content is intended to be equally useful whether you are in the throes of a major wireless data deployment or merely keeping an eye on the technology, waiting for it to mature further. The focus is also on providing information and analysis to organizations that will be users of wireless data, not to the telecom companies and carriers that will obviously be profoundly impacted by increasing wireless adoption.

So, without further ado, let's start with the most obvious questions: What are wireless data networks? And why consider them?

Wireless Data Networks Defined

To link devices like computers and printers, traditional computer networks require cables.[8] Cables physically connect devices to hubs, switches, or each other to create the network. Cabling can be expensive to install, particularly when it is deployed in walls, ceilings, or floors to link multiple office spaces. It can add to the clutter of an office environment. Cables are a sunk cost, one that cannot be recouped when you move. In fact, in some office spaces, running and installing cabling is just not an option. The solution—a wireless network.

Wireless data networks connect devices without the cables. They rely on radio frequencies to transmit data between devices, For users, wireless data networks work the same way as wired systems. Users can share files and applications, exchange e-mail, access printers, share access to the Internet, and perform any other task just as if they were cabled to the network.

How Fast Are Wireless Networks?

A new industry-wide standard, 802.11b, commonly known as WiFi, can transmit data at speeds up to 11 megabits per second (Mbps) over wireless data links. For comparison, standard Ethernet networks provide 10 Mbps. WiFi is more than 5 times faster than prior-generation wireless data solutions and its performance is more than adequate for most business applications.

What Is WiFi?

WiFi is a certification of interoperability for 802.11b systems, awarded by the Wireless Ethernet Compatibility Alliance (WECA). The WiFi seal indicates that a device has passed independent tests and will reliably interoperate with all other WiFi certified equipment. Customers benefit from this standard as they are not locked into one vendor's solution. They can purchase WiFi certified access points and client devices from different vendors and still expect them to work together.

When Do You Need Wireless Data Networking?

The following are a few examples of cases in which a wireless data network may be your ideal solution:

- For temporary offices
- When cabling is not practical or possible
- Supporting mobile users when on site
- Expanding a cabled network
- Ad hoc networking
- Home offices

For Temporary Offices

If you are operating out of an office space that is temporary, use a wireless data solution to avoid the costs of installing cabling for a network. Then, when you relocate, you can easily take your wireless data network with you and just as easily network your new facility. With a wired network, the money you spend on cabling a temporary space is lost when you leave. Moreover, you still need to build a new cabling infrastructure at your new site. If you expect to outgrow your current facilities, a wireless data network can be a shrewd investment.

When Cabling Is Not Practical or Possible

Sometimes landlords forbid the installation of wiring in floors, walls, and ceilings. Buildings may be old or walls solid or there could be asbestos in the walls or ceilings. Sometimes cabling cannot be laid across a hallway to another office. Or you have a space used by many employees where cabling would be messy and congested. Whenever cabling is impractical, impossible, or very costly, deploy a wireless data network.

Supporting Mobile Users When on Site

If you have branch office employees, mobile workers such as your sales force, consultants, or employees working at home, a wireless data network is an excellent strategy for providing them with network connectivity when they visit your premises. Once their laptops are equipped to communicate wirelessly with the network, they will automatically connect to the network when in range of your wireless data access point. You do not burden your IT staff to set up connections and you avoid having often-unused cabling strewn about your facilities just for remote users. You also use your office space more efficiently because you no longer provide valuable office space for workers who are infrequently on site.

Expanding a Cabled Network

You should use a wireless data network to extend an existing network, avoiding the cost and complexity of cabling. You will be able to connect new users in minutes rather than hours. Also, you will be able to provide network connectivity for your conference rooms, cafeteria, or lobby without any cabling hassles. In addition, you will even be able to expand the network beyond your building to your grounds, enabling employees to stay connected when outside. They will also be able to access the network as effortlessly and seamlessly as any worker linked by cabling.

Ad Hoc Networking

If you need to create temporary computer networks, such as at a job site, a conference center, or hotel rooms, wireless data solutions are simple, quick, and inexpensive to deploy. From virtually anywhere at a location or facility, employees will be able to share files and resources for greater productivity. Their wireless PC cards communicate directly with each other and without a wireless data access point.

Home Offices

You should also use a wireless data solution to network your home office, avoiding unsightly cables strewn about the workplace. Moreover, you can network your family, enabling everyone to share printers, scanners, and—if you are using an access router or bridged cable/digital subscriber line (DSL) modem—Internet access. You should also be able to link to the network from any room or even the backyard.

How Private and Secure Is Wireless Data Networking?

If you select a solution with sophisticated security technologies, your wireless data communications will be very safe. Leading wireless data solutions provide 128-bit encryption, and, for the highest levels of security, the most advanced systems will automatically generate a new 128-bit key for each wireless data networking session. These systems also will provide user authentication, requiring each user to log in with a password.

Coming in the Wireless Data Back Door

There are many juicy targets that are vulnerable to eavesdroppers and malicious intruders. In short, with an off-the-shelf directional antenna and a vanilla wireless NIC, you can sit in your car or other public places in many metropolitan areas and connect to hundreds of networks, typically those of sizable corporations. (The Glossary defines many technical terms, abbreviations, and acronyms used in this book.)

Anyone with a pulse has read innumerable accounts of Wired Equivalent Privacy's (WEP) weaknesses and knows that there are widely available script-kiddie-level tools, such as Air Snort, that can quickly crack WEP encryption. Less than half of the networks in the United States have WEP enabled, much less IPSec or some other measure that might be safe from third graders. Remember, wireless data networks are practically always installed inside the firewall, so whatever protections your firewall provides are moot if an intruder comes in wirelessly. It's bad enough if a war-dialing intruder finds an unprotected dial-in port and gets inside your firewall. An 802.11b-based intruder may be connected at 11 Mbps, not 56 kbps, making you a much juicier zombie or warez repository.

There are two causes for the preceding state of affairs, beyond the network managers who don't care if anyone in a quarter-mile radius can access their networks, and those forced to install a wireless data network without effective security despite their objections. First, many people underestimate the distance over which 802.11b radio signals can be picked up. Second, many wireless data networks are being set up informally by users who don't know or care what WEP is or what a firewall blocks out.

In either case, the solution is easy: For example, go down to Fry's or RadioShack and pick up a high-gain 2.4-GHz antenna and an Orinoco card. Connect the antenna to the wireless data card and install the wireless card in a laptop. Take it out to the parking lot or up on the roof and see whether you can find a wireless data network. If it doesn't measure up to your security policy, shut it down until it does. While you're at it, you may not want to limit your audit to the exterior of your building. You may be surprised to find internal wireless data networks that don't leak to the street.

If any of your enterprise's employees, including you, work at home on 802.11b networks, it might be smart to drive by their houses with your wireless data vulnerability tool kit and check them out. Those home firewalls and even the VPN clients you provide home users with may not suffice. You can be sure that most work-at-home employees haven't implemented Kerberos authentication and IPSec. It wouldn't be all that surprising if they also have file sharing enabled without strong passwords, providing opportunities for their neighbors and drive-by intruders to read, modify, delete, and otherwise "share" their files. You'd also be doing your friends and neighbors a service by checking out the vicinities of their 802.11b networks.

There's a minor groundswell underway among "Internet idealists" for explicitly sharing access to one's own wireless data network with the public. Usually, the point of this sharing is to provide unpaid high-speed Internet access to other members of the community. There's an issue regarding whether paying for a DSL or cable modem line gives you the right to open it up to an arbitrary number of other users. Many service providers' terms of service prevent the resale of access services, but it's not clear if such language would apply to given-away service.

In any event, the morality and legality of such sharing will be worked out by the usual methods before long. Before you open up a free public network to anyone with a wireless data card, you'd think long and hard about preventing the things that could get the ISP to shut access down, such as spam-meisters, hack-vandal activity, and other sorts of offensive content. You'd also think long and hard about fencing off your own hosts and devices from what a worst-case malevolent user might do. Then you'd forget about the project altogether.

Now, let's thoroughly examine the current state of the wireless data network infrastructure. It is composed of four parts, of which the first three are designed to address specific aspects of the global wireless data infrastructure. The first part gives an overview of wireless data networks—defining speeds, protocols, and types of networks. The second part discusses the worldwide allocation and rollout of the 3G wireless networks. The third part provides wireless data coverage maps so that one can better understand current coverage levels by network. The final part offers some practical insight and recommendations based on the current state of the networks.

Overview of Existing Networks

Although most of the discussion so far in this chapter has focused on wireless data WAN technologies, other types are presented as well (see Table 1-1).[1] Note that existing first- and second-generation (1G and 2G) technologies are typically much slower than a 56-kbps dial-up line. And yet-to-be delivered third-generation (3G) networks will not come anywhere close to the speed of the wired office LAN for which most corporate applications are designed.

In Table 1-1, the wireless generation is a function of speed and maturity of technology and is usually representative of a family of similar technologies, while 3G networks need to meet International Telecommunications Union specifications. Theoretical throughput is the best-case

TABLE 1-1

Network Speeds and Standards

Type of Network	Wireless Generation	Connectivity/Protocol	Theoretical Throughput
WAN	1G	Mobitex/Motient	9.6 kbps
WAN	2G	CDPD, CDMA, TDMA	19.2 kbps
WAN	2G	GSM	9.6 kbps
WAN	2.5G	Ricochet (filed Chapter 11)	100–150 kbps
WAN	2.5G	GPRS, 1XRTT	100–150 kbps
WAN	3G	CDMA2001x, TS-SCHEMA, W-CDMA, EDGE	384 kbps
LAN		Wired LAN	10–100 Mbps
LAN		801.11b	11 Mbps
PAN		Bluetooth	1–2 Mbps

attainable speed over the network and is typically 50 to 100 percent faster than real-world performance.

Wireless Data Types

There is a dizzying array of wireless data standards and technologies available to choose from. While wireless data services have been much slower to catch on than wireless voice services, they are slowly growing in acceptance, along with the speeds they provide and their availability.

Modem Data Modems transmit data from a serial line over an analog voice facility (analog cellular radio channel) as a series of tones. They work best over analog channels, because digital coding and compressing of audio damages or destroys the modem tones. Analog cellular channels (30 kHz) using the MNP-10 or ETC protocols can transmit at around 9.6 to 19.2 kbps. However, the modem at the other end also has to have similar capabilities. Because of this problem, some wireless carriers installed modem pools using pairs of back-to-back cellular and standard modems.

Digital Circuit-Switched Data Digital circuit-switched data attempts to replicate the modem experience with TDMA, GSM, or CDMA digital cellular or personal communications service. The problem is that modem tones cannot be reliably transmitted through a voice coder. Removing the voice coder requires a new protocol (of which some have been developed), and a modem pool is not an option. But this is different from an analog modem pool, because only a single modem is required as the switch receives the data in a digital format. A rough estimate of the data capacity of digital cellular can be gained by looking at the voice coder bit rates. Usually, this is about the amount of bandwidth available for data. TDMA uses 8-kbps voice coders, and up to three time slots can be aggregated (for a price). GSM uses 13-kbps voice coders and up to eight time slots can be aggregated (but this is usually done only for GPRS, which is a packet data standard). CDMA uses 8- or 13-kbps voice coders, but is more flexible in the amount of bandwidth that can be assigned to an individual customer.

Personal Communications Systems Personal communications systems (PCS) is a name given to wireless systems that operate in the 1800- to 1900-MHz frequency band. According to the initial concept, these systems were supposed to be very different from cellular—better, cheaper, simpler. However, the only technologies that were implemented were upbanded cellular standards; so, now consumers rarely know whether their cellular phone is operating in the cellular or PCS band:

- PCS1900—upbanded GSM cellular
- TIA/EIA-136—upbanded TDMA digital cellular
- TIA/EIA-95—upbanded CDMA digital cellular[4]

The major change from cellular to PCS is that all personal communications systems are digital. The few new concepts that were promoted were never implemented, including:

- J-STD-014—Personal Access Communications System (PACS), a combination of Bellcore WACS and Japan's Personal Handyphone Service (PHS)
- TIA IS-661—Omnipoint composite CDMA/TDMA
- TIA IS-665—OKI/Interdigital Wideband CDMA[4]

NOTE The PCS frequency allocation in the United States is three 30-MHz allocations and three 10-MHz allocations.

Analog Control Channel Data Some clever engineers have figured out ways to use the analog control channel (it is actually a digital channel, set up to service analog cellular systems) to transmit low-bit-rate data. This channel runs at only about 1 kbps and has to be shared with a large number of voice users. Aeris (http://www.diveaeris.com/) and Cellemetry (http://www.cellemetry.com/technical.html) are the prime users of this service.

WARNING URLs are subject to change without notice!

By faking a voice transaction, Aeris and Cellemetry can cause a small amount of data (4 to 16 bytes) to be sent to a central computer [which emulates a home location register (HLR)]. The advantages of this are high mobility (for asset tracking applications) and low capital costs, because the infrastructure is generally in place. These systems are largely used for industrial purposes, although some consumer applications exist, such as alarm monitoring systems.

Analog Packet Data: CDPD Cellular digital packet data (CDPD) uses an analog voice channel to send digital packet data directly from a phone to an IP network. It provides about 19 kbps for each channel, but this must be shared by multiple users. The strength of this technology is that the cost is kept low because it reuses much of the existing cellular infrastructure, but it takes channels away from voice users. Originally, it was planned that CDPD would transmit data when voice channels were idle, thus not consuming any capacity, but this proved to be too difficult to manage. CDPD systems service over 50 percent of the U.S. population and are found in several other countries, including Canada. CDPD has experienced some new life as a bearer protocol for Wireless Access Protocol (WAP), eliminating many of the delays experienced when circuit-switched data are used.

Data-Only Systems There are two major public data-only wireless systems available in the United States: Motient and Mobitex. According to Mobitex, its system covered 95 percent of the U.S. population in 2002 and provides coverage in Canada through a relationship with Rogers Wireless (Cantel). Motient (according to Mobitex) had coverage of 81 percent of the U.S. population at the same time. By comparison, CDPD covered only about 57 percent of the U.S. population. These data systems are similar in performance to CDPD, giving a shared bandwidth (per cell site) in the 9600 to 19,200 bps range.

Digital Cellular/PCS Packet Data The next big game in town is 3G wireless data. This implies speeds of 144 kbps for mobile terminals and 2 Mbps for stationary devices. Here, the world is divided into two camps: GSM/W-CDMA versus cdma2000/1xEV.

The GSM/W-CDMA strategy is to move first to general packet radio service (GPRS), which allows use of multiple time slots within a GSM channel (composed of eight time slots). Theoretically, this should allow speeds up to 115 kbps, but early devices are more in the 20-kbps range. W-CDMA will provide higher capacity, but it is too early to tell what realistic values are.

CdmaOne provided second-generation data rates of 14.4-kbps circuit data and up to 115-kbps packet data in theory. IS-2000/cdma2000 is being more widely implemented for data services. It is claimed to provide 144 kbps in its 1X mode. Future plans are for 1XEV-DO (a data-only system) that will provide 2 Mbps from the cell site and 144 kbps from the mobile unit (see sidebar, "3G Wireless Delivered by CDMA2000 1xEV-DO"). Yet another generation, known as 1xEV-DV (including voice services), is being designed to support about 2 Mbps in both directions.

3G Wireless Delivered by CDMA2000 1xEV-DO

CDMA2000 1xEV-DO technology offers near-broadband[7] packet data speeds for wireless data access to the Internet (see Fig. 1-1).[3] CDMA stands for code-division multiple access, and 1xEV-DO refers to 1x evolution-data optimized. CDMA2000 1xEV-DO is an alternative to wideband CDMA (W-CDMA). Both are considered 3G technologies.

A well-engineered 1xEV-DO network delivers average download data rates between 600 and 1200 kbps during off-peak hours, and between 150 and 300 kbps during peak hours. Instantaneous data

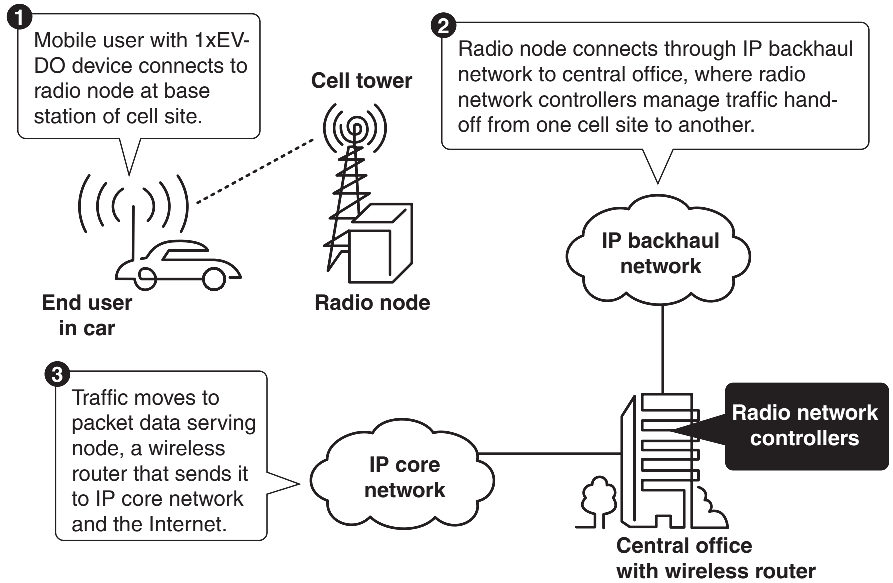


Figure 1-1 CDMA2000 1xEV-DO technology provides high-speed wireless access to the Internet over an all-IP network.

rates are as high as 2.4 Mbps. These data rates are achieved with only 1.25 MHz of spectrum, one-quarter of what is required for W-CDMA.

In an IP-based 1xEV-DO network, radio nodes perform radio-frequency processing, baseband modulation/demodulation, and packet scheduling. Radio nodes installed at a cell site can support hundreds of subscribers. Radio network controllers (RNCs) typically are located in a central office and provide hand-off assistance, mobility management and, terminal-level security via a remote authentication dial-in user service server. Each RNC can support many radio nodes and connects to a service provider's core data network through a standard wireless router called a packet data serving node. Finally, an element management system lets service providers manage 1xEV-DO radio networks.

1xEV-DO takes advantage of recent advances in mobile wireless communications, such as the adaptive modulation system, which lets radio nodes optimize their transmission rates on the basis of instantaneous channel feedback received from terminals. This, coupled with advanced turbo coding, multilevel modulation, and macrodiversity via sector selection, lets 1xEV-DO achieve download speeds that are near the theoretical limits of the mobile wireless data channel.

1xEV-DO also uses a new concept called multiuser diversity. This allows more efficient sharing of available resources among multiple, simultaneously active data users. Multiuser diversity combines packet scheduling with adaptive channel feedback to optimize total user throughput.

A 1xEV-DO network is distinguished from other 3G networks in that it is completely decoupled from the legacy circuit-switched wireless voice network. This has let some vendors build 1xEV-DO networks based entirely on IP technologies. Using IP transport between radio nodes and RNCs lowers backhaul costs by giving operators a choice of backhaul services, including frame relay, router networks, metropolitan Ethernet, and wireless data backhaul. IP-based 1xEV-DO networks take advantage of off-the-shelf IP equipment, such as routers and servers, and use open standards for network management.

1xEV-DO networks have the flexibility to support both user- and application-level quality of service (QoS). User-level QoS lets providers offer premium services. Application-level QoS lets operators allocate precious network resources in accordance with applications' needs. Combined with differentiated services–based QoS mechanisms, flexible 1xEV-DO packet schedulers can enable QoS within an entire wireless data network.

The International Telecommunications Union and Third Generation Partnership Project 2 recognize 1xEV-DO as an international standard. Subscriber devices based on the standard will become available in the first half of 2003 in North America. These devices will come in various forms, including handsets, PC cards, PDA sleds, and laptop modules.

Multimode 1xEV-DO terminals that support CDMA2000 1x voice will let subscribers receive incoming voice calls even while actively downloading data using 1xEV-DO. While 1xEV-DO is capable of supporting high-speed Internet access at pedestrian or vehicle speeds, it is can also be used from homes, hotels, and airports.3

NOTE It is hard to validate the preceding speed claims.

Technology is changing almost as fast as the marketing hype. Furthermore, carriers may decide that high-speed data is not as profitable as lower-speed data and voice services.

NOTE With voice coders running at 8 kbps, someone running at 800 kbps is taking approximately 100 times the resources.

Are voice coders going to pay 100 times the per-minute rate for voice services? Even if higher-speed data service is implemented, packet data channels are shared resources. Combined with overhead from multiple protocol layers, throughput may be limited to much less than the theoretical maximum.

I-Mode I-mode is a Japanese specification for providing Internet-like content to wireless devices.[5] It uses cHTML for data encoding, unlike WAP, which uses WML. Both protocols plan to migrate to xHTML, which should accommodate advances made by both protocols.

Wireless Application Protocol WAP is an application protocol designed to bring Web-like services to wireless data devices with extremely limited input and output capabilities. It uses a variant of HTML coding that, among other things, includes a binary compression scheme to make transmission of Web pages more efficient. Its biggest limitation is probably the fact that wireless devices with a numeric keypad and a tiny, low-resolution screen simply do not make great Web-surfing devices. However, no matter what its detractors say, it was a big advance in data, moving attention away from merely moving bits and bytes to actually supporting real-life applications for consumers and businesses. The specification was developed by the WAP Forum (http://www.wapforum.org/).

Wireless LAN Protocols Wireless LAN protocols have a somewhat easier job with wireless data. Terminals are usually stationary and systems are not expected to cover a wide area. Most of the standards use unlicensed spectrum, so anybody can set up one of these networks. IEEE 802.11 is definitely the premier standard here, allowing transmission at Ethernet speeds (10 Mbps), with higher speeds planned for the future. HomeRF is a competitor, but it seems to be treading on similar territory, and has perhaps missed the window of opportunity. Bluetooth is not truly a wireless LAN standard, but a Personal Area Network (PAN) standard. It provides a 1-Mbps channel to connect up to eight devices together. Rather than aim at connecting computers and printers (which is what 802.11 is usually used for), Bluetooth is more oriented toward personal cable replacement, perhaps connecting a phone, mouse, keyboard, and computer together. RF technology is also often used for wireless data networks. It provides good speeds, but is limited by the need to maintain line-of-sight between communicating devices.

Wireless Data IP Convergence Driven by the consumer hunger for anywhere, anytime communication, IP and wireless data are coming together. It's important to begin exploring this evolving landscape and what it means for the future of communications.

First let's define exactly what is meant by *IP* and what is meant by *wireless data* in this context. IP is short for Internet Protocol. Most data networks combine IP with a higher-level protocol called Transport Control

Protocol (TCP), which establishes a virtual connection between a destination and a source. IP by itself is something like the “snail mail” postal system. It allows you to address a package and drop it in a network without ever establishing a specific or direct link between you and the recipient. TCP/IP, on the other hand, establishes a connection between two hosts so that they can send messages back and forth for a period of time.

As previously explained, *wireless data* describes telecommunications in which electromagnetic waves (instead of some form of wire) carry the signal over part or all of the communication path. A wireless data device can connect to other devices like cellular phones, laptops, personal digital assistants (PDAs) with wireless modems, and wireless LANs. Generally, wireless data IP is a gathered body of data or packets over a wireless transmission path.

It’s always challenging to ensure that technologies complement each other, and the convergence of IP and wireless data is no exception. While IP has the greatest potential for bringing together next-generation voice networks, wireless data technology is seen as one that will bridge the gap between the stationary and mobile workforces—giving end users the “always connected” capabilities they crave.

In this case, the mobile/wireless device landscape is complex. And this complexity leads to some specific issues the industry must address as it adds IP to the wireless data solution set:

- Which devices will be best suited to which applications (wireless IP phone, PDA, etc.)?
- Which devices will gain market segment leadership?
- Will users continue to use targeted, stand-alone devices or migrate to multifunction devices such as those that combine the functionality of a PDA and a cellular phone?
- What technological developments will ease existing device and connectivity constraints?
- Does the solution environment have enough wireless IP bandwidth available?[6]

Generally, striking the right balance will mean evaluating each mobile/wireless data application and its requirements separately. Applications need to be evaluated for the frequency and type of data transfer they require. If an application requires only periodic synchronization with a central repository, but also involves significant amounts of data entry on the client device, then most of the application logic should be on the client device. For example, sync-based content delivery can be effective for applications that handle sales force automation. It would be easy to store catalogs, client information, reference material, and other structured data files on the device and update them periodically when the user returns to the office.

On the other hand, applications that require either frequent or on-demand updates from a central repository, but don't require much input from the client, might be better off with a thin-client architecture on a device that connects more frequently—for instance, a cellular IP phone.

Of course, the greatest challenge will fall to developers of applications that require frequent, on-demand updates and rich graphical displays. These applications will need to add significant value to an organization to justify their development cost—and the high risk of failure inherent in meeting their design goals.

Unfortunately, the development picture for these wireless data applications will only become cloudier because of the ever-changing landscape and its impact on standardizing to a development environment and languages (for example, WML, XML, HTML, C-HTML, WAP, Java/J2ME, C—any derivative, HDML, XHTML, tag versus code). The marketplace's diversity, complexity, and constraints all make it hard for vendors to clearly see how to position themselves for success. For the same reasons (and because of today's economic slump), customers are reluctant to embark on extensive mobile/wireless data projects unless they see the potential for significant cost savings, productivity gains, or a clear competitive advantage.

Device ergonomics, bandwidth, coverage, and roaming constraints (plus the lack of heavy demand for these products) all make it hard to predict just when the market for wireless data IP solutions will take off. The more optimistic vendors point to standards that improve compression algorithms, intelligence controlling the display of the software residing on the device itself, and the growing demand for more information by both consumers and employees.

The eventual market segment opportunity will depend on the availability of more bandwidth and improvements to displays and mobile devices. End users are certainly attracted to the prospect of anytime, anywhere access to reliable information. That's why, despite the challenges, there's high interest in mobile devices, mobile access, and the potential of wireless IP for cellular phones. Vendors looking to penetrate this market segment will need to find a balance between establishing a track record of successful customer implementations and keeping themselves open to abrupt changes in the market segment.

The slowing U.S. economy has led to softer vertical and horizontal demand for wireless data devices. Moreover, this market segment is in for some real challenges in 2003 because of the ever-changing who's who in the wireless data world, the new applications being developed, and the potential for vendors of wireless hand-held devices to support wireless data IP.

The bottom line? Even though the general wireless data industry remains a favorite high-tech opportunity, it's not immune to temporary setbacks and slowdowns. Although wireless and IP are here to stay, vendors and manufacturers will come and go and application development will struggle to stabilize. In the long run, you'll all be accessible anytime, anywhere—and probably wishing you were still relying on your answering machines for near-real-time communications.

Ultra-Wideband Wireless Data Networks The most extreme claims about ultra-wideband (UWB) wireless data networks technology are that it could deliver hundreds of megabits of throughput per second, that its power requirements to link to destinations hundreds of feet away are as little as one-thousandth those of competing technologies such as Bluetooth or 802.11b, that transceivers could be small enough to tag grocery items and small packages, and that traffic interception or even detecting operation of the devices would be practically impossible. A slightly different way to look at the difficulty of detection and interception would be to claim that UWB devices wouldn't interfere with other electromagnetic spectrum users.

While the significant deployment of UWB devices is years away, each of the stupendous claims made for the technology has at least a modicum of supporting evidence. UWB devices operate by modulating extremely short duration pulses—pulses on the order of 0.5 ns. Though a system might employ millions of pulses each second, the short duration keeps the duty cycle low—perhaps 0.5 percent—compared to the near–100 percent duty cycle of spread-spectrum devices. The low duty cycle of UWB devices is the key to their low power consumption.

In principle, pulse-based transmission is much like the original spark-gap radio that Marconi demonstrated transatlantically in 1901. Unlike most modern radio equipment, pulse-based signals don't modulate a fixed-frequency carrier. Pulse-based systems show more or less evenly distributed energy across a broad range of frequencies—perhaps a range 2 or 3 GHz wide for existing UWB gear. With low levels of energy across a broad frequency range, UWB signals are extremely difficult to distinguish from noise, particularly for ordinary narrowband receivers.

One significant additional advantage of short-duration pulses is that multipath distortion can be nearly eliminated. Multipath effects result from reflected signals that arrive at the receiver slightly out of phase with a direct signal, canceling or otherwise interfering with clean reception.

NOTE If you try to receive broadcast TV where there are tall buildings or hills for signals to bounce from, you've likely seen "ghost" images on your screen—the video version of multipath distortion.

The extremely short pulses of UWB systems can be filtered or ignored—they can readily be distinguished from unwanted multipath reflections. Alternatively, detecting reflections of short pulses can serve as the foundation of a high-precision radar system. In fact, UWB technology has been deployed for 20 years or more in classified military and "spook" applications. The duration of a 0.5-ns pulse corresponds to a resolution of 15 cm, or about 6 in. UWB-based radar has been used to detect collisions, "image" targets on the other side of walls, and search for land mines.

So, when will we really see 3G? Let's take a look.

When Will We See 3G?

The deployment of 3G networks has not yet begun in earnest. Once the presumed viability of 3G became widely expected, each country initiated allocation of the 3G radio spectrum within its geography. You can see in Table 1-2 that this is an ongoing staggered process.[2] In some countries the licenses were simply awarded (freeing capital for immediate build-out), while in others auction prices reached staggering proportions, prompting industry analysts to question whether the auction winners will be able to afford to build the networks or find any way to profitably commercialize the services.

TABLE 1-2 *Status of 3G Spectrum Awards*

Country	Licenses Awarded to Date (of Total)	Method	Award Date
	Europe, Middle East, and Africa		
Austria	6	Auction	November 2000
Belgium	3	Auction	February 2001
Croatia	Not applicable	Not applicable	Not applicable
Czech Republic	2 (of 3)	Auction	December 2001
Denmark	4	Sealed bid	September 2001
Estonia	0 (of 4?)	Beauty contest	2002?
Finland	4 + 2 regional	Beauty contest	March 2000
France	2 (of 4)	Beauty contest	May 2001
Germany	6	Auction	July 2000
Greece	3 (of 4)	Auction	July 2001

TABLE 1-2

Status of 3G Spectrum Awards (Continued)

Country	Licenses Awarded to Date (of Total)	Method	Award Date
Europe, Middle East, and Africa (continued)			
Hungary	Not applicable	Not applicable	Not applicable
Ireland	0 (of 4)	Beauty contest	June 2002?
Isle of Man	1	Not applicable	May 2000
Israel	3	Auction	December 2001
Italy	5	Auction	October 2000
Latvia	Not applicable	Not applicable	Not applicable
Liechtenstein	1	Not applicable	February 2000
Luxembourg	0 (of 3)	Beauty contest	2002
Monaco	1	Not applicable	June 2000
Netherlands	5	Auction	July 2000
Norway	3 (of 4)	Beauty contest combined with annual fee	December 2000
Poland	3 (of 4)	Beauty contest (cancelled)	December 2000
Portugal	4	Beauty contest	December 2000
Slovakia	0 (of 3)	Beauty contest	2002
Slovenia	1 (of 3)	Auction	November 2001
Spain	4	Beauty contest	March 2000
South Africa	0 (of 5)	No contest	2002
Sweden	4	Beauty contest	December 2000
Switzerland	4	Auction	December 2000
Turkey	0 (of 4 or poss. 5)	Not applicable	2002?
United Arab Emirates	Not applicable	Not applicable	Not applicable
United Kingdom	5	Auction	April 2000

TABLE 1-2

Status of 3G Spectrum Awards (Continued)

Country	Licenses Awarded to Date (of Total)	Method	Award Date
		Asia Pacific	
Australia	6	Auction	March 2001
Hong Kong	4	Revenue share	September 2001
India	Not applicable	Not applicable	
Japan	3	Beauty contest	June 2000
Malaysia	Not applicable	Not applicable	2002?
New Zealand	4	Auction	July 2000
Singapore	3 (of 4)	Auction (cancelled)	April 2001
South Korea	3	Beauty contest	December 2000
Taiwan	0 (of 5)	Auction	2002
		Americas	
Canada	5	Auction	January 2001
Chile	Not applicable	Not applicable	Not applicable
Honduras	0 (of 1)	Auction	2002?
Jamaica	0 (of 2)	Auction	2002?
Uruguay	Not applicable	Auction	2002
United States	Not applicable	Not applicable	Not applicable
Venezuela	Not applicable	Not applicable	Not applicable

Licensing Costs for 3G

Over 100 3G licenses have now been secured worldwide via a combination of auctions, beauty contests, "sealed bid" competitions, and automatic awards. Table 1-3 shows the UMTS Forum's analysis of 3G licensing costs. Data are supplied for information only.[2]

The costs are either the highest auction cost for 2 × 5 MHz of spectrum or the corresponding administrative cost over the lifetime of the license. The costs for France are not yet completely known and have been estimated.

TABLE 1-3 *Basic Data Concerning the Licensing in Those Countries That Have Issued 3G Licenses (and Two That Are Going to Issue Licenses)*

Country	Date, year-month-day	Cost per $1,000,000 US per 2 × 5 MHz of Spectrum	Population, 1999	GDP, $1,000,000 US	Cost per Head of Population per 2 × 5 MHz of Spectrum	Cost as Percent of GDP
New Zealand	01-01-18	3	3,819,762	63.8	0.8	0.004
Switzerland	00-12-06	12	7,262,372	197	1.7	0.006
Norway	00-11-29	17	4,481,162	111.3	3.8	0.015
Singapore	01-04-11	21	4,151,264	98	5.1	0.020
Portugal	00-12-19	33	10,048,232	151.4	3.3	0.021
Slovenia	01-09-03	34	1,927,593	21.4	17.6	0.151
Denmark	01-09-15	43	5,336,394	127.7	8.1	0.032
Czech Republic	01-09-15	48	10,272,179	120.8	4.7	0.038
Belgium	01-03-02	50	10,241,506	243.4	4.9	0.020
Hong Kong	01-09-19	61	7,116,302	158.2	8.6	0.037
Austria	00-11-03	66	8,131,111	190.6	8.1	0.033
Australia	01-03-19	70	19,169,083	416.2	3.7	0.016
Greece	01-07-13	73	10,601,527	149.2	6.9	0.047
Poland	00-12-06	217	38,646,023	276.5	5.6	0.075
The Netherlands	00-07-24	238	15,892,237	365.1	15.0	0.062
South Korea	00-12-15	272	47,470,969	625.7	5.7	0.041
Spain	00-03-13	419	39,996,671	677.5	10.5	0.059
Italy	00-10-27	1224	57,634,327	1212	21.2	0.096
France	01-05-31	619	59,330,887	1403.1	10.4	0.042
United Kingdom	00-04-27	3543	59,510,600	1319.2	59.5	0.256
Germany	00-08-18	4270	82,797,408	1864	51.6	0.218
Finland	99-03-18		5,167,486	108.6		
Liechtenstein	00-02-15		32,207	0.73		

TABLE 1-3 *Basic Data Concerning the Licensing in Those Countries That Have Issued 3G Licenses (and Two That Are Going to Issue Licenses) (Continued)*

Country	Date, year-month-day	Cost per $1,000,000 US per 2 × 5 MHz of Spectrum	Population, 1999	GDP, $1,000,000 US	Cost per Head of Population per 2 × 5 MHz of Spectrum	Cost as Percent of GDP
Japan	00-06-30		126,549,980	2950		
Thailand	00-01-15		61,230,874	388.7		
Sweden	00-12-16		8,873,052	184		
Ireland			3,797,257	73.7		
Hungary			10,138,844	79.4		

GDP = gross domestic product.

NOTE The UMTS Forum is not responsible for the table's accuracy or completeness.

Apparently there are big differences in the amount of money paid or to be paid in the future, whatever measure of size is used. If the license prices per head of population and per 2 × 5 MHz are plotted after the date of issue of the licenses, there is a clear tendency that the price is declining with time (see Fig. 1-2).[2]

This is an effect of the declining business climate in the telecom sector. However, there is also an effect of the size of the market. If the costs per head of population and per 2 × 5 MHz of spectrum are plotted

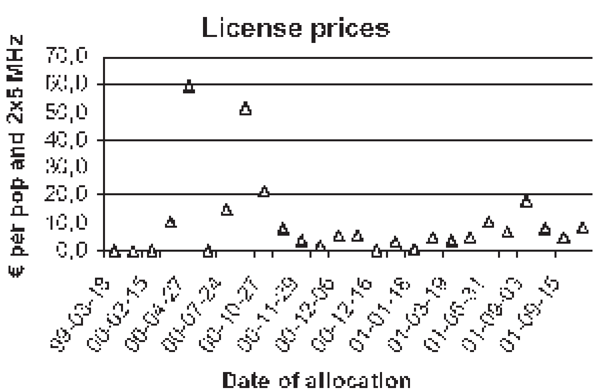


Figure 1-2 License prices are declining with time.

against the size of the country, a tendency becomes apparent that the price increases with the size of the market (see Fig. 1-3).[2]

This tendency is even more clear when the gross domestic product (GDP) is used instead of population (see Fig. 1-4).[2] With the exception of the two early licensings in the United Kingdom and Germany, all countries that have required a license price in the upper part of Fig. 1-4 have had problems in finding applicants for all licenses.

There is another effect of the auctions. If you make a division of the licensees in three categories—global players, regional players, and local players as shown in Fig. 1-5—it becomes clear that the small players in the market have small chance to compete for the expensive auction licenses.[2] The beauty contests, on the other hand, have allowed the local players to have about one-third of the licenses. This effect is by no means unexpected, but may be an important reason for many countries to choose the beauty contest as an allocation method.

Figure 1-3 License prices are increasing with the size of the market.

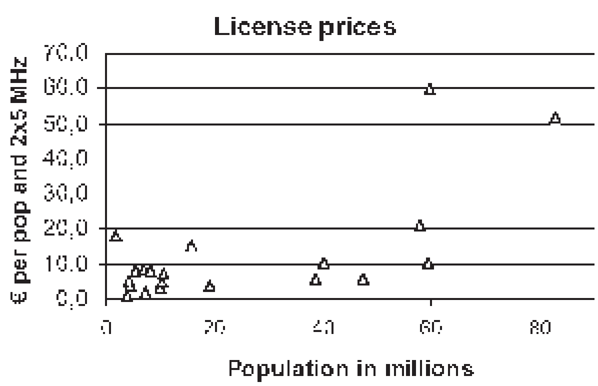
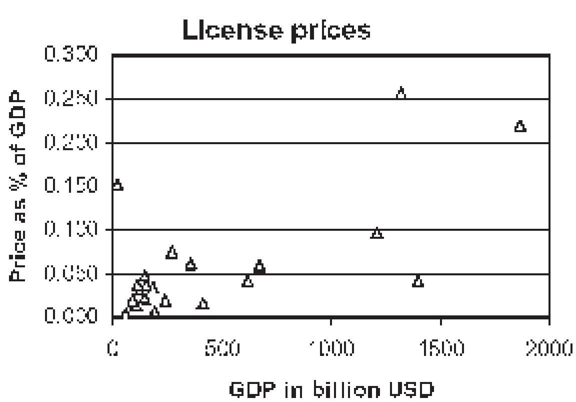


Figure 1-4 The GDP is used instead of population.



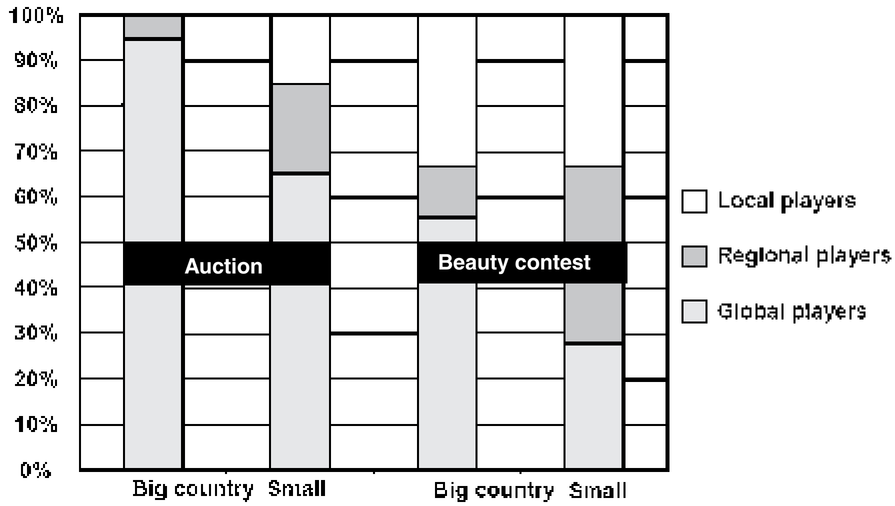


Figure 1-5 The three major licensees.

Standards and Coverage in the United States

The United States in particular faces heightened challenges related to a lack of standards and a vast geographic area. Both factors impact coverage for any given network. The maps in Figs. 1-6 to 1-8 show wireless data coverage in the United States for a variety of networks.[1]

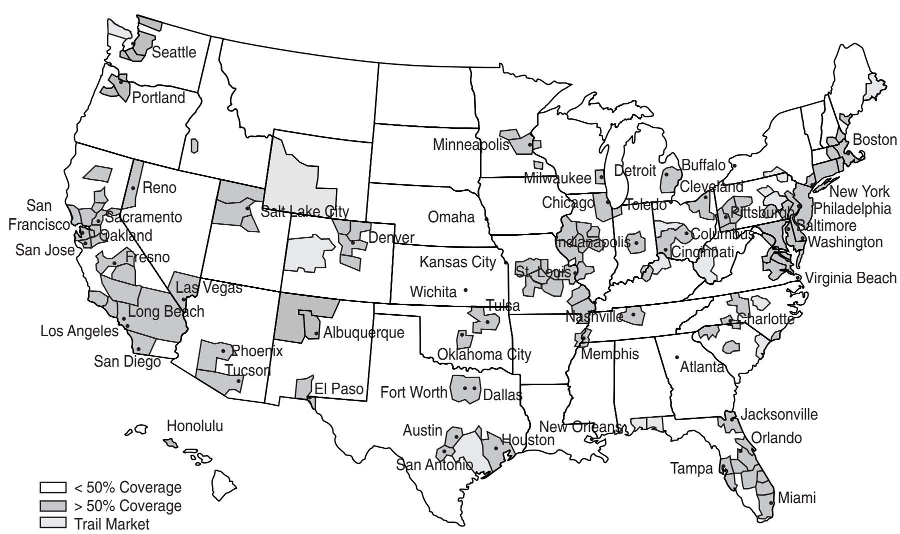


Figure 1-6 U.S. CDPD coverage map.

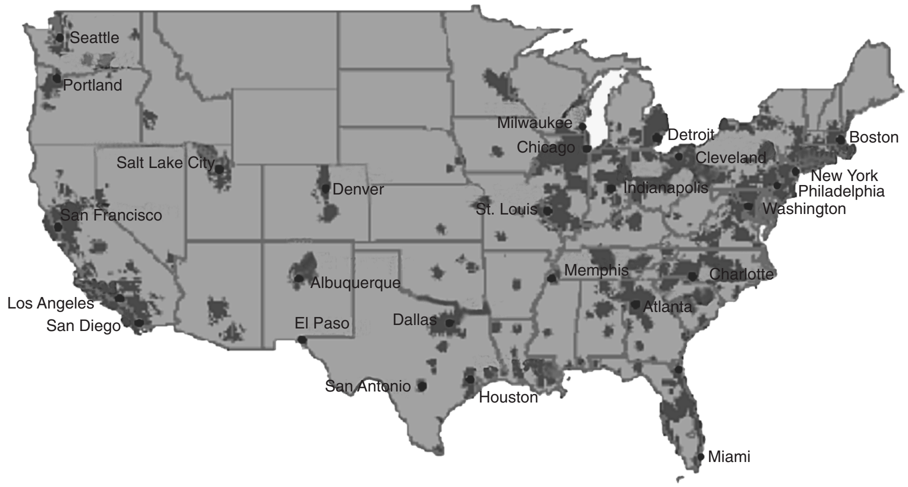


Figure 1-7 Coverage map for Cingular interactive network based on Mobitex.

Figure 1-8 Coverage map for Sprint's CDMA network.

Coverage in Europe

You should compare the level of U.S. coverage for any given technology with that offered in Europe where there is one standard. The maps in Figs. 1-9 and 1-10 are typical for European countries in terms of coverage.[1]

NOTE Coverage in Asian countries varies widely and no single map would be representative for that region.

Implications for the Short Term

Based on the preceding information, the following implications should be considered in planning your near-term wireless data investments:

- Value of 3G technology/spectrum is less than initially thought.
- Deployment is likely to be delayed.
- Standards are still uncertain.
- Coverage is incomplete.

Value of 3G Technology/Spectrum

The fees paid for 3G spectrum licenses have been trending downward, signifying the reduced perceived value of the licenses. This is due to bidding telecom firms' questioning how they can commercialize the service and make a profit based on the cost of the spectrum and building out the network. Look back at the fees paid over time in the United Kingdom, then Germany, then Australia.

Large carriers, including British Telecommunications and NTT DoCoMo, Japan's largest wireless provider, have postponed 3G offerings after technical glitches. Several European 3G auctions have collapsed. And some European operators are now asking for governments to refund the money spent to buy licenses to the 3G wireless spectrum, a dramatic about-face. While all purchasers still believe in the value of deploying the 3G networks, the potential revenue streams are being questioned, and overpaying for the spectrum could have implications on deployment time frames.

Deployment

In the United States, unlike Europe, the spectrum allocated for 3G is currently occupied and being used by the Department of Defense. In order to

Figure 1-9 Coverage map for GSM in France.

Figure 1-10 Coverage map for GSM in Germany.

first auction off the 3G wireless spectrum, sufficient frequency must be allocated, and those occupying the current frequency must be compensated accordingly. Discussions are ongoing with the FCC and Commerce Department, and there is a commitment to resolve this in time for the auction. However, until this is resolved, the auction can't happen.

3G network equipment suppliers (Lucent, Siemens, Nortel, and Cisco) have recently experienced significant revenue shortfalls, and that is partly because of the slowdown in network infrastructure spending by the telecom firms on deployment of 3G networks. The network equipment suppliers' financial results provide a harbinger of 3G technology deployment time frames.

Standards

While the 3G spectrum auctions and early deployments get started, there are a host of competing 3G standards. Actual deployment of 3G networks worldwide could very well overcome the coherence of the existing outside-the-U.S. 2G standard of GSM. The global 3G picture may wind up looking more like the standards mix that exists in the United States today.

Coverage

As the maps in Figs. 1-6 to 1-10 suggest, and as you experience in your daily usage of cell phones, coverage is not complete. Planned 3G rollouts are scheduled to be completed in the 2005–2007 time frame. Additionally, sales of the infrastructure components to support the upgrade of technologies from 2 to 2.5G have remained somewhat sheltered from the downturn, revealing that network providers may suspect that 2.5G technology may suffice until all the 3G issues are worked out.

Perspective on Wireless Data Computing

In recent media coverage, wireless data computing has been presented as a revolutionary paradigm shift. Wireless data computing is perhaps a less dramatic advance. Cellular phones didn't fundamentally change the way people communicated—talking on the phone wasn't new, but the convenience and availability cell phones brought were. Wireless data will bring corporations equally powerful benefits—within a framework you already understand.

A more practical way to look at wireless data is to put it in perspective within the overall context of building and delivering mobile computing solutions. The process of bringing mobile technologies to bear on business processes is nothing new. It requires a disciplined review of the alternative technologies and architectures to determine those best suited to solving the business problem at hand. Wireless data hasn't changed this.

New Connectivity Option

Any enterprise mobile computing solution will involve successive layers of technology, as shown in Fig. 1-11.[1] Viewed from this perspective, you see wireless data as just another connectivity option. This is obviously a bit understated, as the option for wireless data connectivity definitely impacts your choices in the other layers.

The important point is that wireless data does not stand your whole IT operation on its head. It is merely a new connectivity option, one that may allow you to add business value by extending existing systems or further automating business processes.

Another way of adding perspective to this new wireless data option is to look back at how mobile computing has evolved in the past 10 to 15 years. Seeing new options in any given layer is neither rare nor surprising.

Rapid Change in Mobile Computing

In the 1990s, you saw the arrival of sophisticated customer relationship management applications as a prime target for mobilization. Toward the end of the decade, hand-held devices began the transformation from per-

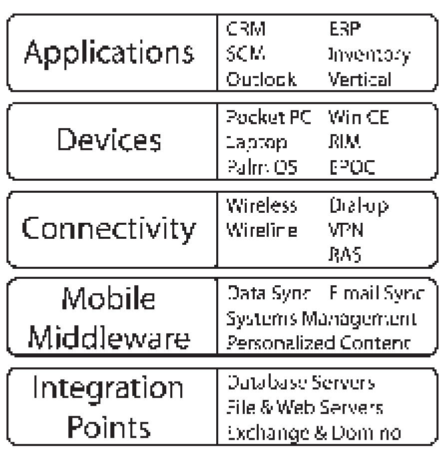


Figure 1-11 Component layers for mobile solutions.

sonal organizers into centrally managed extensions of the existing IT environment. Likewise, you've seen the types of back-end integration points for mobile computing grow from just relational database servers to include e-mail, file, and intranet servers as well.

Seen this way, wireless data represents a new option within one layer of the very dynamic and fast growing space of enterprise mobile computing. What is driving this change? Increased mobility, the ever increasing pace of business, and rapid advances in technologies. All these factors combine to make mobile computing ever more promising—and increasingly a basic requirement to competing successfully. Wireless data is the latest advance and it merits cautious investigation and investment.

The Pros and Cons of Wireless Data

Wireless connectivity for corporate information access offers a variety of potential business benefits driven by user convenience, timeliness of information, and increased ability to transact business. There are organizations out there that have aggressively adopted wireless computing technology and seen the following types of benefits:

- Increased sales
- Decreased costs
- Improved customer service
- Competitive advantage
- Rapid return on investment (ROI)[1]

However, keep in mind that supporting wireless data connectivity also has the potential to increase certain challenges. These challenges are central to mobile computing solutions in general—regardless of the connectivity option chosen. However, the relative immaturity of public wireless data networks does tend to exacerbate them. These challenges include:

- Coverage
- Reliability
- Standards
- Speed
- Costs[1]

In many cases, the unique benefits of wireless data can make it worthwhile to deal with the challenges. Your organization may find innovative ways to wirelessly enable existing business applications. You might find value in formally embracing hand-helds and speeding deployment—with or without wireless data. It all comes back to the business process being supported, and how that translates into the overall solution.

Keep in mind that next-generation wireless data networks will mitigate these challenges sooner or later, and that wireless will emerge as a truly strategic enabling technology. IT organizations are well served to cut their teeth on wireless data today in order to begin building core competencies for the future.

Wireless Data Impact on Other Layers

When building out your mobile solution with wireless data communications, you should take into account the effect on the other layers in the model:

- Applications
- Devices
- Integration points
- Mobile middleware

Applications The application layer should be driven first and foremost by the business problem that you are trying to solve and that led you to mobile computing in the first place. Therefore, it is unlikely that choosing wireless data is going to affect your choice of the application. However, wireless data might let you revisit existing processes and applications to see if there are opportunities to seize competitive advantage with new mobile initiatives.

Devices Regarding devices, all of the major types of mobile computing devices offer one or more options for wireless data connectivity. However, not all devices have options for all networks, so the decision to support a specific device is usually made hand-in-hand with the decision to support a particular type of wireless data connectivity. You can read more about devices, the networks they support, and key criteria for selecting devices in Chap. 20, “Configuring Wireless Data Mobile Networks.”

Integration Points The back-end integration points are largely determined by the application layer. However, you should consider the existing back-end systems within your environment and look for ways to wirelessly enable them to solve business problems and build competitive advantage.

Mobile Middleware Ideally, the mobile middleware you choose will help overcome many of the challenges of going wireless. Your mobile infrastructure platform should support whatever devices, networks, and integration points you wish to mobilize. Thus, the choice to go wireless will indeed affect your choice of mobile middleware, which should be platform-agnostic and support all major standards.

More on the Middleware Layer Remember that basic purpose of a mobile middleware platform is to:

- Help authenticate mobile devices connecting to network resources.
- Optimize for low-bandwidth, intermittent connections.
- Provide secure access only to users authorized to receive information.
- Support all types of information—data, files, e-mail, Web content.[1]

Even if you are dealing with a very specific project for a specific device and network, it is important to plan for the future and choose a comprehensive platform. The alternative is buying and maintaining a portfolio of middleware solutions as you pursue future projects and support other devices and networks and types of information. This is not only more expensive and inefficient, but it creates integration nightmares.

Systems management for mobile and wireless devices also presents unique challenges. There are strong benefits to deploying one mobile middleware solution to meet the preceding requirements as well as providing specialized mobile system management capabilities.

Examples of Strong Wireless Value

The following are examples of the types of solutions that companies have deployed today where wireless data connectivity adds strong value to the overall solution:

- Risk management and insurance
- Electric meter reading
- Wireless data hand-held e-mail

Risk Management and Insurance

A large property and casualty insurer helps clients manage risk by sending risk engineers on site to profile and analyze client facilities. Data are captured on site on laptops, and synchronized back to a central database. An extranet site provides customers having access to their site with reports stored in this database. The company uses wireless data connectivity to make these reports (previously paper-based) available within hours—not weeks. This creates a huge service advantage. This project is typical of a trend in service-related industries, where providing information to customers about their own operations is just as important as providing the actual service performed.

Electric Meter Reading

A major electric utility company employs a large field-based workforce that captures billing information by physically visiting customer sites and reading the values from their electric meters. The historical way this information flowed into the billing process was that the reading was recorded on site on a paper form, which was then forwarded to the corporate office for data entry, and only then could a bill be sent. Using today's wireless data devices, the same utility captures the reading on site directly into a hand-held device, and at the end of the day, the staff member using the device wirelessly uploads the day's readings directly into the billing system database. This knocks several days off the time it takes to collect receivables, and results in more accurate billing—two things any CFO is eager to do.

Wireless Hand-Held E-Mail

Finally, for executives of a large vehicle manufacturer, the ability to keep in touch with key partners and customers from anywhere is an important competitive advantage. Being able to pick up and reply to e-mail while on the go is just as important to this company as doing the same with voice mail. Wireless e-mail opens the door to increased productivity for these mobile knowledge workers who are now able to do work in a taxi, waiting in the lobby for a meeting to start, between flights, or over breakfast in the morning. This easily applies to knowledge workers in a wide variety of industries.

Conclusion

This introductory chapter explored the uncertainty around the deployment of the higher-quality 3G wireless data networks. Organizations will likely have to live with the standards, coverage, reliability, and speed issues that exist today for at least the next several years. Of course, some companies have already proved it's possible to be successful with today's wireless data networks. Nevertheless, there is a reason to be optimistic and proceed cautiously with applying wireless data to your business model today, while we all wait for the exciting high-performance networks of the future.

In any event, the next 22 chapters will thoroughly discuss in finite detail all of the topics examined in this chapter, and much much more. Have a good read, and enjoy!

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