Intermec

White
Paper

TAKING IT TO THE STREETS:
A GUIDE TO WIDE AREA
WIRELESS FOR THE
NON-TECHNICAL BUSINESS
PROFESSIONAL

Introduction

The excitement around wireless data communication has accelerated in the past few years. The ability for remote workers to be in constant contact with the enterprise and have access to almost any data has tremendous potential for productivity gains and cost reduction. From real-time status updates and emergency dispatch to inventory verification and credit card authorization, your organization can benefit in many ways. Understanding the benefits of mobile wireless communications is only the first step. What do you do next? The technology can be confusing and the choices can seem overwhelming.

This guide is written for operations managers who desire a basic understanding of mobile wireless communication. It will provide an introduction to the technologies, the current state of the industry, and considerations for the future. A glossary of selected terms is provided at the end for reference. It may be helpful to browse this prior to reading the complete text.

While every attempt has been made to ensure that the information is accurate at the time of printing, the wireless industry is in a constant state of rapid change. Readers should use this guide to obtain a working background of the technologies and then work with their IT and telecom departments, as well as the local carriers, to discuss the current wireless data offerings.

Types of Wireless Communication

When discussing wireless communications, there are three primary categories: Wireless Wide-Area Networking (WWAN), Wireless Local Area Networking (WLAN) and Wireless Personal Area Networking (PAN). Each has a different purpose and use. In general, WWAN provides mobile communications to a worker over a large geographic territory using a system of switches and base stations or towers, generally maintained by a public entity and used on a fee basis. Examples of WWAN networks in the US are GPRS and CDMA services sold by companies like ATT Wireless, T-Mobile, Sprint PCS, Verizon, and Cingular. WLAN is for a smaller footprint, typically in-building network coverage for areas such as a warehouse or yard, and requires the installation of access points to allow wireless devices to access the network.

WWAN services require a contract with a carrier and purchase of the appropriate wireless capable device, but little investment in infrastructure. Fees are based on usage and are generally billed monthly. On the other hand, WLAN is generally a privately owned network and once the infrastructure is built, there is no on-going fee for sending and receiving data. It also offers higher speed (10mb and higher) communications. The limitation is that it will only provide coverage while the mobile worker is within range (approximately 100 meters) of the access point. Common WLAN technologies are 802.11b and 802.11a and are sold by a number of companies.

The third technology, PAN, commonly referred to as Bluetooth™[1], provides short-range (approximately 10 meters) wireless voice or data communications between Bluetooth compatible (use EITHER "Bluetooth-compatible) OR "Bluetooth-enabled", probably the latter) devices. The primary use of a PAN is to replace cables between mobile computers and printers, scanners, and radios, or between mobile phones and hands-free peripherals. (See Figure 1) This document will focus on Wireless Wide Area Networking, primarily in the U.S. market.

Figure 1: Mobility vs. Wireless Network Technologies

WWAN Coverage

In Vehicle/
Remote

Walk

Fixed

Cable
Replacement

Level of Mobility

1G Wireless Data

2.5G ⟶ 3G
Wireless Data

Wireless LAN
(802.11b)

PAN
(Bluetooth)

0.1   1   10   100

Data Transfer Rate, Mbps
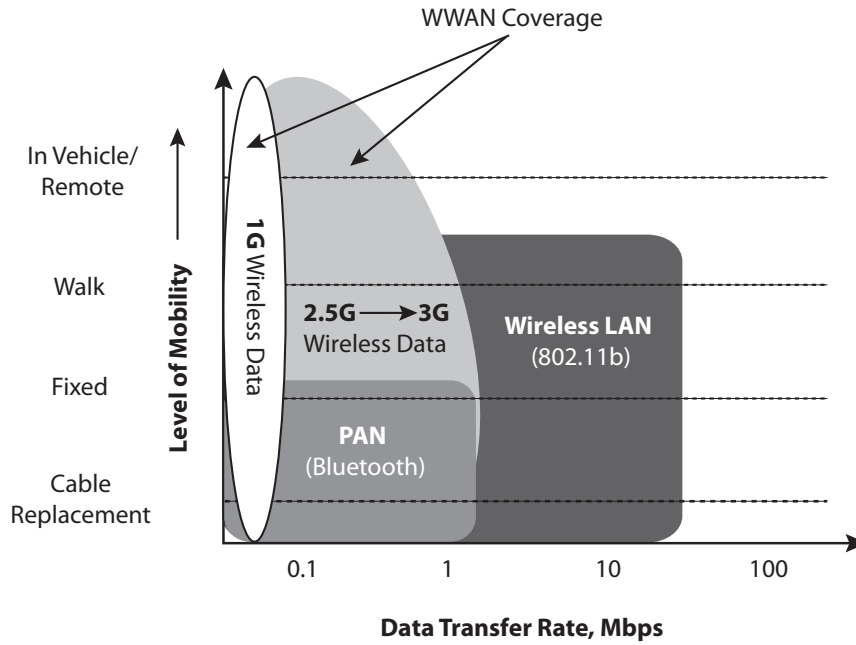
Figure 2: Wireless Networking Technologies

PAN
10 meters

WLAN
100 meters

WWAN
2500 meters

3
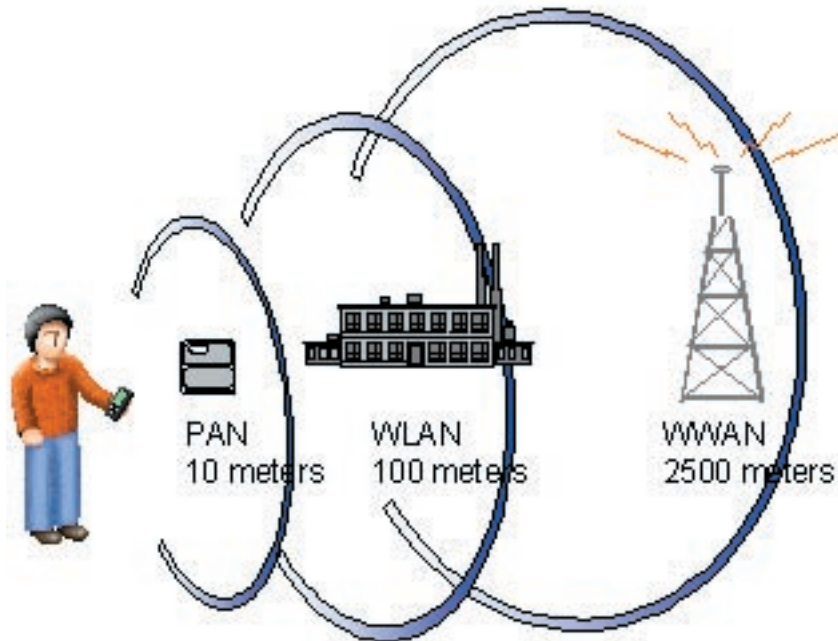
What's In a Letter?

Wide-area wireless technologies are commonly referred to by their generation of technology. 1G (first generation) refer to the original analog systems. 2G represent the digital circuit switched networks. 2.5G is the evolution of the digital network to include packet-switched data. 2.5G networks are near-complete in their rollout in Europe and the U.S. Third generation (3G) technologies are in testing and promise to provide even faster transmission speeds for packet data. For most networks, there will be intermediate steps to achieving "3G" services. The next section will review the evolution of wireless communications in the U.S.

Decades of Wireless Data

While mobile telephones have been used for many years for wireless voice communications, most people think that wireless data is a recent technology breakthrough. In reality, wireless data networks were first developed in the 1980s. The first technology,1G, was analog, which used spectrum and bandwidth very inefficiently and was prone to problems with speed and poor quality transmissions. However, it did employ a single standard throughout the U.S which led to the concept of roaming – using your cell phone outside its "home" area.

The 1G cellular services in the U.S. are called Advanced Mobile Phone Service (AMPS), and it essentially transmits voices as FM radio signals. Ironically, although the U.S. started with a single technology, the upgrade to digital resulted in splintering the networks into multiple technologies. Deployment of second generation (2G) networks introduced the first digital circuit technology, which used spectrum much more efficiently (supporting more concurrent users), offered higher quality service at lower network operating costs, and improved security. Digital transmission technologies also moved mobile wireless data into the mainstream.

In Europe and much of Asia, a single 2G transmission technology called GSM (Global System for Mobile Communications) has been adopted. Using a single technology allows customers to roam throughout Europe with the same handset (although managing roaming agreements can be a hassle and costly). The use of this single standard has been credited with driving the high adoption rates of wireless in those areas.

In the U.S., several different technologies are supported (see U.S. Wireless Network Technologies). While this increases competition, it also means that development costs are higher. Because revenues are diluted between multiple technologies and carriers, it is difficult for network providers and device manufacturers to recover their costs. Ideally the future will draw the U.S. nearer to a single standard. While this may not be likely, the next best solution will be interoperability between the standards and devices to enable global roaming and interoperability. This may take years to realize. Current plans for the U.S. show that at least two different 3G solutions will be available.

Circuit-Switched vs. Packet-Switched Networks

There are two basic types of wireless data transmissions: circuit-switched and packet-switched.

Circuit Data

Circuit-switched data transmission requires the mobile device (phone or PDA) to dial and establish a dedicated circuit between the caller and receiver (much like a voice call). The mobile device communicates with the cellular base station, or tower, which routes the call either to another tower (to communicate with another cell phone) or to the wire line switching center for land-line calls. Wireless telephony does not work through handset-to-handset communication like walkie-talkies, it relies on a number of switches and connections to route calls. Once the connection is made, the circuit is maintained for the duration of the time required to complete the conversation or to send and receive the data. When complete, the mobile device "hangs up" or terminates the circuit. Circuit-data transmissions are controlled and initiated by the mobile device, which prevents companies from "pushing" data, such as an emergency dispatch, from the enterprise to the remote workers. Data at the enterprise is queued until the next time the mobile device initiates communication.

Circuit-data solutions require management of a modem bank, a Microsoft® Windows™ NT or 2000 Remote Access Server (RAS) or equivalent connection point for the mobile device to dial into, similar to how your mobile laptop users connect to your company's network. After the point-to-point connection is established, the server authenticates the caller, receives the data, and then passes the data to the target application on the network. Because information is transferred on a "batch" basis, many applications that use a batch

synchronization process today can easily be wirelessly enabled without software modifications using this approach. In addition, if your wireless phone carrier supports circuit data, you simply need a cable to connect your mobile computer and your mobile phone – there's no need for a separate radio device.

Packet-Switched Data Networks and Paging

Packet networks act as an extension of the local area network, analogous to the way an 802.11b WLAN operates. Data is bundled and organized in a specific way for transmission across the wireless network. The bundle has three primary elements – a header, the text, and the trailer (which is used for error detection and correction). Data is broken into individual packets and transmitted, similar to how network data is transmitted between computers and the Internet. At the receiving end the packets are reassembled into the complete data message. There is no need for the mobile device to "call and connect" because the service is "always on". Applications must be designed to capture the IP address of the device (most 2.5G networks dynamically assign the address, so a database must keep track of and update the address in real time). With this capability, the enterprise can push data out to the device at any time.

Early packet data services used proprietary protocols and did not support TCP/IP, the common networking protocol that is today's standard for transmitting data between computers. As a result, software, referred to as wireless middleware, was required to translate the wireless packets into a data stream the enterprise computers could interpret. Newer packet technologies (2.5G and greater) use standard protocols and do not require wireless middleware. Advantages of the 2.5G networks are discussed later.

Data transmission from the mobile device is generally "addressed" to a specific IP address. It travels from the mobile device over the airwaves to the base station or tower. From there it travels over a wired line to the carrier. The enterprise maintains a high-speed connection (ISDN, Frame Relay, T1 line, etc.) between the enterprise servers and the wireless carrier, over which the packet completes its journey. Because each packet can be addressed with a unique IP address, information can be sent to many different locations from the handheld, it does not need to pass through a single point as in the circuit data model.

Circuit vs. Packet Comparison		
	Circuit	**Packet**
Dial to connect	✓	
"Always on"		✓
Mobile user controls the connection	✓	
True real-time two way communication		✓
Billed by connection time	✓	
Billed by amount of data transmitted		✓
Good for batch transmissions	✓	
Good for frequent, bursty, short messages		✓

Figure 3: Circuit vs. Packet Comparison

Network Costs

Billing for a circuit-switched data transmission is based on minutes of connection time, not the amount of data sent. If you need to transmit small amounts of data frequently, circuit systems can be expensive to operate as you must allow time for connection and authentication (which can take longer than your actual data transmission) at each communication session. Many plans also have minimum billing requirements or round all calls to the minute, which can inflate costs. Even so, if you need to communicate only a few times per day, the benefits of reduced software and hardware investments may make circuit-switched data the most economical solution. Circuit switched data should be considered for applications with large file transfer requirements a few times per day. Packet services are billed by the carrier on a per-packet basis, generally by the kilobyte or megabyte of data transmitted rather than connection time. This can be a significant cost advantage if you send frequent, small messages and don't want to incur the cost of establishing connections several times each day.

U.S. Wireless Network Technologies

As mentioned earlier, the U.S. has promoted the use of multiple wireless technologies. This guide will not attempt to define the technical differences in each, and recommends the reader review the references provided at the end of this white paper for additional information. While most people do not know which wireless carrier is using which network technology, understanding the background of the technology can offer insight into the long term viability of purchasing equipment and services from a carrier, as well as the technical advantages one carrier may offer over another (the benefits beyond contract pricing). When making a decision to deploy wireless data to your field workers, the technology deserves careful consideration.

Early U.S. Circuit and Packet Networks

Circuit –switched systems were primarily used for voice transmissions. However, as companies sought to wirelessly enable batch communication processes, many took advantage of circuit-switched data on the same networks. The primary circuit technologies in the U.S. include TDMA, CDMA, IDEN, and GSM. AT&T Wireless is the major provider of TDMA services in the U.S. and the company tended to discourage the use of the network for circuit data, choosing to promote their CDPD packet data network. Sprint (CDMA) and Nextel (IDEN) both support circuit data on their networks. GSM, while dominant in Europe, has only recently gained popularity in the U.S. as several major carriers are moving from legacy networks to GSM in preparation for 2.5G upgrades. Typically, circuit-switched communications are accomplished by using a cable to connect a mobile phone to a mobile computer – the phone essentially replaces plugging into a wall jack. In some cases, integrated wireless modems for mobile devices can also be found (most of these are GSM). Speeds typically range from 9.6 to 14.4 Kbps[2] (very slow compared to the 56Kbps dial-up most of us are familiar with for PC connections to the Internet).

The first digital, two-way packet-switched network protocol was developed by Ericsson and Swedish Telecom Radio in the early 1980's and was called Mobitex. The primary marketing and service provider in the U.S. was RAM Mobile Data, which became BellSouth Wireless Data (BSWD), now Cingular Interactive. Mobitex transmission speeds run from 9.6 to 19.2 Kbps on newer base stations and modems. A second packet data technology, DataTac, was developed by Motorola for IBM, to provide IBM's 17,000 service engineers access to the company mainframe. The service, named ARDIS, began operation in 1990. Because of its intended application, there was a significant focus on developing a technology with superior in-building coverage. ARDIS was acquired by Motient in 1998 and provides data speeds up to 19.2Kbps. Both Mobitex and DataTAC are data-only networks and use proprietary protocols (not IP-based), which require the use of wireless middleware packages to convert the data into a format the enterprise can understand.

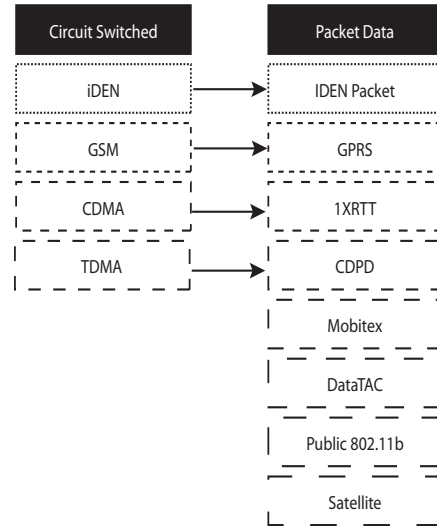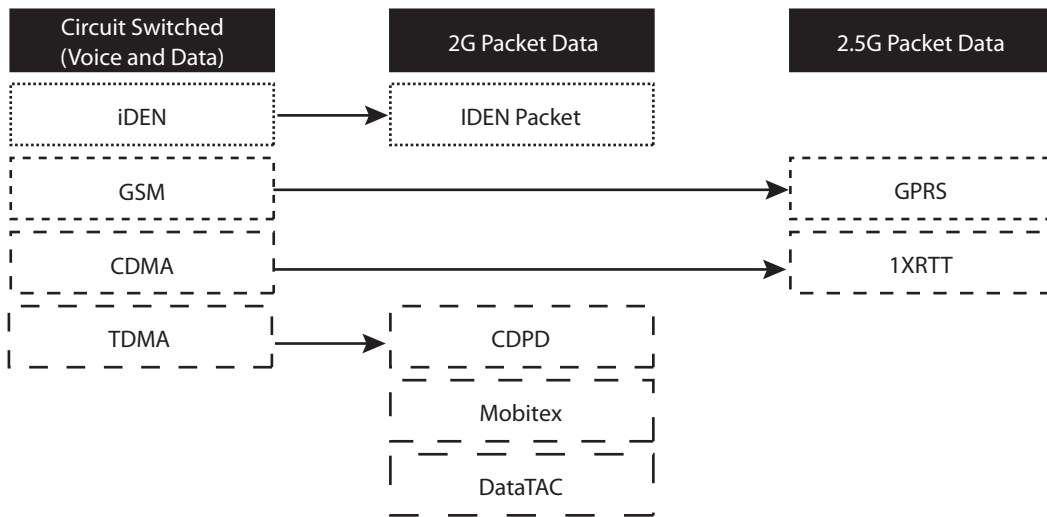**Figure 4: Summary of US Circuit and Data Networks**

Figure 5: Wireless Data Migration to 2.5G

6

Motorola developed another digital transmission standard to compete with GPRS and CDMA called iDEN, which is used by Nextel. This technology provides voice, push-to-talk (two-way radio) and data capabilities. In addition, users have the option of either IDEN circuit data or IDEN packet data. Data speeds run from 9.6Kbps for circuit to 19.2Kbps and higher for packet. Nextel built their network by purchasing and consolidating the spectrum previously used Special Mobile Radio (SMR) networks around the country. SMR was originally intended for wireless dispatch to fleets (ex: taxi cabs or fire trucks). Today it has evolved to support mobile phone calls as well as wireless "teleconferencing" in dispatch mode, allowing several people to hold a conversation at once. IDEN offers this capability for use as a phone or walkie-talkie with its DirectConnect or "push to talk" services marketed by Nextel.

CDPD (Cellular Digital Packet Data) is a packet-switched data transmission technology developed for use on the cellular frequencies. It is considered a precursor to GPRS. It overlays packet data on the unused TDMA voice channels. It offered standard protocols (IP) and eliminated the need for wireless middleware. And, unlike circuit data, it used dedicated channels that eliminated competition from voice calls. Data speeds could reach 19.2Kbps. Unfortunately CDPD was never deployed to as great a geography as either circuit data or the other early packet data networks. ATT Wireless has announced End Of Service for their CDPD network, which makes up the majority of CDPD coverage in the U.S. None of the other carriers, has made such an announcement but they are expected to follow suit.

For the most part, the early packet data networks do not have migration strategies that will move them into the 2.5G space. They suffer from high infrastructure costs with relatively few subscribers. As a result, rate plans of $30-50/month for 1MB of data are not uncommon (this is 10 times higher than rates for newer 2.5G services).

U.S. 2.5G Packet Data Networks
2.5G data networks are complementary to existing voice or circuit networks. In general, they overlay the voice network, so that where you have voice coverage there will be packet data services[3]. Key advantages to 2.5 G technologies for wireless data transmission over the older packet data systems are:
- Use of standard IP communication protocols – no wireless middleware required.
- Higher speeds – 10 to 20 times faster.
- Ability to overlay packet data on voice networks - using dual-mode radios, mobile devices can support both voice and packet data on the same device.
- Lower subscriber costs – as much as 10 times more data for the same costs as older data networks.
- Better coverage – packet data will be available wherever voice calls can be made. While in-building coverage may suffer some, the total geographic areas that will have access to packet data will increase as the carriers invest in additional towers to capture new subscribers.
- Better roaming – with only two primary data technologies rather than four or more, subscribers will have the ability to roam between more carriers supporting the same technology.

There are two different 2.5G technologies being deployed in the US. The first is Global Packet Radio Service (GPRS), which is the data-only packet network overlay for the GSM network. It allows "always on" connections and promises transmission speeds up to 115 Kbps (nearly 10 times faster than older data technologies). However, handsets have not been able to achieve these speeds yet, partially due to problems with heat generation in the handsets. Actual throughput speeds being realized are 20-50 Kbps, with downloads faster than upload speeds. Deployment for GPRS was completed in many large metropolitan areas in 2002 and the rollout of new coverage areas should continue in 2003. However, as with most of the digital voice networks, the Gartner Group predicts that it may be 2007 before GPRS coverage is available outside the urban/suburban areas.

The second technology is 1XRTT, the data-only packet network overlay for the CDMA network. It promises speeds up to 144 Kbps in mobile environments (actual throughput speeds currently average 50-60 Kbps). Deployment for 1XRTT was completed by Sprint PCS in 2002 and is continuing for Verizon and other second-tier carriers. Now, anywhere you can obtain Sprint PCS CDMA voice coverage, you should have access to 1XRTT packet data. As with the GPRS networks, the CDMA carriers will continue to expand the reach of their network across the U.S.

Matching Service Providers to Transmission Technologies
Most people do not take the time to review the underlying technology when choosing a carrier, rather they look at coverage and rate plans. While these are extremely critical factors, it is important to keep the technology in mind, particularly if you are making an investment in the next two years. With the rapid movement toward 2.5G, many carriers are adding new technologies to their existing offerings. As a result, you may be able to purchase several different voice and data plans, each with different underlying technologies. It is important to understand which technology is used so that it matches your roadmap for both features and long term viability. For example, AT&T Wireless still offers their TDMA

voice services and CDPD data services, however it has announced the end of support for CDPD. AT&T Wireless is also focusing the majority of its infrastructure investments on the deployment of GSM/GPRS. While rate plans for the TDMA or CDPD services may look appealing, you must evaluate the long-term viability of building a solution around older technology.

Another reason to consider the technology of the wireless solution is roaming. When you exit an area where coverage is provided by your primary carrier, there may be other carriers using the same technology that will allow you to roam on their network to send and receive calls or data. Roaming depends on having the same technology (i.e. TDMA) and a contract agreement between the carriers for reverse billing. For this reason, you cannot use a phone or mobile data device that is activated on the Sprint (CDMA/1XRTT) network and also use it with an AT&T Wireless (GSM/GPRS) tower. Understandably this can be frustrating when you are virtually standing under a cell tower and still have no signal, but unfortunately it is a repercussion of the U.S. promotion of different technologies.

The figure below identifies the major U.S. carriers and their technologies.

Figure 6: Example US Wireless Service Providers Matched to Network Technology

Circuit Switched (Voice and Data)	2G Packet Data	2.5G Packet Data
iDEN: Nextel, SouthernLink, Telus	IDEN Packet: same	
GSM: AT&T Wireless, T-Mobile (VoiceStream), Cingular		GPRS (same)
CDMA: Sprint PCS, Verizon		1XRTT (same)
TDMA: AT&T Wireless, Alltel	CDPD: AT&T Wireless, Verizon (AT&T dropping support, others expected to follow)	
	Mobitex (Data Only) Cingular, however Cingular is pursuing GSM/GPRS	
	DataTAC (Data Only) Motient	
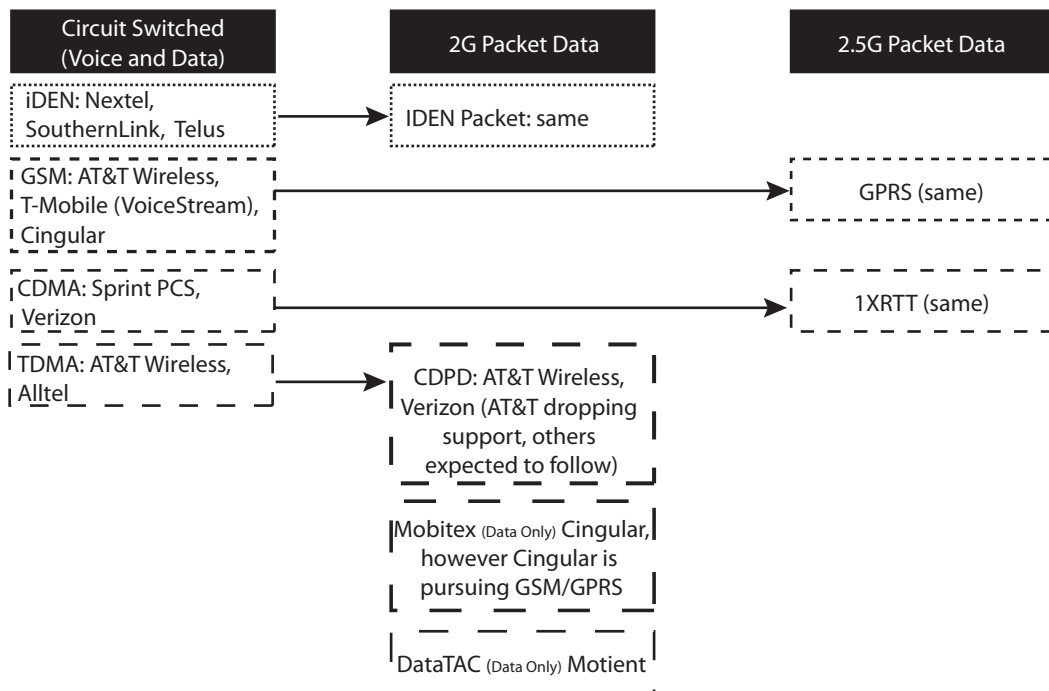
How Does Pricing Compare?

Pricing is a difficult subject to address in print as rate plans can change overnight. Most U.S. carriers rolling out 2.5G packet data services are still finalizing their long term billing plans. To maintain some differentiation, carriers also like to create different bundles of "buckets of data" or package sizes and voice services. This makes it difficult to complete a direct competitive price analysis. In addition, some carriers may offer low introductory packages to encourage early adopters, which will be discontinued after mainstream adopters enter.
In general, packet data is less costly for most businesses than circuit-switched data because the common applications of wireless are messaging and status updates – both occur frequently and are generally short bursts of data. 2.5G data rates are also much more favorable than the older packet data networks. The table below provides examples of data rates that were introduced in the fall of 2002.

Packet Data Cost Comparisions by Service Provider[4]

	1MB	10MB	20MB	Unlimited[5]
2G Packet Data Motient (DataTAC), Mobitex (Cingular), AT&T Wireless (CDPD)	$30-40			
2.5G Packet Data Sprint PCS (1XRTT) Cost/addl MB			$40 $2	$100 N/A
Verizon (1XRTT) Cost/ addl MB		$35 $3.50	$55 $2.75	$100 N/A
ATT Wireless (GPRS) Cost/ addl MB		$40 $4	$80 (40MB) $2	
Cingular (GPRS) Cost/addl MB		$30 (7MB) $4.28	$40 (13MB) $3.85	
VoiceStream (GPRS) Cost/addl MB		$30 $4	$50 $3	
Nextel (iDEN) Cost/addl MB		$40 $10	$60 $10	$55

Moving Forward: 3G

Just as you think you are beginning to understand the options available today, the industry continues to move forward. As U.S. rollouts of 2.5G services mature in 2003, the carriers are busy testing faster technologies. More than 200 industry members are participating in the Universal Mobile Telecommunications Systems (UMTS), an organization working on a global standard (similar to GSM in Europe) for 3G technologies. UMTS and 3G are often used interchangeably. However, it appears that in the U.S. there will be at least two separate 3G solutions. For most wireless carriers, there will also be one or more intermediate steps. It is difficult to predict how quickly carriers will embrace and roll out these new technologies. With current economic conditions, it is reasonable to expect an 18-24 month delay in mainstream adoption of the 2.5G technologies, particularly as enterprises must first secure budgets, prepare the back-office systems for packet data, complete testing and then rollout their solutions. Without proven revenues, wireless carriers may need to focus more on quality of service and aiding users in identifying and extracting business value from existing data networks before they upgrade again. AT&T Wireless has indicated it will move to EDGE and then W-CDMA to enable international roaming with its partner NTT DoCoMo (which owns 17% of AT&T Wireless). In December 2002, AT&T Wireless announced plans to enable W-CDMA in four U.S. cities during 2003: San Francisco, San Diego, Seattle and Dallas.

The current migration paths to 3G are represented in the figure below. This guide will not attempt to provide a detailed explanation on the different technologies (please see the references for additional information). It is important to simply recognize that the technology is continuing to evolve, and that wireless data users should budget for technical upgrades every two to four years to take advantage of newer networks and their features. Because most upgrades will require new hardware, contracts with wireless carriers should be limited to two years or less and then changes can be made as needed.

Figure 6: Example US Wireless Service Providers Matched to Network Technology
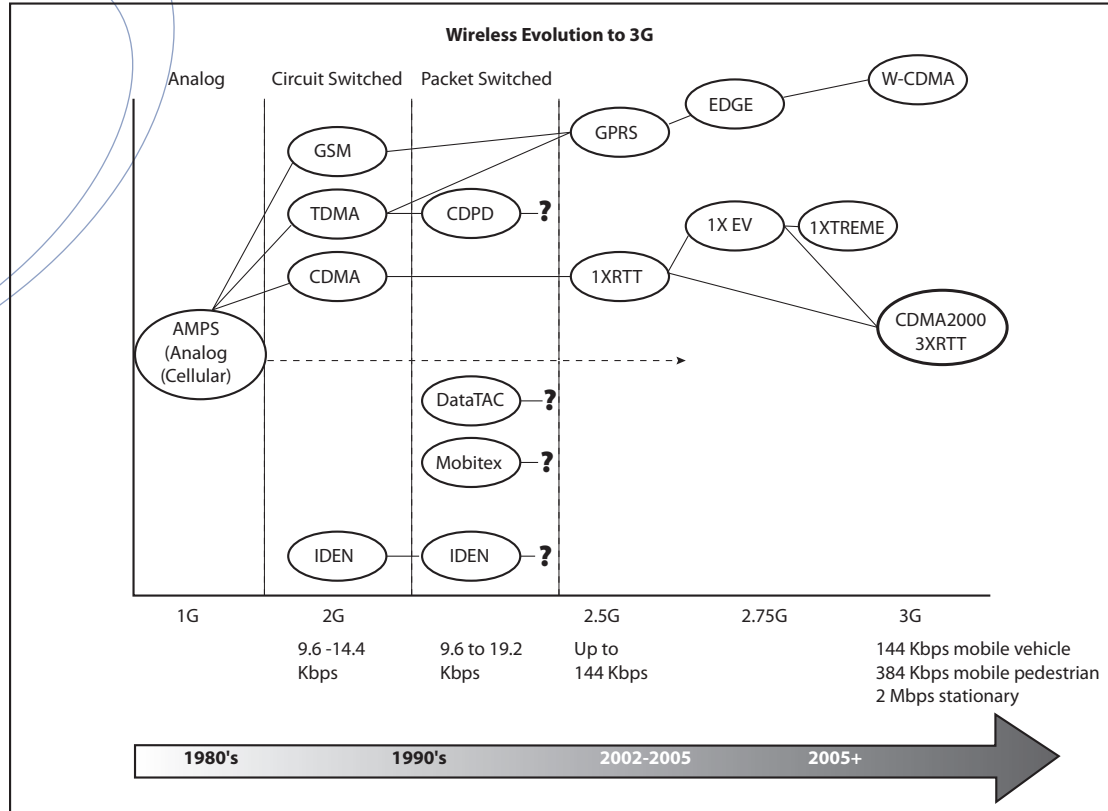
While the 3G broadband packet networks promise great speeds that can enable a range of applications from multi-media service such as streaming video and audio to large file transfers, readers should view the technology with caution. Coverage will remain an issue as most companies are focused on upgrades within the existing subscriber base. While this may represent 98% of the U.S. population, it leaves wide holes geographically, which can be important for mobile workers in the delivery or service business. In addition, current network speeds are relatively slow compared to their theoretical capacity, a problem that is likely to plague the 3G networks as well, possibly preventing some applications from being realized.

Do I Need All That Speed?

In reality, most mobile applications are focused on sending and receiving text messages. These applications are very responsive with low latency even at the old speeds of 14.4Kbps. 2.5G provides speeds that compare to or exceed that of most PC 56Kbps dial-up connections, making web surfing more viable on wireless connections. However, for mission-critical business applications, users cannot rely on a totally web-based solution, as coverage remains a problem. For this reason, most applications will cache the majority of data and graphics on the mobile computer and use the wireless connection for basic text messages and data updates, where again the speeds from 14.4 to 144Kbps are more than sufficient.

In addition to speed and application design, software and web developers must keep in mind the costs associated with wireless. At $30 for 10MB per month, loading pages with high graphic content or downloading large documents or files could quickly consume a month's worth of data in just hours, regardless of how fast the download is.

So why, when the telecom industry faces tough financial positions and has not been able to break even on its current investments, would it continue to research and deploy new technology? One reason is that there is only so much bandwidth for communication, ultimately limiting the number of concurrent users on the system. Newer technologies become more and more efficient, supporting more subscribers and eliminating "network busy" signals. There is also the belief that applications such as live video transmission and multi-media access will bring in additional users and revenue.

10

For most companies, 2.5G is more than sufficient to support mobile field automation. In fact, the limiting factor in software design and selecting what data to send wirelessly may be more a function of controlling monthly costs and maintaining localized databases to prevent disruption when out-of-coverage than a limitation of the technology or connection speed. If your organization will benefit from wireless data and can achieve an ROI in less than 24 months, you should move quickly to deploy one of the current technologies. The move from paper and voice communications to data is a significant undertaking, without trying to add new and unproven technologies such as streaming video.

Can I Manage Investment Protection?

As you research your wireless data needs, it is best to take a tactical approach, focusing on ROI that can be achieved in 24 months or less. Assuming it will take you one year to select vendors, complete your integration and software installation, and completely roll out the solution to the mobile workforce, you must consider a 3-year technology window. Be careful in evaluating older (2G) data technologies to be certain that the carriers will provide you the level of service throughout the entire three years you will require the service, and that device and modem manufacturers will also be able to support your hardware requirements through the same period.

In most cases, there is a strong argument for moving forward and NOT delaying a wireless deployment. In many industries, from field service to pick-up and delivery, the business case for moving from paper and voice to wireless data communications is so compelling, you are throwing away good money each year you delay. The cost of inaction will far exceed the cost of action.

While the 2.5G services are still being rolled out in some parts of the U.S., you can likely time the implementation and rollout schedule for your deployment to coincide with network availability. In most cases, it is better to time your implementation with the 2.5G services than to use an older 2G data network that may have to be replaced before your ROI is achieved.

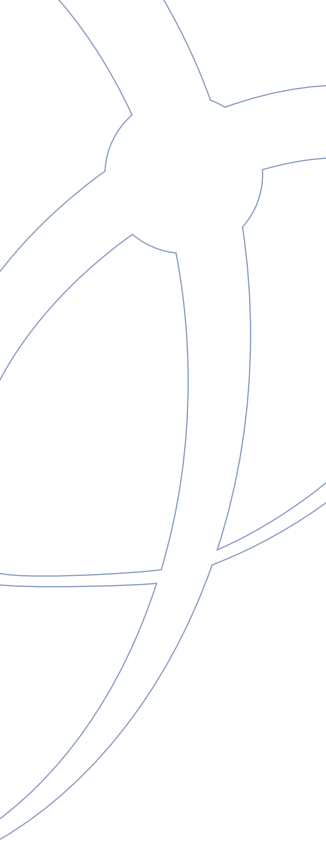### Bluetooth Can Help You Future-Proof Your Mobile Computing Investment

While no one can predict the future, there are certain investments you can make which will provide flexibility and expandability without the need to completely replace your legacy equipment. For example, consider a two-piece mobile data solution using a Bluetooth connection from the mobile computer to the mobile phone. Mobile computers, particularly industrial/rugged devices, have a much longer life than the phone. By keeping the wireless modem separate from the computer, you simply replace the phone when it is time to upgrade. Phones are highly subsidized by the carriers, who often reduce the actual device costs by $100 to $300. Large enterprise subscribers are often able to negotiate free phones with a minimum contract term. These same subsidies are not available today on embedded radios. As a result, your equipment costs are much less if you only replace the phone and not the embedded radio or mobile computer. Bluetooth also gives you more flexibility in switching wireless carriers, allowing you more negotiating power for your contracts.

Wireless Service Providers Must Invest As Well

While it would be ideal to expect wireless carriers and modem manufacturers to provide a more seamless upgrade path that would prevent the user from having to re-invest, it is helpful to understand the investment the service providers must make themselves. And with the technology changes, there are always changes to the modems used in the phones and mobile devices, requirements for different electrical systems and batteries, and inclusion of new technologies, such as GPS or enhanced data storage, that force manufacturers to start from scratch on most handset designs. Likewise, the carriers must also make upgrades to antenna, base stations, switches, software and other infrastructure components.

Yankee Group reports that the upgrade from CDMA to 1XRTT will cost about 30% of the original network costs, which is substantially less than the cost of upgrading other networks. It will also have the advantage of substantially increasing the voice capacity on the same CDMA spectrum. Sprint estimates the cost to be $700M to $1Billion for its 2.5G upgrades in the US.

In comparison, the upgrade from TDMA or GSM to GPRS is relatively expensive, requiring nearly the same capital as the original network. And the move from GPRS to EDGE (Enhanced Data Rates for GSM Evolution) will require the carriers to replace the transceiver (radio antenna) at every cell site, with investments that may cost as much as an additional 60% of the original network costs (and that is after the upgrade to GSM). Carriers such as AT&T Wireless face significant investment requirements (100-150% of original network costs) to deploy their planned migrations.

In addition to infrastructure upgrades, the carriers are also competing for very expensive spectrum licenses that allow them to transmit over certain frequencies in specific geographies. These licenses often sell in the billions of dollars. The combination of these and other costs will keep wireless communications prices high and prevent a large decrease in rates for the foreseeable future.

What if I am using an older wireless data technology?

For some users who have deployed circuit data solutions, the benefit of moving to packet data does not outweigh the costs. The investment for software modification and new hardware, and the fact that users may only require data transmission a few times a day, will make circuit data a viable solution for many more years. In most cases circuit communication is accomplished by tethering a phone to the mobile device. It is reasonable that, as companies switch mobile voice providers, there may be a decrease in CDMA or IDEN circuit data users with a corresponding increase in GSM.

If you are currently using an older packet data technology such as DataTAC, Mobitex, or CDPD, your cost to switch (software modifications, hardware upgrades or new purchases) may be high enough to give you pause. However, it is wise to contact your service provider and review their roadmap in detail. Some carriers are looking to turn off service in certain locations in order to re-deploy the spectrum and infrastructure for 2.5 and 3G. Planning your migration is important so that you avoid unforeseen interruptions in wireless service. AT&T Wireless announced in October 2002 that it would stop selling CDPD services in March 2003 and shut down the network in June 2004. Other CDPD service providers such as Verizon are expected to quickly follow suit. As carriers abandon the technology, modem and device manufacturers will also stop producing equipment for those networks, which can also create problems in maintaining your current deployments.

As of this writing, Motient and Cingular are still supporting the DataTAC and Mobitex networks. But as their key customers migrate to newer networks, taking away tens of thousands of users, the fate of these networks is questionable. Cingular is supporting GSM/GPRS primarily through roaming agreements today. This will not be a migration for Mobitex users but rather a technology replacement. Motient has not announced any plans to offer a 2.5G solution. Likewise, Nextel operates on the proprietary Motorola protocol, IDEN, which also does not have a published 2.5G strategy.

If you are selecting your technology now, look closely at the 2.5G solutions. They will offer higher speeds and lower rate plans, as well as investment protection against purchasing equipment for older networks. In addition, there are no new investments expected to improve the old data network coverage maps. The majority of investments are expected in 2.5G and 3G rollouts.

What's the Buzz? Buzzwords and Industry trends

SIM Cards

SIM (subscriber information modules) are removable cards that contains a mini-microprocessor and memory to store information about the user, such as mobile phone number, address book, and calendar. A SIM card is the foundation of security and encryption for the phone. It can also store account or credit card information securely, enabling the phone to be used for m-commerce. For anyone who has switched mobile phones and faced re-keying all their phone numbers, this technology is a welcome relief. The cards improve the ability to move between mobile devices or upgrade handsets. The SIM card was first deployed in GSM phones and will be supported in GPRS and CDMA/1XRTT devices as well.

The original intent for SIM cards was built around roaming, particularly internationally. However, it was quickly realized that it would allow a subscriber to very easily switch between carriers that use the same technology. To reduce the number of defectors, wireless carriers have the ability to employ what is called a "SIM Lock". In this situation, the SIM card is activated for the phone with features that make it unique and bound to that particular carrier. This reduces churn and makes it more difficult for subscribers to switch carriers (for example, to move from AT&T Wireless to T-Mobile GSM services with the same phone). As SIM technology is introduced for 2.5G data solutions, it is yet to be seen if the carriers will employ a similar restriction on modems used in mobile computing devices.

"Hot Spots"

As introduced at the beginning of this paper, wireless local area networking (WLAN) is another method for transferring electronic data over the air. The technology has been commercially available since 1989 and is now mature. The 802.11b standard has improved the ability for device and network interoperability and provides speeds up to 11Mbps – 50 times faster than the current speeds of 2.5G wide-area wireless. In the past, this technology was only deployed for business-to-employee connectivity within a campus or enterprise as a replacement for Ethernet cables. Now, creative companies are searching for a sustainable business model to commercialize the service. What does this mean to your mobile work force?

First of all, you may consider setting up your own WLAN in areas employees frequent but where they do not want to dock their devices. For example, yards and dock doors are great places for drivers to upload and download information without leaving their trucks. If you purchase and install the access points and infrastructure on your property, you "own" the network and can administer your own security, determine your coverage areas, control access, and send and receive data without additional recurring costs. This is often referred to as "wireless docking", and it can offer significant cost savings over WWAN if you have large data files, such as new versions of software that can be queued to send when the device enters the WLAN area.

Second, the emergence of WLAN "hot spots" – public places offering wireless access to the Internet – may provide alternative and/or complementary wireless connectivity to wide-area wireless. Availability is limited today. There were an estimated 1,000 hot spot locations at the close of 2001 but high growth is expected to raise this number to more than 20,000 locations by the end of 2004. Growth will be driven by the ability to address revenue, billing and interoperability issues. Users can find most hot spots in locations frequented by traveling business employees such as airport lounges, hotels, even Starbucks.

Initially, wireless service providers considered WLAN a potential threat to their 2.5/3G rollouts. But now they are considering it as a potential business opportunity: a way to support the power users, reducing traffic on their networks and enabling better coverage inside buildings. T-Mobile currently has more than 1,000 active hot spots and expects to more than triple that by the end of 2003.

To take advantage of public hot spots as a supplement to wide-area wireless, mobile users must have a device that supports both the 2.5G/3G modem and an 802.11b radio. This will mean additional impact on device cost, battery life, and size. Users considering the combination of WLAN and WWAN should seriously consider industrial devices that have been optimized for these environments to avoid usability issues.
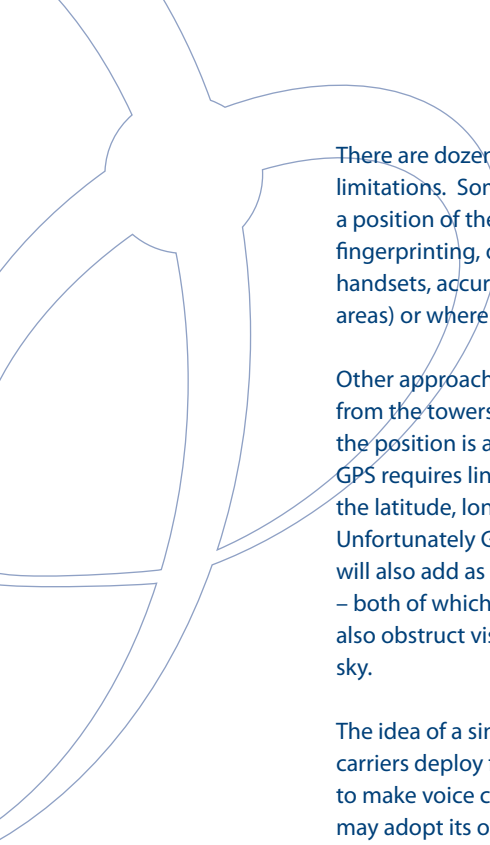
Hot spots also create new and different application and security considerations for use on the public networks. And just as the future will bring changes in technology to support 3G, hot spot operators are likely to move towards a new WLAN standard, 802.11a, to increase bandwidth and avoid interference issues.

While hot spots may sound intriguing, unless your company is a service or delivery organization that caters to the locations where the initial deployments will occur, most mobile work forces will not be able to take advantage of them. In addition, costs will not be inexpensive. For example, T-Mobile pricing (which is in addition to rate plans for GSM/GPRS coverage) starts at $30 per month for coverage in a specific metro area and $50/month for service at any T-Mobile location. Roaming between hot spot network operators is also an issue that has not been resolved.

Location-Based Services

Location technology has been largely driven by the FCC and its Enhanced 911 (E-911) mandate. It is estimated that 30-50% of all 911 calls originate from cell phones. The experience of September 11, 2001 also made the entire U.S. population aware of the value of locating cell phone callers. Accurately capturing location information is fraught with many challenges and potentially huge investments. Several deadlines for providing location information accurate to within 300 meters or less have passed with very few wireless carriers in compliance.

Currently, wireless carriers can identify which cell the caller is presently occupying within three to five seconds. However the size of a cell can be very large (square miles) and does not provide the level of location precision required for emergency services. It is also not accurate enough to drive revenue-based services such as tracking, location-based advertising, and m-commerce. Although the networks have this location information, it is very unusual that they would supply this information to end customers. It is primarily for use by emergency location services.

There are dozens of ways to capture location information, each with varying degrees of accuracy and limitations. Some use the signal from the phone to the surrounding base stations to attempt to triangulate a position of the caller, using either angle of the incoming signal, time and distance of arrival, radio wave fingerprinting, or cell site intersections. While these technologies only affect the networks, not the phones or handsets, accuracy can be negatively impacted if multiple towers cannot be accessed simultaneously (rural areas) or where urban canyons create interference and reflections that distort the incoming signal.

Other approaches use modifications to the phone or handset, again using time and distance calculations from the towers or adding a Global Positioning System (GPS) to the device. Using the handset to calculate the position is a much more costly solution to both carriers and users, but it can yield more accurate results. GPS requires line of sight to three or more of the 24 low-earth orbiting satellites. The GPS receiver estimates the latitude, longitude and elevation based on the time it takes for a signal to communicate with the satellite. Unfortunately GPS can take as long as 60 seconds to obtain a coordinate and cannot be used indoors. GPS will also add as much as 25% to the cost of a phone, requires a second antenna and consumes battery power – both of which could result in larger phones. Interference from storms, trees, mountains, or tall buildings can also obstruct visibility to satellites, particularly if the receiver is at the "horizon" and the satellites are low in the sky.

The idea of a single device for data and voice communications may be hampered by the methods wireless carriers deploy for location-based services. It is likely that carriers will require that any mobile device certified to make voice calls on their network comply with their chosen implementation of E-911. Because each carrier may adopt its own methods, this could create problems for roaming and for managing equipment spare pools. For example, it is possible that when you purchase a wireless modem for your PDA, you would specify which carrier it will operate on. Because there may be technical differences in the modem, you may not be able to "upgrade" or switch it to another carrier. For large, multi-region workforces that require multiple carriers, this issue may force purchase and spare pool management of different radios or devices, even when they are all based on the same underlying technology.

Even with all these challenges, wireless carriers are moving to comply with the E911 edict, and 2.5G technologies are being deployed with that in mind. The ultimate objective is to obtain accuracy to less than 100 meters. Gartner predicts that by 2004, the majority of mobile phones sold in the U.S. will contain location-capable technology. That will cause more debate on issues such as privacy and revenue-based uses. While location information must be provided to emergency responders, should employers have the ability to monitor employee movements? Will consumers accept incoming advertisements as they are walking past a store? Resolving these questions will be important before location-based services can be commercialized. Users should also expect that access to location information for purposes other than emergency services will be fee-based, in addition to their current monthly service plans.

Satellites
Wireless data communication via satellite will not be covered in detail as it is used by a very small population. Instead of sending and receiving signals from mobile devices to ground or terrestrial based antennas, satellite-enabled devices communicate with satellites circling the earth. The advantage is that satellites have a broader "beam" to pick up on signals, essentially creating very large cells of coverage. Existing orbits of satellites can cover over 80% of the earth's surface, providing coverage in many areas without digital or even analog cellular services.

The disadvantages to satellites have been primarily cost-related for both the data transmission rates and the hardware. Rates may run $2/minute and higher. Special antennas, which are generally mounted on the top of a vehicle and resemble domes the diameter of a dinner plate or larger, are generally used. Very few data devices are available with integrated satellite communications – most rely on cabling to an external vehicle-mounted antenna. Specialized phones and integrated mobile devices are used in specific industries such as the military, marine, forestry, pipeline, and international press operations. In addition to cost, latency (the time it takes to send and receive a message) can be much higher than on terrestrial networks – sometimes running into minutes. This prevents the use of web browsers and other software application designs that rely on fast response times. Data speeds are currently averaging 9.6Kbps. While coverage is often referred to as "ubiquitous", users must have direct line of sight to the orbiting satellites, away from tall buildings or large structures. Rain clouds or even dense trees can prevent visibility.

In some cases, commercial businesses have found that wireless communication is so critical to their operation that the business case supports the use of satellite communications. Sears has employed satellites in several areas of the country where terrestrial coverage is spotty at best. Insurance claims agents responding to national disasters such as flood or hurricane areas have also been users of satellite technology. It is difficult to predict the long-term positioning of satellite communications, as the costs challenge most ROI models and terrestrial systems continue to expand their presence. For most companies that are automating for the first time, focusing on terrestrial-based wide-area wireless where coverage is available is the best approach. As the benefits of wireless data are proven within the company, consideration can be given to using satellites to broaden the service to mobile workers that lie outside the current coverage maps. [6]

Wireless Service Provider Consolidation
With fierce competition in the U.S., huge investments in infrastructure upgrades and a market diluted across multiple technologies, wireless service providers are struggling to maintain profitability. Many analysts predict that the six primary carriers in the U.S. today will drop to four or less in the next two years. Worldwide, consolidation is expected to eliminate nearly 30% of the wireless service providers, particularly as large multi-national carriers purchase local wireless carriers to broaden their footprint.

One consideration for consolidation is spectrum. The federal government is working to open up new spectrum for wireless services by reallocating existing users to a new spectrum (including some military groups). Auctions may take place as early as 2004, but the spectrum would not be available for use until 2008. However, carriers are faced with high demand now. Strategic mergers may occur where companies have complementary spectrum portfolios with minimal overlap, allowing them to expand services to a larger area. Mergers may also help build capital that can be used to fund the purchase of the new spectrum, which is likely to sell for billions of dollars.

The total amount of spectrum available for mobile wireless communications in the U.S. (as of January 1, 2001) was capped by the FCC. In order to promote competition, the FCC limited the amount of spectrum any one carrier can own in a single market or geographic region. As a result, there are a minimum of five competitors in metropolitan markets and four in rural. It is under debate if these caps should be raised to allow for consolidation. This could also better utilize the available spectrum as some carriers may be saturated with users while others have lower volumes.
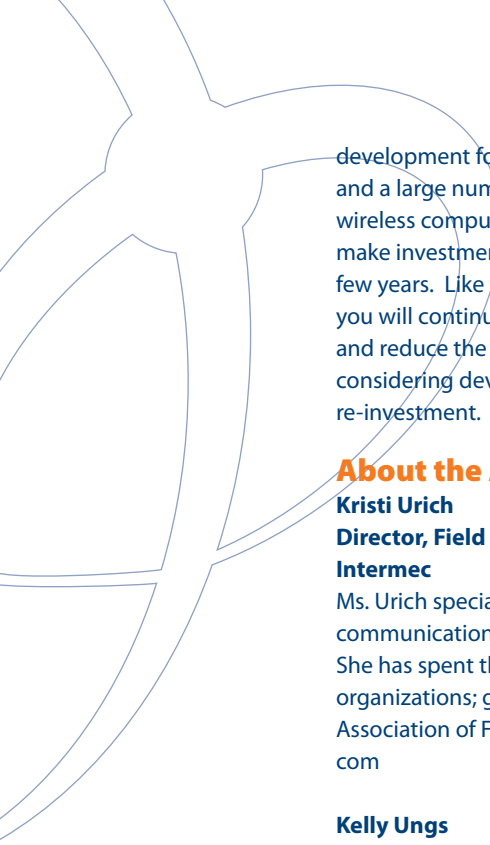
As consolidation happens, the technology paths will remain more or less on course. However, mergers can have an impact on timing so readers should view plans for 3G rollouts with caution. In addition, rate plans, roaming and service availability from carriers will change after the merger. For this reason, readers should consider short-term contracts (two years or less) with their carrier, so that they can easily take advantage of new rate plans and technologies in the future.

Summary
The next few years will bring dramatic changes to the technologies for wireless data communication in the U.S. Speeds, rates and coverage are improving. And most enterprises have completed their back-office automation and are now poised to extend the information to the field. Early adopters are proving that the ROI can be very favorable when the applications are focused on providing the right amount of data at the right time. All of these factors will contribute to significant growth in wireless data adoption.

For mobile workers still relying on paper systems, the payback of wireless communications can be significant – often generating 20-30% ROI. In addition, speed of information can be critical to meeting customer expectations on responsiveness and maintaining a competitive advantage (or responding to competitive threats). The move from paper to electronic data should be carefully planned. As part of the requirements analysis, companies should focus on identifying the information that has particular value in real time. To keep costs low (both for integration and support as well as air time fees), enterprises should focus on a dual-communication approach, using wide-area wireless where there is an identified value. Other data can be sent a few times a day in a batch mode using Ethernet, 802.11b wireless, or even dial-up. In addition, application designs should still take into consideration the limitations of coverage, speed and data costs. Many will find that using a "thick" mobile application where the application, business logic, and database reside on the mobile device, will be advantageous. Critical information can then be sent in real time or queued for transmission when coverage is restored.

Companies who are evaluating mobile wireless solutions should use a tactical approach, using the next few years to prove the value of wireless data, debug their systems, and gain valuable skills within their IT and user communities. While there are more changes coming, it is best to use the current 2.5G capabilities as baseline for application

development for the next three to five years. The build-out of these systems will near completion in 2003 and a large number of devices including Bluetooth, GPRS and 1XRTT phones as well as integrated mobile wireless computers will be available. Focus on deployments that will break even in two years or less, and make investment decisions that will allow you to upgrade or enhance your wireless services over the next few years. Like the desktop PC and laptop revolutions, once you have proven the value of the technology, you will continually need to budget for maintenance, support and upgrades to the system. You can manage and reduce the cost of obsolescence by using technology leasing programs on hardware purchases, and by considering devices with integrated Bluetooth that will allow peripheral expansion or changes without major re-investment.

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About Intermec

Intermec Technologies Corp., a Unova, Inc (NYSE: UNA) company, was the first company to automate mobile workers in 1979 and now serves more than 250,000 field personnel globally. Route sales, utilities, transportation and field service businesses around the world rely on Intermec mobile computing. Intermec is a leader in global supply chain solutions and the development, manufacture and integration of wired and wireless automated data collection, Intellitag® RFID (radio frequency identification) and mobile computing systems used to improve productivity, quality and responsiveness of business operations, from supply chain management and enterprise resource planning to field sales and service.

Intermec has demonstrated its leadership in delivering industrial and rugged mobile devices for enterprise users, supporting Mobitex, DataTAC and CDPD for over 10 years.   Thousands of mobile workers connect Intermec devices to Nextel phones to send wireless transmissions each day. And more than four generations of Intermec mobile computers have been certified to run on the GSM networks in 6 continents. In 2001, Intermec produced the first rugged PocketPC mobile computer supporting integrated WLAN and WWAN solutions (users could choose from 802.11b, CDPD, GSM, Mobitex, and DataTAC modems). In 2002, it was the first to offer the rugged PocketPC mobile computer with the ability to have all three wireless technologies – WLAN ((802.11b), 2.5G WWAN (GSM/GPRS or CDMA/1XRTT) and PAN (Bluetooth compatibility) integrated in a single device. In addition to designs that focus on ergonomics, long battery life, and peripheral support for scanners, keyboards, digital imagers and printers, Intermec produces a number of toolkits and provides developer support for mobile applications to aid customers and software developers in speeding their time to deployment.

For additional white papers on wireless networking and related topics, please visit our web site. www.intermec.com -> About -> White Papers.

Selected Glossary of Terms

- **1XRTT:** Part of the CDMA 2000 standard. 1X refers to the 1.25 MHz of operating bandwidth and RTT is short for Radio Transmission Technology. Expected to provide packet data rates of 144 Kbps in a mobile environment. 3XRTT is the second phase of the CDMA 2000 standard, using 3x the bandwidth and promising speeds up to 2Mbps.
- **Bandwidth:** The breadth of frequencies, that is the difference between the lowest and highest frequencies supported, which can carry a signal without distortion on a transmission medium. For example, the cellular band is 824-849Mhz and 869-894Mz and the PCS band is 1850-1900 MHz. Bandwidth is analogous to the size of the "pipe" – the larger the diameter, the more that can travel through it.
- **Bluetooth:** In 1998, several computer companies met and decided to develop a standard for short range, relatively fast, open-standard radios. The consortium was named Bluetooth, after King Harold Bluetooth, a Danish king famous for getting warring clans together and convincing them to work as one. The idea behind this Bluetooth Special Interest Group (SIG) was to create a device that has the ability to connect disjointed computer devices in a wireless network environment. The result: a royalty- free, global technology for small form factor, low-cost, short range radios that link mobile PCs, mobile phones, and other portable devices without cables.
- **CDMA (Code Division Multiple Access):** A spread-spectrum approach to digital transmission. With CDMA, each conversation is digitized and then tagged with a code. The mobile phone is then instructed to decipher only a particular code to pluck the right conversation off the air. Sprint PCS is a U.S. carrier using this technology.
- **CDPD (Cellular Digital Packet Data):** Technology that allows data files to be broken into a number of packets' and sent along idle channels of existing cellular voice networks. AT&T Wireless and Verizon are two U.S. carriers who have offered this technology.
- **ESMR- (Enhanced Specialized Mobile Radio):** Digital mobile telephone services offered to the public over channels previously used for two-way analog dispatch services.
- **Frequency:** A measure of the energy, as one or more waves per second, in an electrical or light-wave information signal. A signal's frequency is stated in either cycles-per-second or Hertz (Hz). At higher frequencies, more information can be transmitted due to the shorter wavelength. However the shorter wavelength decreases the distance of the signal and increases the potential for interference. For example, it can take four times as many cell towers to provide PCS coverage to the same geography covered by one analog cellular tower. As a result, analog cellular still provides the greatest geographic coverage in the US. Because the FCC requires the original analog companies to continue to maintain analog services on a portion of their spectrum to accommodate existing users, many of the mobile phones have to incorporate the analog transceiver – which is the primary reason mobile phones in the US tend to be larger than phones in the rest of the world.

- **GPRS (General Packet Radio Service):** is a packet-oriented overlay to GSM networks supporting connection- and connectionless-oriented services and diverse quality-of-service mechanisms. The theoretical maximum speed can be as high as 171.2 Kbps however real-life user throughput is expected to be much lower — less than or equal to 56 Kbps. GPRS will become the bearer service of choice for most GSM-based WAP services because its "always on" nature.
- **GPS - Global Positioning System:** A satellite system using 24 satellites orbiting the earth at 10,900 miles that enables users to pinpoint precise locations using the satellites as reference points. GPS works on the principle of triangulation: By knowing its distance from three or more satellites, the receiver can calculate its position by solving a set of equations.
- **GSM - Global System for Mobile Communications:** A world standard for digital wireless transmissions that operate at 900MHz, 1800MHz and 1900MHz frequencies. In Europe, GSM utilizes the 905-915MHz and 950-960MHz reserved spectrum to provide the capability of roaming over 18 countries, with competition within and between countries. GSM 1900, the North American version of GSM, allows the standard to be used in the 1900MHz frequency band, which the U.S. Federal Communications Commission and Industry Canada have allocated for PCS (see also PCS). GSM is the most widely used standard in the world today with more than 150 million users worldwide.
- **IDEN – (Integrated Digitally Enhanced Network):** A wireless technology developed by Motorola that works in the 800 MHz, 900 MHz, and 1.5 GHz radio bands. The technology supports, on one handset, voice
- both dispatch radio and using PSTN connection -numeric paging, Short Message Service (SMS), data and fax transmission.
- **IP:** Internet Protocol commonly used on most corporate networks
- **Network Architecture:** The wireless network consists of several infrastructure components. A wired-line connection runs from the network service provider to the tower or base station. From there, voice or data is transmitted over the air through radio waves to the terminal (wireless phone, PDA or pager). The architecture can be referred to as "cellular" as the towers provide coverage over a specific geography or "cell".
- **Network Service Provider/Carriers:** These are the companies that have secured spectrum, built a network and provide mobile wireless network services to their subscribers. There are three major classes, although the lines are beginning to blur. These include cellular voice and data communications providers like AT&T Wireless and Sprint PCS; data-only network providers like Motient and Cingular; and paging service providers like Arch and Metrocall.
- **Network Technology/Protocol:** The transmission technology is the method through which signals are transmitted and received between the wireless handset and the base station. Unlike European markets that have generally standardized on GSM, the US uses several different transmission technologies, such as CDMA, TDMA, GSM, and IDEN (see Glossary). "Cellular" is also used to refer to the analog transmission technology, as well as network architecture. This can create a lot of confusion. For example, Sprint promotes its PCS voice services as superior to Cellular (the analog technology) while PCS is still based on a cellular architecture.
- **PCS (Personal Communications Services):** FCC terminology describing two-way, personal, digital wireless communications systems. This is a low-power, high-frequency cellular technology, operating in the 1.5MHz to 1.8MHz range. In the United States, PCS also operates at 1.9GHz. Several traditional cellular companies now offer PCS services.
- **Power:** Power is the energy in the wave, and when increased, the length that the wave will travel is increased and potential for interference is decreased. That's why a 50,000-watt radio station can be heard over a wider area than a 25,000-watt station. That is also why you can often hear an incoming voice caller but they cannot hear you. The power from the tower is much greater than the power transmitted from your small mobile phone antenna.
- **SMR – (Specialized Mobile Radio):** Private business voice and data radio service using mobile radiotelephones and base stations similar to other wireless services. It is usually used in dispatch applications, such as delivery companies or taxicab organizations. Specialized Mobile Radio is the forerunner of ESMR service.
- **SMS (Short Message Service):** A service to send short alphanumeric messages between devices. SMS is a bi-directional paging function that is built into GSM systems. Each message can be up to 160 ASCII characters long. The network stores messages for up to several days (typically a maximum of 72 hours) and attempts to deliver the message whenever the portable phone is switched on. Confirmation of receipt is available as an option in some networks for an additional fee.

- **Spectrum:** the specific frequency and bandwidth of that frequency. Spectrum for wide area wireless communications, like that for radio and television transmissions, is controlled and licensed by the Federal Communication Commission (FCC). The demand for spectrum has rapidly exceeded the supply, as a result spectrum licenses are very expensive. Recent auctions have resulted in billions of dollars in exchange for spectrum.
- **TCP/IP (Transmission Control Protocol/Internet Protocol):** The standard set of protocols used by the Internet for transferring information between computers, handsets, and other devices.
- **TDMA (Time Division Multiple Access):** A method of digital wireless communications transmission allowing a large number of users to access (in sequence) a single radio frequency channel without interference by allocating unique time slots to each user within each channel. TDMA breaks signals into sequential pieces of defined length, places each piece into an information conduit at specific intervals and then reconstructs the pieces at the end of the conduit.
- **Unlicensed Spectrum:** There are some unlicensed frequencies where other wireless devices, such as garage door openers and cordless phones, can operate. Enterprise applications within the 2.4Ghz frequency are commonly used for local area wireless communications (access points, etc.) and for Bluetooth.

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www.nextel.com - Nextel iDEN voice and data services

www.qualcomm.com - Qualcomm CDMA technology overviews

www.sprintpcs.com - Sprint PCS CDMA voice and data network services

www.t-mobile.com - T-Mobile GPRS voice and data network services

www.verizon.com - Verizon CDMA voice and data network services

www.wireless-data.com/coverage_maps.html - Wireless Data coverage maps for many networks

www.wow-com.com - World of Wireless general information web site by the Cellular Telephone and Internet Association (CTIA)

Footnotes

[1] Bluetooth is a registered trademark of the Bluetooth Special Interest Group (SIG).

[2] A note on data speeds. Most carriers will promote their "theoretical" maximum data speeds. Actual realized speeds are often much lower due to many factors – distance from the tower or base station, speed at which the mobile user is moving, interference, the power of the transmission, and the gain or power of the receiving antenna. For example, 3G technologies promise speeds up to 2Mbp, however that can only be achieved in a stationary environment. Speeds decrease to 384 Kbps in a mobile pedestrian environment and 144 Kbps in a mobile vehicular environment.

[3] Packet data does require hardware and software upgrades to the network and will not be immediately available in all areas. Packet data also requires the appropriate GPRS or 1XRTT in the phone or mobile device, and subscribers will be required to add packet data services to their voice contracts.

[4] Pricing information was compiled in October 2002. Sources included wireless carriers, carrier public web sites, Gartner and publications such as the Wall Street Journal, Forbes, and Andrew Seybold's Outlook, 2002.

[5] Beware of "unlimited" packages. If your monthly use fluctuates below the next lowest package, you may be better to take advantage of lower monthly fixed costs and simply pay overage charges when needed. Also, "unlimited" is a relative term. All carriers have a clause stating that if your usage negatively impacts their ability to provide service to other customers or negatively impacts their network, they reserve the right to terminate you without notice. Unlimited packages are often used to encourage early adoption by providing a "fixed fee" for budgeting. In other cases, the packages are promoted because the carrier has not upgraded their billing systems to handle packet-based billing. In either case, the carrier may discontinue the unlimited rate plan at any time. Be careful when designing your application that they are not wasteful in the amount of data that is sent and received, or you may be faced with re-designing the application in the future when plans are more strictly controlled and priced.

[6] Author's note Wireless data communication via satellites should not be confused with using satellites with GPS technology. GPS receivers use satellites to triangulate and calculate the device's longitude, latitude and elevation but are receivers only. They do not transmit signals, thus do not require the antenna, power or batteries of satellite phones or mobile devices. If your application requires GPS coordinate information to be sent back to the enterprise, the GPS receiver must be combined with a wide-area wireless or satellite communication device that is capable of sending the data.

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