1: Wireless Network Technologies

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Introduction

This document provides an overview of the different network technologies in the wireless industry. It discusses Network technologies, multiple access methods, and data communication systems (past, present, and future).

The technologies discussed in this document are primarily Wireless Wide Area Network (WAN) technologies, but a brief discussion of Wireless Local Area Network (LAN) and Wireless Personal Area Network (PAN) technologies are also included. The technologies covered in this document are:

- AMPS CSC—Advanced Mobile Phone Service Circuit-Switched Cellular
- CDPD—Cellular Digital Packet Data
- TDMA—Time Division Multiple Access
- GSM—Global System for Mobile Communications
- GPRS—General Packet Radio Service
- CDMA—Code Division Multiple Access
- Bluetooth—Wireless Personal Area Network (PAN)
- WLAN—Wireless Local Area Network (LAN)

Each of these technologies is discussed in detail, giving a brief history, a technology overview, a discussion of the strengths and weaknesses of each technology, the deployment of the network, and the future outlook for the technology. Applications and compatible products for each technology are also highlighted in each section.
AMPS CSC

**Full name**  Advanced Mobile Phone Service (AMPS) Circuit-Switched Cellular (CSC)

**Category**  Connection-oriented cellular communications

**History**
Circuit-switched cellular allows for data transmission over existing analog cellular systems (AMPS in North America) originally designed for voice. This became available shortly after cellular service was introduced back in 1984. AMPS was designed by Bell Labs in 1969. Analog cellular systems are referred to as the first generation (1G) of wireless systems.

**Technology**
AMPS uses the 800 MHz frequency band and was originally designed for voice transmission. Technologies were developed to allow for data over these same voice channels. This cellular data transfer requires a “session” between each end, similar to a voice connection. During this session, cellular data transmission sends data over an airlink (through a nearby cell, the regional switching office, and Public Switched Telephone Network (PSTN)) to a remote computer.

Since cellular phones utilize radio signals, common radio performance impairments such as interference, noise, fading, and overall channel degradation can affect data transmission. Therefore, special “cellular-enhanced” protocols have been introduced to control modulation, data compression, and error correction, helping provide faster and more reliable transmission when both modem ends use the same protocol. The most common of these protocols are ETC (Enhanced Throughput Cellular from AT&T Paradyne Inc.) and MNP-10 (Microcom Network Protocol from Microcom Inc.).

Billing for AMPS data service is most often based on airtime, normally in one-minute increments. Similar to an AMPS cellular phone, additional charges for long distance and roaming are also applied.

**Strengths**

**Coverage**  Circuit-switched cellular (CSC) networks have been over a decade in the making, providing virtually ubiquitous coverage. This means CSC data services can be widely available, relying on the existing AMPS cellular infra-
structure. No additional equipment is needed for voice, fax, or data. Therefore, wherever a cell phone can go for cellular voice communications, wireless data can go too.

**Stability of the network** AMPS cellular has achieved a high level of maturity and robustness over its lifetime. It is a proven technology that is widely adopted, now for data as well. New modem technologies (protocols) have also been developed specifically for transmitting data over the CSC network resulting in improvements in reliability and performance.

**Payment structure** Since CSC data connections are almost identical to the typical cellular voice connections, billing procedures are more familiar for the end user. CSC data transfer is billed by the connection time similar to a cellular phone. Since these rates have also become more economical with increased subscriber bases, a variety of rate plans are now available.

**Weaknesses**

**Age** AMPS CSC is an older technology that has been superseded by the newer cellular technologies, which offer faster, more stable, and more secure data communication options.

**Cost** Since a connection or “circuit” is established when transferring data over an AMPS cellular network, charges are based on connection time similar to a cellular phone call. This means if the wireless application transfers short bursts of data, the cost of the connection time can outweigh the time of the actual data transmission. In addition to the payment format, additional charges for long distance or roaming can be applied unlike packet-switched networks.

**Delay** Since CSC involves a connected cellular circuit, dial-up delays are introduced. These delays are not only realized when the data connection is to be made but also when the monthly bill based on connection time is received.

**Transmission rate and errors** Transmission speeds for circuit-switched connections generally range from 2.4 to 14.4 kbps. Throughput is affected by interference, noise, fading and overall channel degradation, common RF-related effects, and varies from one location to another. Dropped calls are also not uncommon. However, several modem technologies have been introduced to address these data-related issues.

**Security** Cellular does not provide any data encryption, meaning an appropriately modified radio scanner can intercept voice transmissions. Data, on the other hand, is much harder to track since it is sent through co-operating modems using specialized cellular protocols. These modems may also
incorporate a compression standard such as MNP-7 or V.42bis, which would make it very difficult to intercept data transmissions over cellular.

**Complexity** Compared to a packet-switched data technology like CDPD, CSC connections can be more difficult to initially set up and use.

**Markets and applications**

Circuit-switched cellular lends itself to fax, data files, and interactive application transmissions. CSC was a good back-up option for those applications that crossed geographical areas that did not have support for other wireless data service options such as CDPD.

**Future outlook**

Other data technologies such as CDPD and circuit-switched data communications using digital systems (such as GSM, TDMA, and CDMA) continue to take up a larger piece of the mobile data user base. AMPS CSC is an older technology that is no longer available in many markets.
CDPD

Full name  Cellular Digital Packet Data
Category  Digital cellular data system used over analog cellular networks

History

Despite rapid growth of cellular subscribers between 1982 and the early 90s, cellular carriers were concerned that the revenue per subscriber was decreasing. Therefore, carriers began to look for ways to increase revenue for their networks. In 1992, all of the leading cellular carriers formed a group to develop a digital service that was in line with the Internet protocols to provide data. It was to become CDPD and it was designed to address critical mobile data issues such as roaming, billing, security, and authentication. Key members of Sierra Wireless's technical team participated in this effort.

Technology

CDPD is a packet switched communications network based on TCP/IP that normally operates as an overlay on top of the existing advanced mobile phone services (AMPS) infrastructure. It is in fact a digital cellular system designed for data transport that can operate independently or on any cellular system that uses 30 kHz channels (such as AMPS analog systems in North America). CDPD authors wrote the standard in such a way that in the future, it could be used over a wide range of physical layers including those used by CDMA and TDMA.

CDPD utilizes the spare channel capacity of these existing cellular systems originally designed for voice transmission to send bursts of data called “packets”. Using a channel-hopping scheme that makes use of the short periods of time between voice calls, data transmission hops from one voice channel to another to maximize the use of the cellular system’s capacity. Since it does not require the full use of the voice channel in order to transmit data and it does not establish a circuit or dial a number, it is often called a “connectionless” service. All data packets are sent once the CDPD modem is registered on a valid CDPD network.
**Strengths**

**Implementation and coverage**  Due to CDPD's reliance on the existing analog cellular infrastructure in North America and on the Internet, carriers implementing CDPD only require the addition of Mobile Data Base Stations (MDBS) and Mobile Data Gateways (MDG). This means that CDPD can be quickly deployed by cellular carriers. Although no single nationwide CDPD service exists across the U.S., most major metropolitan areas are covered and roaming agreements between CDPD carriers allow a single account to be used across the CDPD footprint.

**Transmission rate**  CDPD is a wide area wireless packet data network offering raw transmission rates of 19.2 kbps. Actual throughput is lower due to overhead for error control. Additional data compression techniques can be used to increase these rates.

Throughput is also enhanced by the limited overhead associated with the CDPD protocol. Other data services (such as Mobitex and RD/LAP) rely on “gateways” to convert from their native protocol to IP, which introduces delays, errors, and may demand custom interfaces to the modem. CDPD also compresses the IP protocol overhead while other protocols must carry all of the overhead plus the overhead of their own protocol. This not only affects throughput but also wastes valuable RF spectrum.

**Transfer mode**  Not only can CDPD offer raw data rates of 19.2 kbps, but it also provides full-duplex communications allowing a radio modem to talk and listen at the same time. This allows CDPD to handle real-time interactive applications that competing packet networks cannot support due to their half-duplex nature. A half-duplex radio modem must switch between transmit and receive modes, taking up valuable time.

**IP-based and open specification**  CDPD is a native IP protocol service. The CDPD carrier in effect acts as an Internet Service Provider (ISP). Since it is IP-based, it is easy to develop for, and integrate into, existing applications. A CDPD remote device can access anything accessible over the Internet. At the same time, CDPD is a fully open specification meaning there are no licenses or royalties to pay when developing for the network.

**Cost**  Many carriers in the U.S. have “flat rate” packages where a CDPD subscriber can transmit and receive as much data as desired for a flat rate per month. A remote device can be connected to a CDPD network indefinitely without being charged extra.
Reliability and security  CDPD uses forward error correction methods to reduce the effects of noise and interference on the airlink. In fact, there are usually fewer errors than with circuit-switched data. Authentication and encryption are also incorporated into all packet transmissions. CDPD carriers claim six levels of security.

Weaknesses

Coverage  Although CDPD’s coverage across the U.S. has grown over recent years covering most major metropolitan areas and approximately 50% of the U.S., it still lacks a single nationwide network. Instead, multiple cellular networks from several cellular providers have been patched together through inter-carrier agreements in hopes of providing the wireless user with the feeling of one large, ubiquitous network at their fingertips.

Transmission rate  With higher speed technologies being rolled out by many carriers around the world, CDPD throughput of 19.2 kbps may be considered an older technology in the near future.

Deployment

CDPD can be found in 209 markets including 123 metropolitan areas, 43 rural areas, and 43 international markets. Coverage extends to nearly 39 million people in the U.S., almost 55 percent of the population. (Figures from the Wireless Data Forum reported in Radio Resource Magazine June-July 1998.)

CDPD has an emerging international presence as well including:

• Ecuador
• New Zealand
• Venezuela
• Columbia
• Peru
• Indonesia
• China
• Israel

For further CDPD coverage details, please refer to: www.sierrawireless.com/SupportDownload/coverage.html

Markets and applications

CDPD lends itself to various mobile applications including:
• Financial news—up to date financial data including stock quotes and analysis, bank rates, industry announcements, and so on.
• Financial transactions—credit card verification and other point-of-sale applications.
• Mobile professional—e-mail, Web, corporate application and database access from anywhere.
• Public safety—real-time access to critical information for law enforcement officers, ambulances, and fire fighters.
• Health care—home patient monitoring, remote medical support, and on-site prescription tracking.
• Field sales—customer and sales order database access on the road.
• Field service—work orders, service order details, customer and equipment histories, and product information to service employees in the field.
• Telemetry—monitor and control remote equipment. (such as utility meters, vending machines, alarms, and office equipment).
• Transportation—dispatch and vehicle routing information to drivers, fleet managers, and customers.

Related products
Sierra Wireless AirCard® 300 Wireless Network Card; fits into any device with a standard Type II PCMCIA slot.

Sierra Wireless MP200 Modem; for rugged mobile and industrial applications.

Panasonic Toughbook - Contains an embedded CDPD wireless modem.

Future outlook
Since CDPD in its current state relies on the existing cellular infrastructure and customer bases and is so closely tied to the Internet, it is in a position to see continued use among carriers. CDPD’s premise—aligning Internet access with mobile data services—will also be carried into the future.
TDMA

**Full name**  Time Division Multiple Access  
**Category**  Multiple Access Method  

**History**

The cellular technology developed in the early 1980s was running out of capacity to meet all foreseeable demand—at least in certain high-traffic areas. Hence, carriers looked for new technologies to provide added capacity without requiring additional spectrum. The favored technologies are all digital—taking advantage of the impressive improvement in voice coder technologies and of some subtle RF design parameters (most notably resistance to co-channel interference) to provide superior capacity.

TDMA is one of these digital systems that was chosen as the technology of choice for 800 MHz cellular markets in North America (and 1.9 GHz markets) in 1989. The term TDMA covers a broad range of communications systems, including GSM, but in the context of this paper it will mean the North American based standard for cellular communications known as TIA standard IS-54 and derivatives thereof (IS-136).

**Technology**

TDMA is a simple technology to describe. A 30 kHz frequency slot allocated for use by a single analog voice channel is used to carry 48.6 kbps. This 48.6 kbps is divided into six time slots, each of which may be used for a single voice channel. With current voice coding technology, two such time slots are combined, so only three voice channels are supported and a 3-to-1 gain is immediately achieved.

As a digital multiple access technology, that can help provide greater capacity and quality on a wireless network, TDMA can be used with cellular networks at 800 MHz, using the same 30 kHz channels as analog AMPS (hence the occasional use of the term D-AMPS or Digital AMPS for TDMA). The protocol can also be used over personal communications services (PCS) networks at 1900 MHz. The following standards have already been defined for each:

- IS-54—original TDMA standard for 800 MHz digital cellular networks with no support for data.
- IS-136—evolved TDMA standard for both cellular and PCS systems in North America that introduced improved signaling and support for 9.6 kbps data transmission.
Data over TDMA

The IS-136 standard allows 9,600 bps to be carried in a pair of time slots. Two or three pairs of these can be concatenated to provide 19.2 kbps or 28.8 kbps.

Strengths

Increased Capacity  Using its multiple time slot technique, TDMA can increase user capacity over current analog cellular systems. The actual improvement depends on many factors, but the TDMA trade organization (UWCC) claims a 10-fold increase.

Adaptable for data  As a digital technology, it has the promise of providing data services with more re-use of common voice network and device components than analog cellular or digital CDPD.

Extended battery life  Since mobile TDMA devices are only transmitting a portion of the time (at specified time slots), batteries will last longer than is the case with analog.

Improved voice quality  Improvements in voice coder quality offer voice services of higher quality than analog.

Weaknesses

Bit rate  Since TDMA (like all digital cellular systems) is designed to carry digitized voice at below 10 kbps, it is not readily adaptable to carry higher speed data. Only by displacing several voice channels can higher data rates be obtained (such as three voice channels needing to be displaced to achieve 28.8 kbps data).

Hardware support  Hardware support is very limited for data over TDMA.

Related technologies

CDMA  Code Division Multiple Access: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in the U.S., it now has international deployment. Although CDMA is a generic technical term, it is used by convention to refer to the North American IS-95 standard and derivatives.

GSM  Global System for Mobile: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in Europe, but with significant international deployment.
**PCS**  Personal Communication Services: cellular-like system in the 1900 MHz range within North America and in the 1800 MHz range in Europe.

**Deployment**

35 countries were reported to be using TDMA in Q1 1999. The following link provides further TDMA details: www.3gAmericas.org

**Markets and applications**

TDMA supports voice, data, fax, and messaging services although it is currently mostly used for voice applications.

**Future outlook**

In February 1999 a new roadmap was announced to take TDMA from its present format to “3G” services. In order to provide high bandwidth the TDMA technology has to increase the band of transmission beyond 30 kHz, which limits the technology for future expansion. As such the alternatives are to implement new technology or migrate to GSM or CDMA. Most carriers have decided to migrate to GSM and deploy GPRS and then move to EDGE or 3G’s Wideband CDMA.
GSM

**Full name**  Global System for Mobile Communications  
**Category**  Digital Cellular System

**History**

In 1982, the European Conference of Post and Telecommunications Administrations (CEPT) began a study to develop a single cellular system for Europe. During the 1980s, numerous cellular networks, known as first generation analog networks, existed but all were incompatible with each other. Therefore, CEPT proposed a system that would provide good speech quality, low mobile station and service costs, ISDN compatibility, international roaming support, and additional value-added services. In 1991, limited GSM service began in Europe and by 1993 22 countries offered GSM service with over one million users. North America followed suit in 1995 with a service called “PCS 1900” (or GSM 1900). PCS 1900 uses GSM's normal Frequency and Time Division Multiple Access (FDMA/ TDMA), but operates in the 1900 MHz frequency band, whereas GSM in Europe operated originally in the 900 MHz band, but now also operates in the 1800 MHz frequency range.

Today GSM exists on every continent. As part of the international promotion of the technology, the letters “GSM” came to stand for “Global System for Mobile Communications” rather than the original acronym based on the CEPT sub-committee that developed it—the “Groupe Speciale Mobile”. GSM is commonly referred to as a second-generation mobile communications technology or 2G. The first generation was the original analog mobile communications technology, made up of multiple incompatible systems.

**Technology**

The GSM network may be considered as having three parts:

**Mobile Station (MS)**  This is the mobile equipment carried by the user (such as a phone) which includes the “Subscriber Identity Module“ (SIM). The SIM is the transferable module that gives the mobile station its identity and authentication credentials. An International Mobile Equipment Identity (IMEI) number provides a unique identity for the mobile equipment in much the same way as Network Interface Cards (or LAN Cards) are given unique identities with their MAC Address. The SIM card uses a unique International Mobile Subscriber Identity (IMSI) that makes the user known to the GSM network.
**Base Station (BS)** This controls the radio link to the Mobile Station and is the interface between the MS and the fixed network infrastructure. Base stations cover areas, called cells, from as small as a few hundred meters in diameter to several kilometers in diameter.

**Network** At the heart of the GSM network is the Mobile Switching Center (MSC), which handles all mobile user functionality including registration, authentication, call routing, and so on. The network also contains transmission lines (such as fiber optics, copper pairs, and microwave) to connect the base stations to the MSC as well as elements for billing, network management, and operations.

In Europe and in many non-European countries GSM was assigned the frequency range 890–960 MHz. The North American standard (PCS 1900) uses the frequencies 1850–1990 MHz. In both cases, 200 kHz separates each GSM carrier. A third standard, GSM 1800, is used for European PCS systems, operating in the frequencies 1710–1880 MHz.

Since the radio spectrum is limited, bandwidth within these ranges must be used as efficiently as possible, especially as subscriber numbers increase. GSM uses a combination of Time and Frequency Division Multiple Access (TDMA/FDMA) to accomplish this.

**Data over GSM**

There are four main data transmission options using GSM networks, each with different data transmission characteristics.

**Short Messaging Service (SMS)** Short Message Service, also commonly referred to as text messaging, is a service that supports the transmission of short messages to and from mobile devices. The service uses the Short Message Service Center (SMSC) as a hub to accept and forward messages to their destination. The SMSC also acts as a store and forward system, guaranteeing message delivery, where messages that cannot be immediately delivered to a mobile device because it may be out of coverage area or turned off, will be saved and sent later when the device is able to accept messages. SMS messages are sent over the voice control channels. Messages can be received simultaneously with a voice call and messages can be transmitted without activating a voice call or calling a specific number to submit the message into a server. Hence the sending and receiving of SMS messages is very convenient and very low cost. In many parts of the world, text messaging is a very popular form of personal communication.
Although designed more for short text messaging, carriers have developed gateway products that allow SMS to interface to standard applications. SMS is currently the major bearer service for data type messaging in GSM accounting for billions of messages sent each month. A variety of services have been introduced, including electronic mail and fax integration, paging integration, interactive banking, and information services such as stock quotes, sports scores, and news. Extensions to the SMS definition called Enhanced Message Service (EMS) allow for the transmission of longer messages and messages containing data other than text, such as sound and graphics. EMS is used to allow such services as the downloading of ringing tones or images (cartoon characters) to a handset.

**Circuit-Switched Data**  
GSM was the first digital standard to offer commercial circuit-switched data service. Connection options are provided to conventional analog V.xxx modems as well as to digital ISDN DTE equipment. Most offerings today use an adapter card to connect the end user’s computer to a GSM phone. GSM circuit-switched data speeds can reach 14.4 kbps. GSM circuit-switched data services are widely available in GSM networks.

To meet the demand for faster data communications, High Speed Circuit-Switched Data (HSCSD) has been developed to boost circuit-switched data service throughput up to 56 kbps and higher. HSCSD will allow data-intensive applications such as videoconferencing, emergency health services, and Web browsing. The biggest advantage to this high-speed development is that it does not require any changes to the existing GSM infrastructure. It does, however, involve changes to the radio link protocol. GSM divides each 200 kHz channel into eight time slots. In normal use, one time slot represents a voice channel. Where data is being carried, each time slot can carry up to 14.4 kbps. To go beyond this level requires the use of more than one time slot (more than one potential voice channel). In the case of HSCSD, up to four time slots are needed. Therefore, a carrier must recover the revenue lost from four voice subscribers if this service is offered.

Currently HSCSD has had limited deployment in Europe with service offerings from Vodafone, Orange, Telia, and SwissComm. One reason for the slow deployment of HSCSD is the view that other upcoming technologies such as GPRS, EDGE, or UMTS will provide the same or better service at a lower cost to the subscriber.

**Packet Data (GPRS)**  
All of the above addresses circuit-switched data. However, for many applications, a packet switched approach is preferred. A service called General
Packet Radio Service (GPRS) has been defined. GPRS offers packet connection at rates up to 14,400 bps (using only the equivalent of one voice channel) and going up to a theoretical user data rate of 115 kbps by displacing voice channels with data traffic. GSM with GPRS service is commonly referred to as 2.5G as it is part way to the service promised by 3G (UMTS) networks. A more detailed discussion of GPRS can be found in the following section on GPRS.

**EDGE** Enhanced Data rates for GSM Evolution (EDGE) is a comparatively recent development in GSM that offers a “2.5G” solution with superior spectral efficiency. Using a different modulation scheme from basic GSM, but operating over the existing GSM frequency spectrums, 800, 900, 1800, and 1900 MHz, EDGE offers up to 384 kbps in a 200 kHz bandwidth, and can be used for circuit-switched or GPRS packet services. (EDGE is sometimes referred to as a 3G technology as its high bandwidth rate of 384 kbps meets one of the requirements for 3G networks as defined by the ITU-T.)

**Strengths**

**Global Coverage** GSM is the world’s leading digital wireless technology with extensive coverage and subscriber bases. This allows carriers and hardware vendors to achieve economies of scale while at the same time providing subscribers with coverage almost anywhere they go, at least for wireless voice communications.

**Data services** GSM’s early circuit-switched data service is the only data option for digital cellular widely available commercially today, with some HSCSD services available. The Short Message Service is currently the most ubiquitous data service worldwide and is the most popular type of data service used by the general public to date. GPRS networks are currently available in Europe and North America and are offering public services. GPRS-enabled mobile handsets are available from all major manufacturers and PDAs with GPRS interface modules are being developed.

**Application options and roaming** GSM offers many value-added service options that subscribers can use anywhere thanks to global roaming capabilities. Roaming is not only available from one network to another but it is also available, in principle, between different GSM frequency ranges (i.e. GSM 900, 1800, 1900). The introduction of WAP browsers on GSM handsets made it possible to access Internet-like services from a mobile phone. With the introduction of GPRS the ability to access the Internet wirelessly will be greatly enhanced and should bring with it new data services for mobile users.
Security  Like any digital technology, voice services are more secure than over an analog cellular service. GSM offers encryption for voice and data transmissions with the result that over-the-air security has never been an issue for this technology.

Weaknesses

Transmission rate  The circuit-switched speeds of 14.4 kbps are possible, but many carriers only support 9.6 kbps today. Although the GPRS theoretical maximum user data rate is 115 kbps, realistic data rates are in the range of 53 kbps. Speeds between 20 and 40 kbps are likely in cells with moderate traffic, but GPRS services will be better and should be cheaper than existing circuit-switch data services.

Related technologies

CDMA  Code Division Multiple Access: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in the U.S., but has limited international deployment. Although CDMA is a generic technical term, it is used by convention to refer to the North American IS-95 standard and derivatives. CDMA has a number of packet services based on differing air interfaces. These are:
- CDMA IS-95a Low Speed Packet Data
- CDMA IS-95b Medium Data Rate
- CDMA2000 1xRTT High Speed Packet Data
- CDMA2000 3xRTT
- CDMA2000 1xEV-DO

TDMA  Time Division Multiple Access: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in the U.S., but with international deployment. Although TDMA is a generic technical term, it is used by convention to refer to the North American IS-54 standard and derivatives. It is a cellular-like system in the 1900 MHz range within North America, and in the 1800 MHz range in Europe.

UMTS  Universal Mobile Telecommunications System, also referred to as 3G, for third generation, is the next evolution for GSM networks. UMTS will work with the GSM infrastructure to allow GSM calls to be handed-off to UMTS networks and visa versa with no interruption of service to the users. UMTS exploits Wideband CDMA technology that allows a higher density of callers in a single cell and provides higher speed
data services than GSM. UMTS will also support a variety of multi-media services (text, music, video) essentially extending Internet-like services to 3G mobiles.

**Deployment**

As of October 2001, GSM exists on every continent (within four different frequency ranges) and GSM users can roam between 171 countries. There are an estimated 600 million GSM subscribers worldwide. Data services are provided with many GSM phones (in conjunction with adapter kits) and there are hundreds of devices and software applications that are GSM-compatible, creating the largest wireless digital data network today.

For news on GSM deployments worldwide see the GSM Association’s web site at:

www.gsmworld.com

For more information on GSM technology and future development in North and South America, see:

www.3gamericas.org/English/About_3G_Americas/

**Future outlook**

GSM’s global acceptance helps pave the way towards a promising future. Data communications over GSM networks is relatively new but with the development of such data communications technologies as HSCSD, GPRS, and EDGE, GSM will be a viable option for more wireless data communication applications.

Looking a little further out UMTS networks may begin to appear in the 2003/4 timeframe in high density markets where capacity problems for both voice and data users are present.

**Related links**

www.gsmworld.com/ — GSM Association’s Web site, the association behind the GSM specifications worldwide.

www.umts-forum.org/ — UMTS forum

www.etsi.org/3gpp/ — ETSI (the European Telecommunications Standards Institute) an organization that produces European telecommunications standards
GPRS

**Full name**  General Packet Radio Service  
**Category**  Digital Cellular System

**History**  
In 1991 the Deutsche Bundespost presented the first proposal for the General Packet Radio Service to ETSI. The idea for a packet service over GSM originated out of a European Union research project. Coincidental with the development of GPRS specifications was the popularization of the Internet. In the early to mid-1990s the Internet became a household term and the cell phone became commonplace. As these two technologies were widely adopted it became obvious that a melding of cellular technology with the Internet was the next advancement. GSM/GPRS and similar data over wireless wide area network technologies would be the point where the cellular and Internet networks would intersect making the Internet mobile.

**Technology**  
GPRS overlays a data packet network on to the existing GSM voice frequencies and timeslots (channels), allocating some of the channels for packet data transmissions on request by a user and freeing those channels when they are not required. Thus GPRS behaves like a connectionless packet data network. Resources are allocated to transport packets as they arrive in the network and are freed immediately after the packet has been forwarded to its destination. This dynamic allocation of resources is especially useful for wireless networks where radio frequencies are scarce and must be shared among a population of users for voice and data traffic.

GPRS supports the Internet Protocol (IP) for user data traffic. In addition to the dynamic allocation of resources GPRS also offers higher data throughput speeds than GSM circuit-switched data rates of 9.6 kbps to 14.4 kbps. GPRS offers a maximum user data rate of over 115 kbps (theoretical maximum of 171 kbps) if all eight timeslots in a cell are allocated for data transmission, (one timeslot can provide between 9 and 21 kbps). In reality this would not normally occur since it would use all of the resources on one cell. As well, no devices exist that support 8 timeslots. It is estimated that a realistic and consistent user data throughput rate of 26.8–53.6 kbps (2–4 channels at 13.4 kbps per channel) is expected, with 56 kbps possible under good conditions.
In order for GPRS to be implemented, there are two new network elements required. These are the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN).

To connect the SGSN and GGSN into the existing GSM infrastructure, software modifications are required on the Mobile Switching Center (MSC), and Base Stations Sub-system (BSS). The following diagram is simplified overview of the GSM/GPRS infrastructure interconnections.

**Strengths**

**IP connectivity** GPRS brings IP connectivity to mobile devices. Connectivity to the Internet implies—at least in theory—that any service available on the Internet will be accessible from a mobile device. Limitations of the mobile device such as screen size, battery life, and GPRS data throughput speed will make accessing some types of Internet content difficult. Despite these limitations, most of the common Internet services like e-mail, e-commerce, and information lookup will all be available to a GPRS enabled mobile device.

**Packet data** The “bursty” nature of Internet traffic is well suited to a packet data solution like GPRS. For example web browsing usually involves the user submitting a request for a web page and then waiting for the answer. While waiting for the response, this latency in the network would leave the allocated timeslot unused if the transaction was occurring over a circuit-switched connection. In GPRS the unused timeslots can be used to carry data traffic from other users in the same
cell. Packet data over the cellular network allows for a greater number of users to share the limited frequencies available for data and voice traffic. This leads to the ability of the network to support more users and thus the cost of the infrastructure per user is defrayed leading to a cheaper service offering than if the same service were offered over circuit-switched data connections.

“Always on” ability  The always-on always-connected nature of IP allows for data traffic to be sent to the user while the user is not actively looking for the data. An example is e-mail. Once connected to an e-mail server the server can download to the GPRS enable laptop or Personal Digital Assistant any incoming e-mail. The user would only receive notice of the newly arrived message once it has been completely received on the laptop. There exists a class of applications where unsolicited data traffic can be pushed to a mobile device, only notifying the user once the complete message has arrived. This opens up an entire range of services from location based advertising, to personal messaging, to stock tracking, and so on, with varying business models serving a wide range of users.

Weaknesses

Bandwidth restrictions  One of the obvious limiting factors of GPRS is the available bandwidth. Common Internet applications such as e-mail will work well over GPRS, but more advanced services such as streaming video/audio, and videoconferencing will only work to a certain degree over GPRS.

Quality of service  A second factor to be aware of with GPRS is that there is no guaranteed quality of service for a given connection. This is not a problem for applications that do not require guaranteed packet delivery within a specified delay, but for an application such as Voice over IP, this becomes an issue that can impact the quality of the service received by the user.

Related technologies

CDMA  Code Division Multiple Access: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in the U.S., but with international deployment.

EDGE  see GSM

UMTS  see GSM
Deployment

GPRS has been widely deployed in Europe during 2001 and is rolling out in North America among the PCS-1900 carriers in 2001/2.

Markets and applications

Apart from the always-on always-connected and Internet access discussed above, there are a number of services being developed for GPRS and the wireless Internet in general that will add a new dimension to mobile data. One of the inherent capabilities of the mobile device is that its location must always be known by the network in order to maintain connectivity. Service providers can create ingenious services to exploit this location information. One obvious service is location specific directed content, such as “find me all the Italian restaurants within a half kilometer of my current location”.

A user’s presence on the network is another area currently being examined. If a user registers on the network, other users or servers on the network can be made aware of their presence. This could be useful for instant messaging services and can be especially useful for long distance communication where the time differences are significant.

Personalization of services through user profiles is another area being studied. With the information overload available today users can set up filters and customize the types of information they wish to receive or not receive on their mobile devices.

Related products

Sierra Wireless AirCard® 710/750 Wireless PC Cards; fits into any device with a standard Type II PCMCIA slot.

Future outlook

GPRS will be the first globally implemented wireless packet data technology. From a business perspective, the deployment of GPRS will remove any coverage and interoperability issues surrounding wireless data.

From a technical perspective GPRS lays the foundation for higher speed wireless data technologies such as EDGE and 3G. These high-speed technologies will address the technical
issues of bandwidth and quality of service. With these problems solved the creation and delivery of multimedia services to mobile users will be possible.

**Further information**

*GSM and UMTS: The Creation of Global Mobile Communication*

Friedhelm Hillebrand (Editor)
Hardcover 590 Pages
November 2001

**Related links**

www.gsmworld.com/ — GSM Association's Web site - association behind the GSM specifications world-wide

www.3gamericas.org/English/About_3G_Americas/ — More information on GSM technology and future development in North and South America
CDMA

**Full name**  Code Division Multiple Access

**Category**  Digital technology for increasing user capacity

**History**

Originally developed by the US military, CDMA is one of the digital technologies developed to provide added capacity without requiring more spectrum. Introduced in a trial state in 1991, the first commercial CDMA service was launched in Hong Kong. Since then, CDMA has become one of the two preferred technologies used in North America and elsewhere outside of Europe.

**Technology**

CDMA allows multiple users to more efficiently share the same radio spectrum. Instead of dividing RF spectrum into narrow channels (30 kHz each) and assigning one (AMPS) or more (IS-136 TDMA) conversations to each channel, CDMA spreads many conversations over a broad spectrum (1.25 MHz in the case of North American CDMA standard IS-95).

To separate a particular call from the other calls using the same spectrum at the same time, a unique digital code called a “Pseudo-Random Code Sequence” (PRCS) is assigned to each user. Many users share the same spectrum, each using their unique code, and decoders separate the codes at each end in a process exactly like a tuner that separates different frequencies in more conventional systems.

**Data over CDMA**

CDMA specifications provide for three types of data services: short message service (SMS), circuit switched data, and packet switched data.

SMS provides two-way pager-like functionality, allowing short text messages to be sent, received, and acknowledged. Circuit-switched data allows dial-up modem connections over the cellular network. Circuit-switched support is initially available at speeds up to 14.4 kbps.

Packet-switched data provides Internet Protocol connectivity. It was initially available at speeds of 14.4 kbps (CDMA IS-95A), but has increased to a maximum of 153 kbps as
carriers have implemented the CDMA2000 1X (1xRTT) network. IS-95B can transfer packet data at 64 kbps (this is known as medium-data-rate (MDR)).

CDMA has a number of Packet services based on differing air interfaces. These are:

- CDMA IS-95A Low Speed Packet Data
- CDMA IS-95B Medium Data Rate
- CDMA2000 1xRTT High Speed Packet Data
- CDMA2000 3xRTT
- CDMA2000 1xEV-DO

From an end user perspective, the noticeable difference between CDMA IS-95 and CDMA2000 1X are features such as speed and voice support. CDMA2000 1X is a 3G technology that offers both voice and data capabilities.

**Strengths**

**Increased capacity and speeds** Using a combination of voice coder technology and an improved resistance to interference that allows the same frequencies to be re-used more often than in analog systems, CDMA offers increased voice capacity over analog. This also gives it the advantage of being able to have higher throughput speeds than other systems.

**Low power** The properties of spread spectrum permit signals to be transmitted at lower power than analog signals for similar performance—hence devices should have longer battery lives than analog. This is particularly true for voice services.

**Security** CDMA offers two levels of security. To the network operator it includes encryption to prevent fraudulent “cloning” of phones. To the user, the complexity of the pseudo random code sequence makes casual eavesdropping very difficult.

**Easy addition of new functions** The implementation of CDMA allows many new features to be added (often as software upgrades are done to the switch) including the different forms of data supported. It is one of the advantages of CDMA that it requires very little additional equipment to add new services.

**Network availability** There is very good coverage of most of North America for CDMA. Where CDMA2000 1X service is not available, there is almost always CDMA IS-95 service available. CDMA 1xRTT devices are backwards compatible.
with CDMA IS-95 technology, allowing the user to access the 1xRTT network where available, and fall back to the IS-95 network where there is no 1xRTT coverage.

**Weaknesses**

**Global availability**  CDMA is still not available globally. Outside of North America and Asia Pacific regions (such as China, Korea, Australia, New Zealand, and Japan), coverage is fairly limited.

**Related technologies**

**TDMA**  Time Division Multiple Access: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in the U.S., but with international deployment. Although TDMA is a generic technical term, it is used by convention to refer to the North American IS-136 standard and derivatives.

**GSM**  Global System for Mobile: another digital cellular technology for providing greater user capacity than is available with analog technology. Developed in Europe, but with significant international deployment.

**PCS**  Personal Communication Services: cellular-like system in the 1900 MHz range within North America and in the 1800 MHz range in Europe.

**CDMA2000 1xEV-DO**  An evolution of CDMA2000, this “data optimized” version is also an approved 3G standard. 1xEV-DO provides peak data rates of up 2.4 Mbps in a standard 1.25 MHz CDMA channel.

**UMTS**  Also known as WCDMA (Wideband CDMA) is an approved 3G standard which utilizes one 5 MHz channel for both voice and data, offering data speeds up to 2 Mbps.

**Deployment**

CDMA is largely a North American technology that has been adopted by several other non-European countries, and competes for global leadership with GSM—a European technology that has also been adopted by several other non-European countries. Currently GSM has a substantial lead in global deployment.

Most North American carriers have deployed circuit-switched CDMA with QuickNet Connect, fax services at speeds up to 14.4 kbps, and short messaging service (SMS). In May 1999 a new standard was introduced, commonly referred to as 1xRTT
or CDMA2000 1X, that offers a 153 kbps service. Although less mature as a standard than IS-95B, most carriers have skipped IS-95B and gone straight to CDMA2000 1X as their next offering; positioning it as a 3G service.

**Markets and applications**

Primarily a voice service, the market for CDMA is anywhere where there is a need for cellular voice services. Its main advantage is to the carrier, by offering more capacity and lower cost per user. To the user, the advantages are better voice quality and handsets with longer battery life.

Secondary services include the data services discussed above as well as simpler short messaging services. The traditional “vertical” markets that use wireless data today can use the data services offered by CDMA. In addition, several vendors are promoting the use of the “SmartPhone” concept where the phone itself is the data terminal. This seems to have some appeal for the casual data user, and integration with short messaging service and simple displays on the phone provide some “horizontal” market appeal.

**Related products and companies**

Sierra Wireless AirCard® 510 Wireless Network Card; fits into any device with a standard Type II PCMCIA slot. Compatible with the CDMA IS95 technology.

Sierra Wireless AirCard® 555 CDMA2000 1X Wireless network card; fits into any device with a standard Type II PCMCIA slot. Compatible with the CDMA 1xRTT and IS-95 technologies.

Audiovox® Thera Handheld Pocket PC with Built-In CDMA Phone; contains an embedded wireless CDMA modem, compatible with the CDMA2000 1X and IS-95 technologies.

**Related links**

[www.cdg.org/](http://www.cdg.org/) — CDMA Development Group

[www.qualcomm.com/](http://www.qualcomm.com/) — Qualcomm, the licensor of CDMA technology
Bluetooth

Bluetooth wireless technology is a global specification for low power, short-range, two-way wireless communication. Bluetooth is essentially a cable-replacement technology allowing wireless data communications at ranges of about 10 meters. It is a cross between the DECT (Digital European Cordless Telephone) and iRDA (infra Red Data Association) technologies. Bluetooth is sometimes referred to as a Wireless PAN (personal area network).

Conceived initially by Ericsson, Bluetooth is a standard for a small radio chip that can be plugged into computers, printers, mobile phones, and so on. A device with Bluetooth wireless technology enables data, images, sound, video, and remote control commands to be wirelessly exchanged with any other Bluetooth device.

Using Bluetooth does not involve mobile network fees—its spectrum is in the unlicensed spectrum area (at 2.45 GHz). Data transmission speeds using Bluetooth are expected to be between 720 kbps and 1 Mbps.

Applications of Bluetooth technology are devices such as a headset that communicates with a mobile phone, or paying electronically for movie tickets, parking meters, and so on.

Bluetooth has not yet lived up to its hype, due to delays in getting the cost of Bluetooth devices down to a level where they become a reasonable alternative to cables.

The name “Bluetooth” comes from a 10th century Viking, Harald Blåtand (which translates to “Bluetooth” in English) who united Denmark and Norway. This is the inspiration for “uniting devices through Bluetooth”.

For more information, visit www.bluetooth.com
WLAN

A wireless LAN lets users roam around a building with a computer (equipped with a wireless LAN card) and stay connected to their network without being connected to a wire. The standard for WLANs put out by the Institute of Electrical and Electronics Engineers (IEEE) called “802.11B” or “Wi-Fi” is making WLAN use faster and easier. A WLAN can reach 150 m radius indoors and 300 m outdoors. WLANs require a wired access point that connects all the wireless devices into the wired network.

802.11B transfers data at speeds of up to 11 Mbps in the 2.4 GHz radio band (a license is not required for this band). The next version, 802.11A, is supposed to transfer data at even higher speeds of up to 54 Mbps in the 5 GHz band.

WLANs are used on college campuses, in office buildings, or in houses, allowing multiple users access to one Internet connection. Some airports also plan to offer WLAN access (some already do). Starbucks® coffee shops are beginning to equip their coffee shops with WLANs, which will allow laptop users to connect to the Internet in some of their stores.

One drawback in WLANs is the lack of security. A research group at the University of California at Berkeley put out a report stating that they had found flaws in the 802.11 standard. They were able to intercept transmissions over the wireless network and broke the encrypted transmissions.

Another problem is overcrowding of the bandwidth. Too many people or businesses using WLANs in the same area, can overcrowd the frequency band that they are transmitting on. Problems with signal interference are already occurring and there are fears that the airwaves may become overloaded. There is also some confusion coming with 2 new, incompatible, higher speed standards (one in a different frequency band and both use different RF modulation).

Despite these drawbacks, WLANs are a successful and popular technology, which are widespread and being incorporated into many new laptops.