# GPRS TECHNOLOGY OVERVIEW

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Wireless wide area cellular network solutions have been around for many years. Widespread adoption has been slow due to issues with coverage, cost, performance, and secure remote access to business networks. The deployment of the Global System for Mobile Communications (GSM)-based General Packet Radio Service (GPRS) has the potential to change this situation and to provide connectivity "anytime and anywhere."

GPRS is a packet-based radio service that enables "always on" connections, eliminating repetitive and time-consuming dial-up connections. It will also provide real throughput in excess of 40 Kbps, about the same speed as an excellent landline analog modem connection.

This white paper reviews the underlying GSM circuit-switched technology, then discusses the packet-data capabilities added by GPRS. The paper also identifies some GPRS solutions that will be helpful in business environments, including notebook computer solutions, methods for accessing business networks via GPRS, and new middleware solutions that address wireless deficiencies and application performance issues.

## GSM Background

Wide-area[1] cellular networks have enjoyed phenomenal growth worldwide since they were first deployed in the early 1980s, and this growth is expected to continue. Already, in a number of countries, wireless users outnumber wired landline phone users. Today, most use the wide-area wireless networks for voice calls on cell phones, but there is a growing trend in nonvoice data and messaging applications such as the short message service (SMS).

There are several major second-generation (or 2G) digital cellular standards used throughout the world. The most widespread are GSM, the Code Division Multiple Access (CDMA) standard called cdmaOne, Time Division Multiple Access (TDMA), and Personal Digital Communications (PDC) used mainly in Japan. Over the next few years, there will be a transition to 2.5G and 3G technologies that, in addition to voice services, will add support for "always on" packet data access and, eventually, new multimedia types of wireless service. In some countries such as the U.S., there is a complementary trend to deploy localized wireless local area networks (WLANs) in public places such as hotels, airports, and cafes. These wireless LANs allow users to access the Internet and intranets through broadband service providers.

More than two out of three digital cellular subscribers worldwide connect using GSM, making GSM the dominant worldwide standard. Additionally, a number of major North American TDMA service providers have decided to deploy GSM/GPRS overlays, rather than continuing on a separate and unique evolution path towards 3G networks. Figure 1 shows the evolution paths of current technologies to 2.5G and 3G.

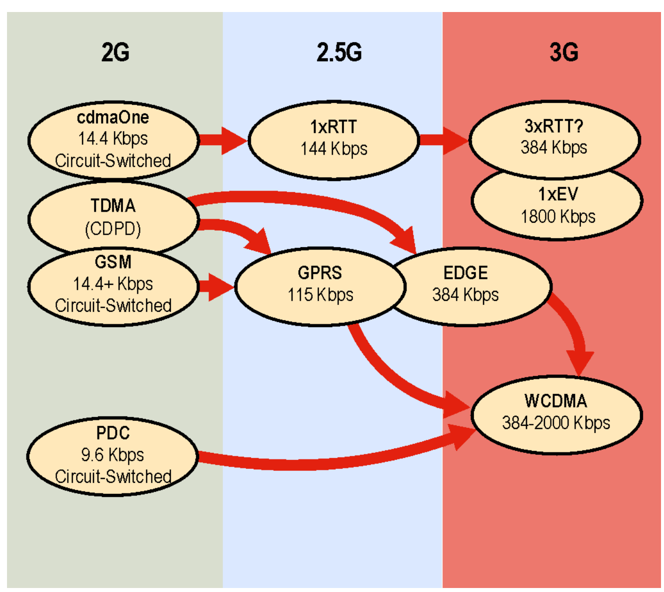


**Figure 1. Wide-Area Cellular Network Evolution to 3G**

1. In this context, "wide area" refers to wireless networks that offer broad metropolitan, regional, or national coverage, both indoors and outdoors.

The ARC Group forecasts that by the end of 2003, GPRS will account for 68 percent (or approximately 138 million) of the worldwide mobile data subscribers. By the end of 2006, GPRS worldwide subscribers are forecast to grow to almost 600 million.[2]

## GSM Network Overview

At a high level, GSM is a mobile telephony network based on the cellular concept. Users can place and receive calls without being fixed to a specific location or wired to a physical connection. To supply this capability, a GSM network consists of three basic components:

- **Subscriber Terminal Devices** — Today, these devices are typically cell phones, but there are other devices such as personal digital assistants (PDAs) with various input/output capabilities. All have integrated radio transceivers.
- **Radio Base Station Network** — Cellular networks are composed of small, low-powered, terrestrial radio cells that typically range in coverage area from tens of kilometers in sparsely populated rural areas to less than 500 meters in densely populated urban areas. The frequencies used by the network are reused again and again in different cells throughout the network to increase network capacity.
- **Network Switching and Services Infrastructure** — The traffic to and from the radio network is concentrated at a set of switching nodes that interface to other fixed public or private networks. These nodes handle the call setup, channel resource allocation, and the administration of subscriber services.

These components allow the GSM network to provide coverage as a user moves from an area covered by one cell to an area covered by another cell. The network terminates the old cell connection and immediately establishes a new cell connection. This process is designed to be transparent to the user.

In addition, users can “roam” or travel outside of a “home” coverage area to a new city, region, or country. The arrival of the visitor is detected by the new system through an automatic registration process. The new system informs the user's home system of the new location so that calls can be delivered.

## GSM Technology Characteristics

The GSM radio technology is based on 200-kHz wide radio channels with a gross data rate of 270 Kbps. Each radio channel is divided into eight time slots using TDMA. Several users can efficiently share these radio channels. Separate radio channels are used from the mobile devices to the network and the network to the mobile devices through the frequency division duplex (FDD) technique. In GSM, voice calls are supported by sampling the user’s voice and compressing the data using digital encoding algorithms.

GSM is currently defined for three major frequency bands, including blocks of radio spectrum within the 900-, 1800-, and 1900-MHz bands. The 900- and 1800-MHz bands are the principal bands used in Europe and Asia, and the 1900-MHz band is used in North America. North American TDMA operators are also considering the deployment of GSM within the 850-MHz band as well. The 450-MHz band is used in some Eastern European countries. There are terminal devices that support multiple bands, allowing them to operate in different countries and networks.

## GSM Data Services

Today, in addition to circuit-switched voice services, GSM supports the following data services:

- **Circuit-Switched Data** — A GSM circuit-switched data call is similar to a landline modem dial-up call. A dedicated connection is set up for the duration of the call, regardless of whether data is being transferred. The data throughput rate is 9.6 or 14.4 Kbps, depending on the coding scheme supported by the network and terminal device. Support for high-speed circuit-switched data services (HSCSD) was recently added. HSCSD can support the concatenation of multiple time slots for data rates of up to 38 Kbps.
- **SMS** — GSM also supports sending and receiving short text messages (approximately 160 characters) known as SMS on a signaling channel. SMS is widely popular for person-to-person messaging, pushing

2. ARC Group, **www.arcgroup.com**

stock quotes and sports scores, and so forth. Billions of these messages are sent per month and the numbers are growing.

The circuit-switched services provided by the GSM technology are augmented by packet-switched services provided by the GPRS overlay.

## What is GPRS?

GPRS is a packet data overlay onto existing GSM networks. As a global standard, it is expected to be widely deployed on GSM networks. Figure 2 depicts a simplified GPRS network.

### New End User Devices

New terminal devices are required to take advantage of GPRS. The new devices will range from cell phones to PDAs to PC Card modems. Some will support simultaneous connections to packet- and circuit-switched services, and others, nonsimultaneous connections. Still others will only support the new packet data services.

### Upgraded Radio Base Station Network

GPRS requires an upgrade to the GSM radio network, known as the Base Station Subsystem (BSS). This normally includes a software upgrade to the radio transceivers and base station control nodes. In addition, a new hardware unit called a Packet Control Unit (PCU) is typically added to the BSS to manage the packet data transfer between user devices and the GPRS core network. The PCU also supports data frame retransmission and other specific GPRS protocol functions.

### New GPRS Support Nodes

To efficiently handle packet data, GPRS adds two new components to the network: the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). These nodes interact with the Home Location Register (HLR) node to obtain subscriber profile and authentication information.

The SGSN is connected directly to the base station network and controls access, tracks user mobility, and implements various security functions. The GGSN is a gateway to external data networks and provides services such as authenticating external network access, quality of service (QoS), and tunneling. External networks may include the Internet, private intranets, or legacy X.25 networks. The GGSN also supports roaming by routing incoming traffic to the appropriate SGSN where the user is located.

## How Does GPRS Work?

When a user turns on a GPRS device, typically it will automatically scan for a local GPRS channel. If an appropriate channel is detected, the device will attempt to attach to the network. The SGSN receives the attach request, fetches subscriber profile information from the subscriber’s HLR node, and authenticates the user. Ciphering may be established at this point.

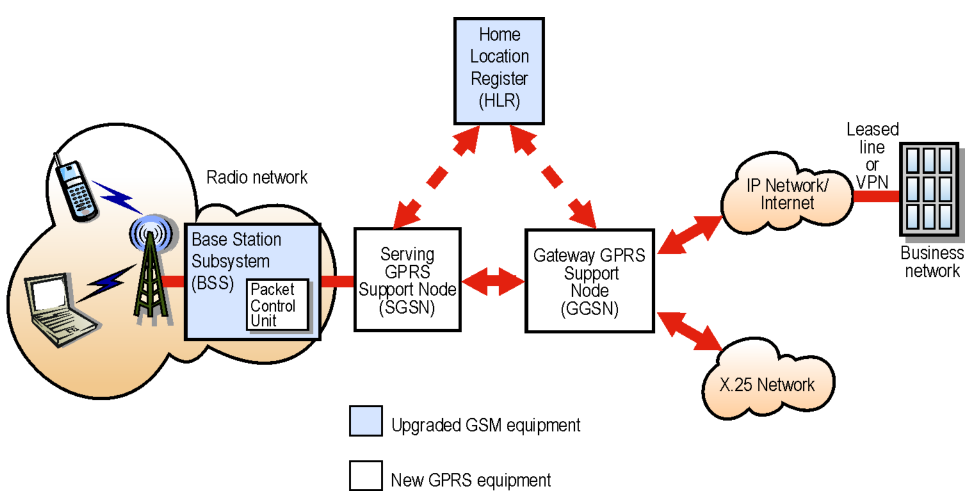


**Figure 2: GPRS Network**

The SGSN uses the profile information (including the access-point name, which identifies the network and operator) to determine which GGSN to route to. The selected gateway may perform a Remote Authentication Dial-In User Service (RADIUS) authentication and allocate a dynamic Internet Protocol (IP) address to the user before setting up connections to outside networks. This process is called the "packet data profile context activation" and the setup may vary from one carrier to the next. It may include additional functions like QoS management and virtual private network (VPN) tunnel management.

When the mobile device is powered off or moved out of a GPRS coverage area, its context is deactivated and the device is detached from the network.

### Sending and Receiving Packets

When the mobile user sends data, the SGSN routes the packets to the appropriate GGSN. The GGSN then routes the data according to the current "context" established for the session.

Conversely, packets destined for the user are routed to the GGSN associated with the user's IP address. The GGSN checks the received packets against the current context, identifies the SGSN that is serving the user, and routes the traffic accordingly. The SGSN then forwards the packets to the BSS where the subscriber is located.

## Advantages of GPRS

GPRS provides faster data transfer rates, "always on" connection, robust connectivity, broad application support, and strong security mechanisms.

### Faster Data Transfer Rates

GPRS currently supports an average data rate of 115 Kbps, but this speed is only achieved by dedicating all eight time slots to GPRS.[3] Instead, carriers and terminal devices will typically be configured to handle a specific number of time slots for upstream and downstream data. For example, a GPRS device might be set to handle a maximum of four slots downstream and two slots upstream. Under good radio conditions, this yields speeds of approximately 50 Kbps downstream and 20 Kbps upstream. This is more than three times faster than current 14.4-Kbps GSM networks and roughly equivalent to a good landline analog modem connection.

The aggregate cell site bandwidth is shared by voice and data traffic. GPRS operators will vary in how they allocate the bandwidth. Typically, they will configure the networks to give precedence to voice traffic; some may dedicate time slots to data traffic to ensure a minimum level of service during busy voice traffic periods. Unused voice capacity may be dynamically reallocated to data traffic.

With its faster data transfer rates, GPRS enables higher-bandwidth applications not currently feasible on a GSM network. The following table compares the performance of typical user applications over a 9.6-Kbps GSM network and a 56-Kbps GPRS network.

| | Data Transfer Time (in Seconds) | |
|---|---|---|
| | GSM (9.6 Kbps) | GPRS (56 Kbps) |
| E-mail | 25 | 4 |
| Web page | 42 | 7 |
| Photo | 83 | 14 |
| Microsoft® Word document | 250 | 43 |
| Microsoft PowerPoint® document | 833 | 143 |
| Audio clip | 1,667 | 286 |
| Video clip | 3,333 | 571 |

### Always-On Connection

An "always on" connection eliminates the lengthy delays required to reconnect to the network to send and receive data. Information can also be pushed to the end user in real time.

GPRS allows providers to bill by the packet, rather than by the minute, thus enabling cost-effective "always on" subscriber services.

### Robust Connectivity

GPRS improves data transmission integrity with a number of mechanisms. First, user data is encoded with redundancies that improve its resistance to adverse radio conditions. The amount of coding redundancy can

3. The GPRS maximum theoretical data rate under perfect radio conditions is 171 Kbps. This rate requires that all eight time slots be dedicated to GPRS and that the data be encoded using the currently unsupported CS4 coding scheme. (See "Robust Connectivity" for a brief discussion of GPRS coding schemes.)

be varied, depending on radio conditions. GPRS has defined four coding schemes—CS1 through CS4. Initially, only CS1 and CS2 will be supported, which allows approximately 9 and 13 Kbps in each time slot.

If an error is detected in a frame received in the BSS, the frame may be repeatedly retransmitted until properly received before passing it on to the GPRS core network.

### Broad Application Support

Like the Internet, GPRS is based on packet-switched data. This means that all native IP applications, such as e-mail, Web access, instant messaging, and file transfers can run over GPRS. In addition, its faster data transfer rates enable GPRS to accommodate higher-bandwidth applications (such as multimedia Web content) not suited to slower GSM dial-up connections. GPRS is particularly well suited for applications based on the Wireless Application Protocol (WAP). WAP has gained widespread acceptance in a new breed of microbrowser-enabled phones.

### Security Support

GPRS builds on the proven authentication and security model used by GSM. At session initiation, a user is authenticated using secret information contained on a smart card called a Subscriber Identity Module (SIM). Authentication data is exchanged and validated with records stored in the HLR network node. GPRS enables additional authentication using protocols such as RADIUS before the subscriber is allowed access to the Internet or corporate data networks.

GPRS supports the ciphering of user data across the wireless interface from the mobile terminal to the SGSN. In addition, higher-level, end-to-end VPN encryption may take place when a user connects to a private corporate network.

## Implementing GPRS in a Business Network

In business environments, GPRS support for notebook computers, methods of accessing the business network, and application performance are key considerations.

### GPRS Notebook Solutions

GPRS allows a notebook computer user to connect to a GPRS network using a cell phone or a GPRS-enabled notebook.

- **Notebook Connection Using Cell Phone** — In this scenario, the user tethers the notebook to a GPRS-capable cell phone, which acts as an external wireless modem. The connection may be a physical cable, infrared (IrDA), or the emerging Bluetooth™ short-range wireless personal area networking standard.
- **GPRS-Enabled Notebook** — Another approach is to move the GPRS capability into the notebook, either in the form of a PC Card modem or, when practical, an integrated solution. In contrast to the cell phone approach, this approach provides the “always on” connectivity possible with GPRS. The modem can be configured to connect and remain connected to the GPRS network whenever the notebook is powered on.

### Corporate Access Using GPRS

In addition to accessing the Internet and specific operator-supplied content, business GPRS users will want to connect securely and efficiently to their corporate networks. There are two key ways, depicted in Figure 3, to wirelessly access these private networks:

- **Direct Enterprise Network Connection** — This method relies on a direct secure connection from the “home” GSM/GPRS network to the enterprise. The physical connection may be a leased telecom E1/T1 trunk facility with a permanent virtual circuit (such as Frame Relay) that supports the aggregation (or multiplexing) of data traffic from many GPRS users.
- **Internet-Based Connection** — This approach relies on the public Internet to transfer data traffic between a GPRS user and a private corporate network. To enhance security, VPNs may be employed. Beginning with an Internet connection, the user establishes a secure VPN “tunnel” over the Internet to the private network. GPRS traffic is encrypted by client software on the notebook and sent over the secure VPN tunnel to the corporate network. The tunnel terminates at a VPN server that authenticates the user into the corporate intranet.

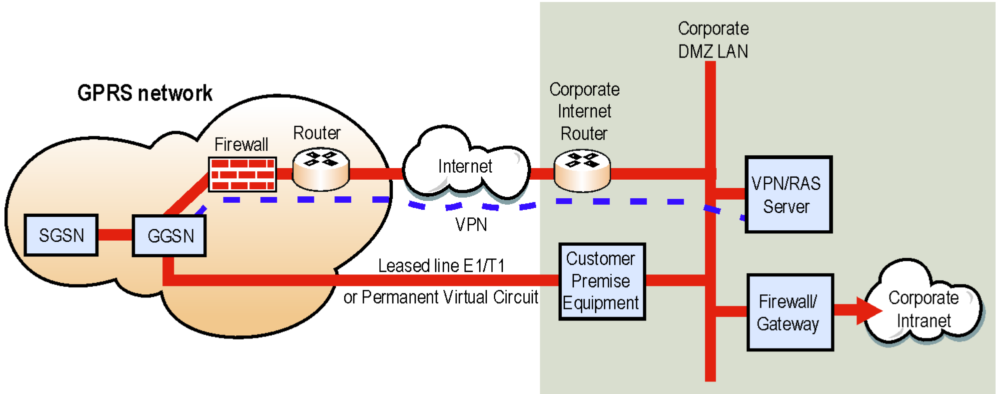


**Figure 3. Accessing the Corporate Network Via Direct Enterprise Network Connection or Internet-Based VPN Connection**

Similarly, traffic from the VPN server to the client notebook is also encrypted.

### Optimizing Application Performance

GPRS performance will vary, depending on factors such as GPRS network, subscriber device, and current radio conditions. As radio conditions deteriorate (for example, near the edge of a cell), the network compensates by decreasing throughput, which increases latency. Many, but not all, software applications have been designed to tolerate these varying data rates. In particular, many TCP/IP applications such as corporate e-mail (for example, Microsoft Exchange) are designed for reliable, "fixed-line" connections, and may not work well when used over wireless networks.

To address this issue, optimization software has been introduced by a number of companies. This layer of software between the network and applications, often referred to as middleware, dramatically improves the robustness, efficiency, and speed of data transmission over wireless networks. Currently, optimization solutions for accessing Web and corporate e-mail systems eliminate unnecessary protocol handshakes, compress application data, and give the user more control over downloads. Filtering techniques allow mobile users to select only the content that they need to access while traveling. Middleware can also allow users to maintain the connection while moving between coverage areas.

## 3G: The Next Step

GPRS represents the first major step toward a new era of anywhere, anytime connectivity. Beyond GPRS, the industry is beginning to focus on 3G networks that build on 2.5G networks to eventually provide higher capacity and data rates, and to support future multimedia services. Key 3G technologies include:

- **Enhanced Data Rates for GPRS Evolution (EDGE)** — Increases the data rates for a GPRS network up to approximately 384 Kbps per radio channel.
- **Wideband CDMA (WCDMA)** — Uses a 5-MHz CDMA radio channel to support theoretical data rates of up to 2 Mbps. WCDMA is expected to be the dominant 3G standard and will be globally deployed in conjunction with GSM/GPRS networks.
- **Cdma2000** — Supports higher 3G data rates with the introduction of a 2.4-Mbps overlay called 1xEV, which is likely to be deployed in the U.S. and in parts of Asia.

Wide-scale deployment of these networks is expected to begin over the next few years.

## Dell GPRS Solution

Dell is committed to providing competitive wireless networking solutions, both WLAN and WWAN, for Latitude™ and Inspiron™ notebook computers. This includes a complete end-to-end GPRS business solution implemented with leading GPRS network operators and integrators. The initial offering, available in the United Kingdom, will include the following elements:

- Dell™ Latitude or Inspiron notebook
- Dell TrueMobile™ GPRS PC Card
- Factory-installed software drivers and utilities
- GPRS carrier access with service-ready SIM card
- Wireless middleware optimization software for Microsoft Exchange and Web access
- Integration services

The integration services are a key component. They include helping an IT organization to perform needs assessments, configure corporate infrastructure, install middleware to improve performance, and providing an ongoing service contract. As the GPRS market matures, Dell will expand these services to include other wireless technologies and markets.

## For More Information

- An upcoming (Spring 2002) Dell white paper discusses, in more detail, GPRS deployments in enterprise networks. See **www.dell.com/r&d**.
- **www.mobilewhitepapers.com/pdf/gprs.pdf**
- **www.gsmworld.com**
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