GPRS White Paper

1 Introduction

The General Packet Radio System (GPRS) is a new service that provides actual packet radio access for mobile Global System for Mobile Communications (GSM) and time-division multiple access (TDMA) users. The main benefits of GPRS are that it reserves radio resources only when there is data to send and it reduces reliance on traditional circuit-switched network elements. The increased functionality of GPRS will decrease the incremental cost to provide data services, an occurrence that will, in turn, increase the penetration of data services among consumer and business users. In addition, GPRS will allow improved quality of data services as measured in terms of reliability, response time, and features supported. The unique applications that will be developed with GPRS will appeal to a broad base of mobile subscribers and allow operators to differentiate their services. These new services will increase capacity requirements on the radio and base-station subsystem resources. One method GPRS uses to alleviate the capacity impacts is sharing the same radio resource among all mobile stations in a cell, providing effective use of the scarce resources. In addition, new core network elements will be deployed to support the high burstiness of data services more efficiently.

In addition to providing new services for today's mobile user, GPRS is important as a migration step toward third-generation (3G) networks. GPRS will allow network operators to implement an IP-based core architecture for data applications, which will continue to be used and expanded upon for 3G services for integrated voice and data applications. In addition, GPRS will prove a testing and development area for new services and applications, which will also be used in the development of 3G services.

1.1 Market Overview

To understand the market potential of GPRS, it is important to understand the penetration of GSM, its underlying technology. GSM is the most prominent digital cellular standard in the world. Figure 1 shows the current and forecast GSM subscriber growth. GSM 900/1800 subscribers refer to dual-band users.

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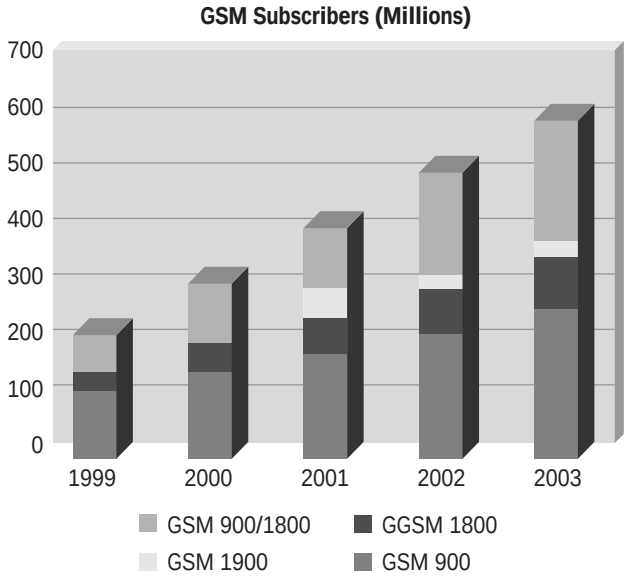
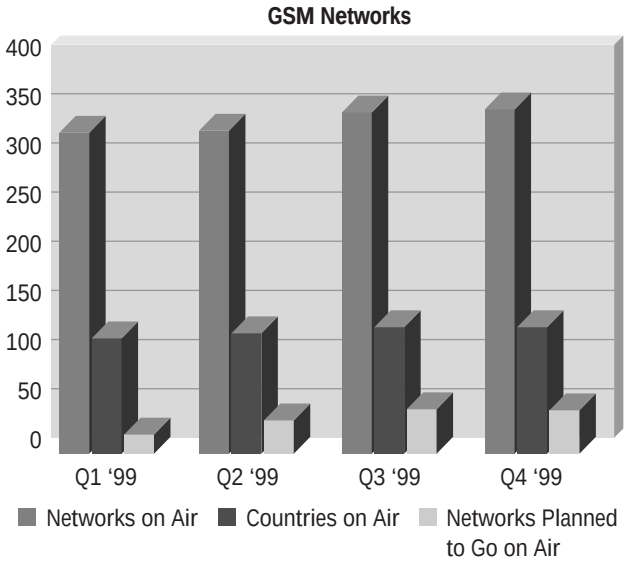
Figure 1 GSM Subscriber Growth



Source: GSM Association

Figure 2 illustrates the recent growth in the number of worldwide GSM networks.

Figure 2 GSM Networks

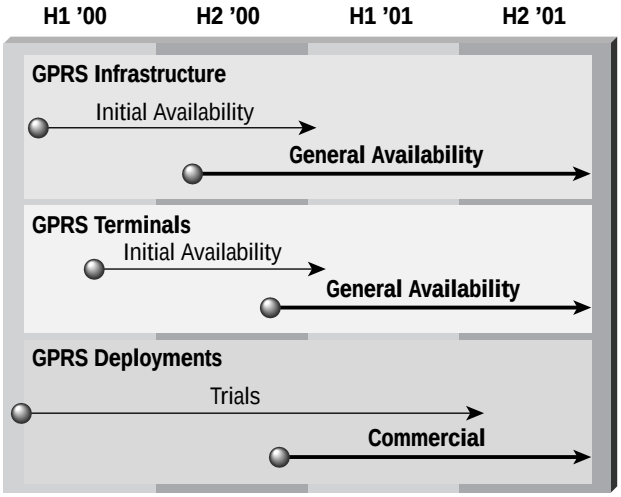


Source: GSM Association

1.2 Market Timeline

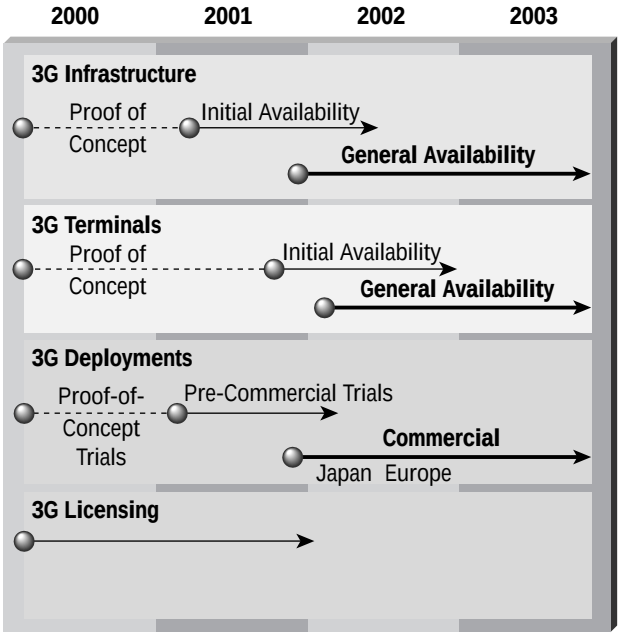
The deployment timeline for GPRS is dependent on several factors, including infrastructure availability and terminal availability. Figure 3 illustrates an overall deployment timeline for GPRS. Initial availability of infrastructure and terminals includes uses for trials and limited-scale deployments. General availability refers to availability for widespread commercial deployments.

Figure 3 GPRS Timeline



In addition to the GPRS timeline, it is necessary to investigate the 3G deployment timeline. Because many GPRS operators are either planning to deploy or are investigating 3G, GPRS can be seen as a migration step toward 3G. Several proof-of-concept type trials are currently under way, and these trials will lead to more technical- and application-oriented trials in early 2001. As with GPRS, terminal and infrastructure availability are driving factors. In addition, completion of the licensing process is a necessary step for commercial deployment. These factors are illustrated in Figure 4.

Figure 4 3G Timeline



2 GPRS Applications

GPRS will enable a variety of new and unique services to the mobile wireless subscriber. These mobile applications contain several unique characteristics that enhance the value to the customers. First among them is mobility—the ability to maintain constant voice and data communications while on the move. Second is immediacy, which allows subscribers to obtain connectivity when needed, regardless of location and without a lengthy login session. Finally, localization allows subscribers to obtain information relevant to their current location. The combination of these characteristics provides a wide spectrum of possible applications that can be offered to mobile subscribers. The core network components offered by Cisco enable seamless access to these applications, whether they reside in the service provider's network or the public Internet.

In general, applications can be separated into two high-level categories: corporate and consumer. These include:

- Communications—E-mail; fax; unified messaging; intranet/Internet access
- Value-added services (VAS)—Information services; games
- E-commerce—Retail; ticket purchasing; banking; financial trading
- Location-based applications—Navigation; traffic conditions; airline/rail schedules; location finder
- Vertical applications—Freight delivery; fleet management; sales-force automation
- Advertising

Source: ARC Group

2.1 Communications

Communications applications include all those in which it appears to the users that they are using the mobile communications network purely as a pipe to access messages or information. This differs from those applications in which users believe that they are accessing a service provided or forwarded by the network operator.

2.1.1 Intranet Access

The first stage of enabling users to maintain contact with their office is through access to e-mail, fax, and voice mail using unified messaging systems. Increasingly, files and data on corporate networks are becoming accessible through corporate intranets that can be protected through firewalls, by enabling secure tunnels (virtual private networks [VPNs]).

2.1.2 Internet Access

As a critical mass of users is approached, more and more applications aimed at general consumers are being placed on the Internet. The Internet is becoming an invaluable tool for accessing corporate data as well as for the provision of product and service information. More recently, companies have begun using the Internet as an environment for carrying out business, through e-commerce.

2.1.3 E-Mail and Fax

E-mail on mobile networks may take one of two forms. It is possible for e-mail to be sent to a mobile user directly, or users can have an e-mail account maintained by their network operator or their Internet service provider (ISP). In the latter case, a notification will be forwarded to their mobile terminal; the notification will include the first few lines of the e-mail as well as details of the sender, the date/time, and the subject. Fax attachments can also accompany e-mails.

2.1.4 Unified Messaging

Unified messaging uses a single mailbox for all messages, including voice mail, faxes, e-mail, short message service (SMS), and pager messages. With the various mailboxes in one place, unified messaging systems then allow for a variety of access methods to recover messages of different types. Some will use text-to-voice systems to read e-mail and, less commonly, faxes over a normal phone line, while most will allow the interrogation of the contents of the various mailboxes through data access, such as the Internet. Others may be configured to alert the user on the terminal type of their choice when messages are received.

2.2 Value-Added Services

Value-added services refer strictly to content provided by network operators to increase the value of their service to their subscribers. Two terms that are frequently used with respect to the delivery of data applications are *push* and *pull*, as defined below.

- *Push* refers to the transmission of data at a predetermined time, or under predetermined conditions. It could also apply to the unsolicited supply of advertising (for example, delivery of news as it occurs, or stock values when they fall below a preset value).
- *Pull* refers to the demanding of data in real time by the user (for example, requesting stock quotes or daily news headlines).

To be valuable to subscribers, this content must posses several characteristics:

- Personalized information is tailored to user-specific needs with relevant information. A stock ticker, focusing on key quotes and news, or an e-commerce application that knows a user's profile are two examples of personalized information.
- Localized content is based on a user's current location; it can include maps, hotel finders, or restaurant reviews.
- Convenience suggests that the user interface and menu screens are intuitive and easy to navigate.
- Trust pertains primarily to e-commerce sites where the exchange of financial or other personal information is required.

Several value-added services are outlined in the following sections.

2.2.1 E-Commerce

E-commerce is defined as the carrying out of business on the Internet or data service. This would include only those applications where a contract is established over the data connection, such as for the purchase of goods, or services, as well as online banking applications because of the similar requirements of user authentication and secure transmission of sensitive data.

2.2.2 Banking

The popularity among banks of encouraging electronic banking comes from the comparable costs of making transactions in person in a bank to making them electronically. Specific banking functions that can be accomplished over a wireless connection include: balance checking, moving money between accounts, bill payment, and overdraft alert.

2.2.3 Financial Trading

The immediacy with which transactions can be made using the Internet and the requirement for up-to-the-minute information has made the purchasing of stocks a popular application. By providing push services such as those detailed in the VAS section earlier and coupling these with the ability to make secure transactions from the mobile terminal, a very valuable service unique to the mobile environment can be provided.

2.3 Location-Based Services and Telematics

Location-based services provide the ability to link push or pull information services with a user's location. Examples include hotel and restaurant finders, roadside assistance, and city-specific news and information. This technology also has vertical applications such as workforce management and vehicle tracking.

2.4 Vertical Applications

In the mobile environment, vertical applications apply to systems utilizing mobile architectures to support the carrying out of specific tasks within the value chain of a company, as opposed to applications that are then being offered for sale to a consumer. Examples of vertical applications include:

- Sales support—Provision of stock and product information for sales staff, as well as integration of their use of appointment details and the remote placing of orders
- Dispatching—Communication of job details such as location and scheduling; permitting interrogation of information to support the job
- Fleet management—Control of a fleet of delivery or service staff, monitoring their locations and scheduling work
- Parcel delivery—Tracking the locations of packages for feedback to customers and performance monitoring

2.5 Advertising

Advertising services will be offered as a push type information service. Advertising may be offered to customers to subsidize the cost of voice or other information services. Finally, advertising may be location sensitive where, for example, a user entering a mall would receive advertising specific to the stores in that mall.

3 GPRS Terminals

A complete understanding of the application availability and GPRS timeline requires understanding of terminal types and availability. The term "terminal equipment" is generally used to refer to the variety of mobile phones and mobile stations that can be used in a GPRS environment; the equipment is defined by terminal classes and types. Cisco Gateway GPRS Serving Node (GGSN) and data network components interoperate with GPRS terminals that follow the GPRS standards.

3.1 GPRS Terminal Classes

A GPRS terminal can be one of three classes: A, B, or C. A Class A terminal supports GPRS and other GSM services (such as SMS and voice) simultaneously. This support includes simultaneous attach, activation, monitor, and traffic. As such, a Class A terminal can make or receive calls on two services simultaneously. In the presence of circuit-switched services, GPRS virtual circuits will be held or placed on busy rather than being cleared.

A Class B terminal can monitor GSM and GPRS channels simultaneously, but can support only one of these services at a time. Therefore, a Class B terminal can support simultaneous attach, activation, and monitor, but not simultaneous traffic. As with Class A, the GPRS virtual circuits will not be closed down when circuit-switched traffic is present. Instead, they will be switched to busy or held mode. Thus, users can make or receive calls on either a packet or a switched call type sequentially, but not simultaneously.

A Class C terminal supports only nonsimultaneous attach. The user must select which service to connect to. Therefore, a Class C terminal can make or receive calls from only the manually (or default) selected service. The service that is not selected is not reachable. Finally, the GPRS specifications state that support of SMS is optional for Class C terminals.

3.2 Device Types

In addition to the three variables, each handset will have a unique form factor. Some of the form factors will be similar to current mobile wireless devices, while others will evolve to use the enhanced data capabilities of GPRS.

The earliest available type will be closely related to the current mobile phone. These will be available in the standard form factor with a numeric keypad and a relatively small display.

PC Cards are credit card-sized hardware devices that connect via a serial cable to the bottom of a mobile phone. Data cards for GPRS phones will enable laptops and other devices with PC Card slots to be connected to mobile GPRS-capable phones. Card phones provide functionality similar to that offered by PC Cards, without needing a separate phone. These devices may need an earpiece and microphone to support voice services.

Smart phones are mobile phones with built-in voice, nonvoice, and Web-browsing services. Smart phones integrate mobile computing and mobile communications into a single terminal. They come in various form factors, which may include a keyboard or an icon drive screen. The Nokia 9000 series is a popular example of this form factor.

The increase in machine-to-machine communications has led to the adoption of application-specific devices. These "black-box" devices lack a display, keypad, and voice accessories of a standard phone. Communication is accomplished through a serial cable. Applications such as meter reading utilize such black-box devices.

Personal digital assistants (PDAs) such as the Palm Pilot series or Handspring Visor are data-centric devices that are adding mobile wireless access. These devices can either connect with a GPRS-capable mobile phone via a serial cable or have GPRS capability built in.

A final category of GPRS terminals is handheld communications. Again, these are primarily data-centric devices that are adding mobile wireless access. Access can be gained via a PC Card or via a serial cable to a GPRS-capable phone.

4 GPRS Architecture

From a high level, GPRS can be thought of as an overlay network onto a second-generation GSM network. This data overlay network provides packet data transport at rates from 9.6 to 171 kbps. Additionally, multiple users can share the same air-interface resources.

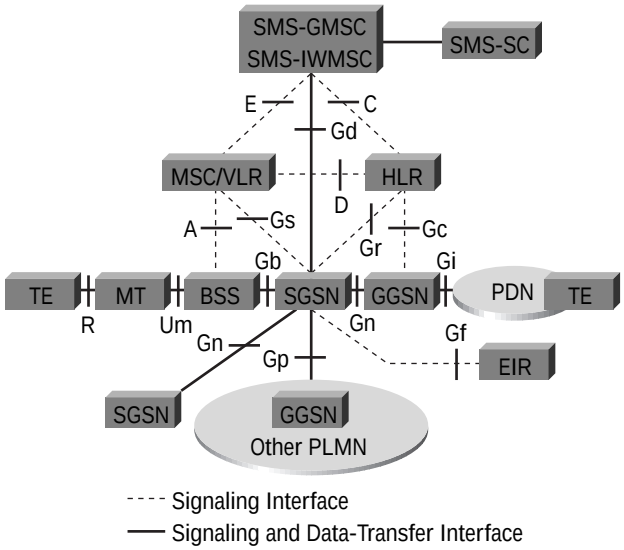
GPRS attempts to reuse the existing GSM network elements as much as possible, but in order to effectively build a packet-based mobile cellular network, some new network elements, interfaces, and protocols that handle packet traffic are required. Therefore, GPRS requires modifications to numerous network elements, as summarized in Table 1 and illustrated in Figure 5.

Table 1 Modifications Required for GPRS

GSM Network Element	Modification or Upgrade Required for GPRS
Subscriber Terminal (TE)	A totally new subscriber terminal is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.
BTS	A software upgrade is required in the existing base transceiver site (BTS).
BSC	The base station controller (BSC) will also require a software upgrade, as well as the installation of a new piece of hardware called a packet control unit (PCU). The PCU directs the data traffic to the GPRS network and can be a separate hardware element associated with the BSC.
Core Network	The deployment of GPRS requires the installation of new core network elements called the Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN).
Databases (VLR, HLR, and so on)	All the databases involved in the network will require software upgrades to handle the new call models and functions introduced by GPRS.

4.1 GPRS Reference Architecture

Figure 5 Generic GPRS Network Architecture



Source: ETSI

4.1.1 GPRS Subscriber Terminals

New terminals (TEs) are required because existing GSM phones do not handle the enhanced air interface, nor do they have the ability to packetize traffic directly. A variety of terminals will exist, as described in a previous section, including a high-speed version of current phones to support high-speed data access, a new kind of PDA device with an embedded GSM phone, and PC Cards for laptop computers. All these TEs will be backward compatible with GSM for making voice calls using GSM.

4.1.2 GPRS BSS

Each BSC will require the installation of one or more PCUs and a software upgrade. The PCU provides a physical and logical data interface out of the base station system (BSS) for packet data traffic. The BTS may also require a software upgrade, but typically will not require hardware enhancements.

When either voice or data traffic is originated at the subscriber terminal, it is transported over the air interface to the BTS, and from the BTS to the BSC in the same way as a standard GSM call. However, at the output of the BSC the traffic is separated; voice is sent to the mobile switching center (MSC) per standard GSM, and data is sent to a new device called the SGSN, via the PCU over a Frame Relay interface.

4.1.3 GPRS Network

In the core network, the existing MSCs are based upon circuit-switched central-office technology, and they cannot handle packet traffic. Thus two new components, called GPRS Support Nodes, are added:

• Serving GPRS Support Node (SGSN)

• Gateway GPRS Support Node (GGSN)

The SGSN can be viewed as a "packet-switched MSC;" it delivers packets to mobile stations (MSs) within its service area. SGSNs send queries to home location registers (HLRs) to obtain profile data of GPRS subscribers. SGSNs detect new GPRS MSs in a given service area, process registration of new mobile subscribers, and keep a record of their location inside a given area. Therefore, the SGSN performs mobility management functions such as mobile subscriber attach/detach and location management. The SGSN is connected to the base-station subsystem via a Frame Relay connection to the PCU in the BSC.

GGSNs are used as interfaces to external IP networks such as the public Internet, other mobile service providers' GPRS services, or enterprise intranets. GGSNs maintain routing information that is necessary to tunnel the protocol data units (PDUs) to the SGSNs that service particular MSs. Other functions include network and subscriber screening and address mapping. One (or more) GGSNs may be provided to support multiple SGSNs. More detailed technical descriptions of the SGSN and GGSN are provided in a later section.

4.1.4 GPRS Mobility Management

Mobility management within GPRS builds on the mechanisms used in GSM networks; as a MS moves from one area to another, mobility management functions are used to track its location within each mobile network. The SGSNs communicate with each other and update the user location. The MS profiles are preserved in the visitor location registers (VLRs) that are accessible by the SGSNs via the local GSM MSC. A logical link is established and maintained between the MS and the SGSN in each mobile network. At the end of transmission or when a MS moves out of the area of a specific SGSN, the logical link is released and the resources associated with it can be reallocated.

5 Cisco GPRS Solution

Cisco offers the GGSN network element, while the SGSN solution is available through Cisco partners.

5.1 GGSN Overview

The Cisco GGSN combines in one box:

• GGSN features as defined by the European Telecommunication Standards Institute (ETSI)

• Value-added networking functionality of Cisco routers

The GGSN functionality embedded in the Cisco IOS® software is what differentiates the Cisco GGSN. The Cisco IOS software within a GGSN provides a sophisticated suite of networking capabilities that reside at the heart of internetworking devices. These capabilities provide interoperability with more standards-based physical and logical protocol interfaces than any other internetworking solutions. They connect otherwise-disparate hardware and provide security, reliability, and investment protection in the face of network growth, change, and new applications.

The Cisco GGSN is compliant with ETSI's GPRS standards. Key GPRS features supported by GGSN include GPRS-defined routing and transfers, mobility management in conjunction with SGSN, GPRS quality-of-service (QoS) classes mapping to Internet QoS, QoS negotiation and handling, mobile authentication through Remote Authentication Dial-In User Service (RADIUS), dynamic IP addressing through Dynamic Host Configuration Protocol (DHCP), network management, and charging data collection. The Cisco GGSN supports all Cisco IOS features. A partial list of supported Cisco IOS features within GGSN includes IP routing, IP tunneling, and support of the Domain Name System (DNS), DHCP, and RADIUS. Additional technical information can be found in the Cisco GGSN data sheet.

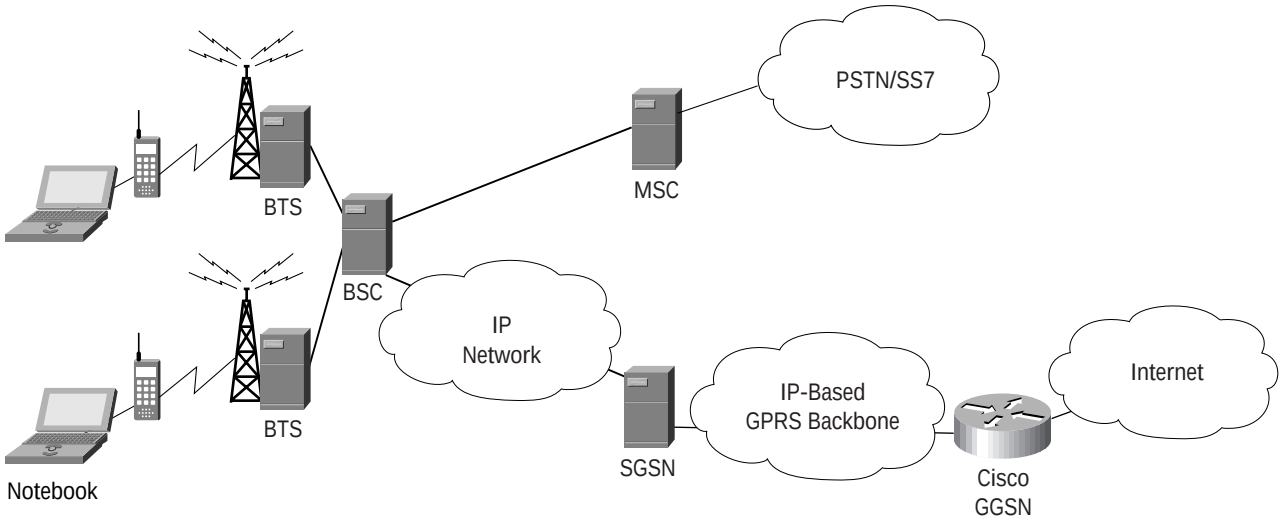
5.2 GGSN Applications

The GGSN can be deployed in a variety of network topologies and architectures. The following sections illustrate several alternatives.

5.2.1 Standalone PLMN

Operators of a standalone Public Land Mobile Network (PLMN) who own the frequency may have one or more SGSNs and GGSNs. The GGSN serves as a gateway to the Internet (external packet data network). (See Figure 6.)

Figure 6 The Cisco GPRS solution enables GSM operators to provide packet data service to their mobile subscribers.



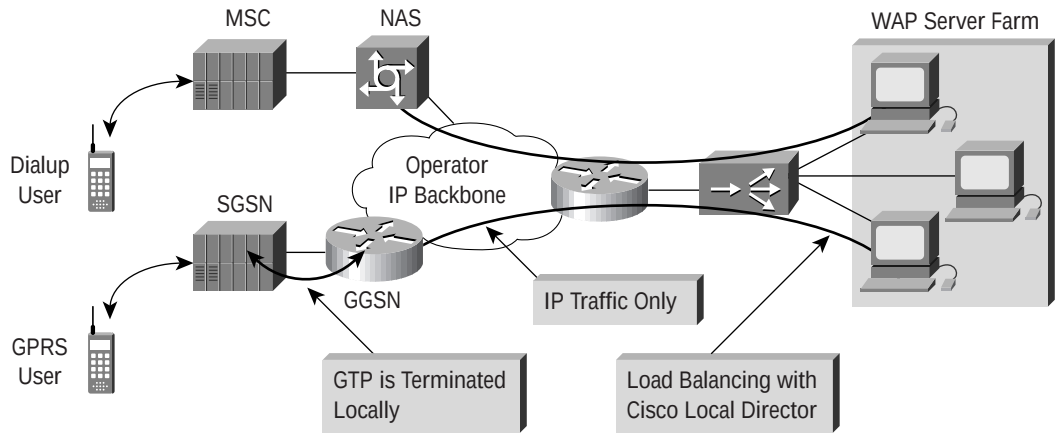
5.2.2 WAP services in GPRS environment

The Wireless Access Protocol (WAP) empowers mobile users of wireless devices to easily access live interactive information services and applications from the screens of mobile phones. Services and applications include e-mail, customer care, call management, unified messaging, weather and traffic alerts, news, sports and information services, electronic commerce transactions and banking services, online address book and directory services, as well as corporate intranet applications.

WAP utilizes HTTP 1.1 Web servers to provide content on the Internet or intranets, thereby taking advantage of existing application development methodologies and developer skill sets such as CGI, ASP, NSAPI, JAVA, and Servlets. WAP defines an XML (eXtensible Markup Language) syntax called WML (Wireless Markup Language). All WML content is accessed over the Internet using standard HTTP 1.1 requests.

To take advantage of today's extremely large market penetration of mobile devices, the user interface components of WML map well onto existing mobile phone user interfaces. This means end users can immediately use WAP-enabled mobile phones and services without re-education. WAP specifications enable products which employ standard Internet technology to optimize content and airlink protocols to better suit the characteristics and limitations of existing and future wireless networks and devices. Since WAP transport is based on IP, Cisco can provide all the required features and products to scale mass market WAP applications (see Figure 7).

Figure 7 SN in a WAP enabled network



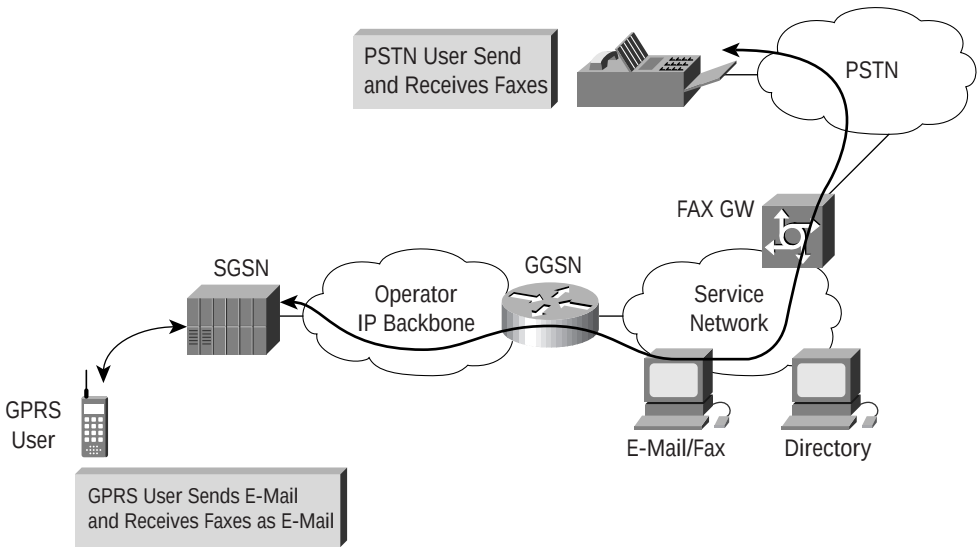
5.2.3 FAX over GPRS

Faxes are ubiquitous—and inexpensive compared to postage. Not only are faxes fast and easy to use, they provide immediate and reliable confirmation that a remote fax machine received the message. In parts of the developing world, fax is a lifeline—the only reliable means of exchanging important business, government, and personal documents.

The fax store-and-forward solution addresses each of these issues through a combination of Cisco and partner technology (see Figure 8):

- Integration of fax with electronic documents converts faxes into Multipurpose Internet Mail Extension (MIME) messages with attached Tagged Image File Format (TIFF) documents that can be reconverted to fax or accessed electronically.
- Improved delivery control is realized through directory services based on Simple Mail Transfer Protocol (SMTP) mail servers (provided by Netscape or Software.com) plus directory services that map fax numbers to user accounts.
- Message storage and retrieval includies software to convert PC documents into TIFF documents.
- Least-cost routing, billing, management and user access via the Web is achieved through partner software that enables service providers to offer store-and-forward fax services profitably.

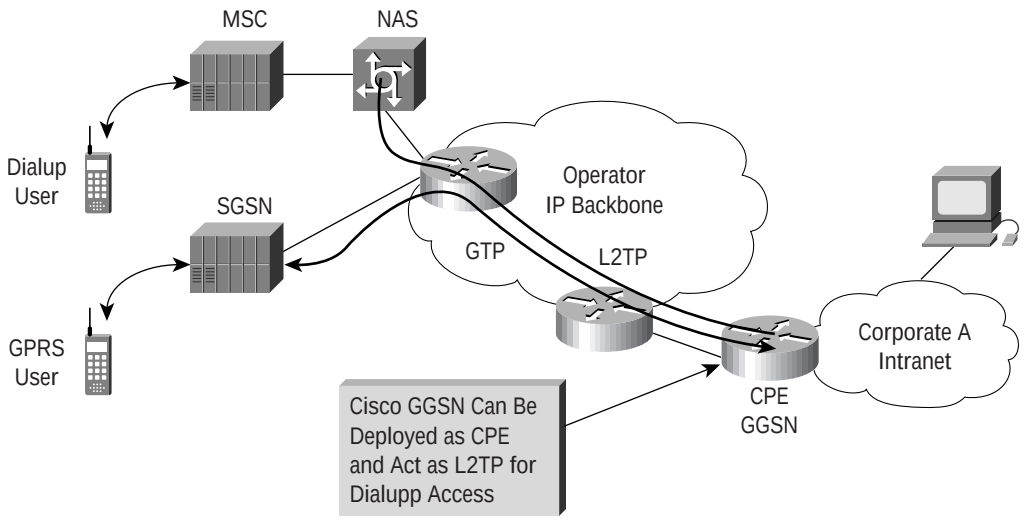
Figure 8 Fax over GPRS



5.2.4 Corporate Voice and Data

Cisco GGSN enables offering alternative solutions where GGSN can be placed at the customer premises. Based on leading routing technology, Cisco IOS software, it is the ideal solution that integrates GPRS with already-deployed IP services, such as virtual private dial-up networks (VPDNs) and voice over IP (see Figure 9).

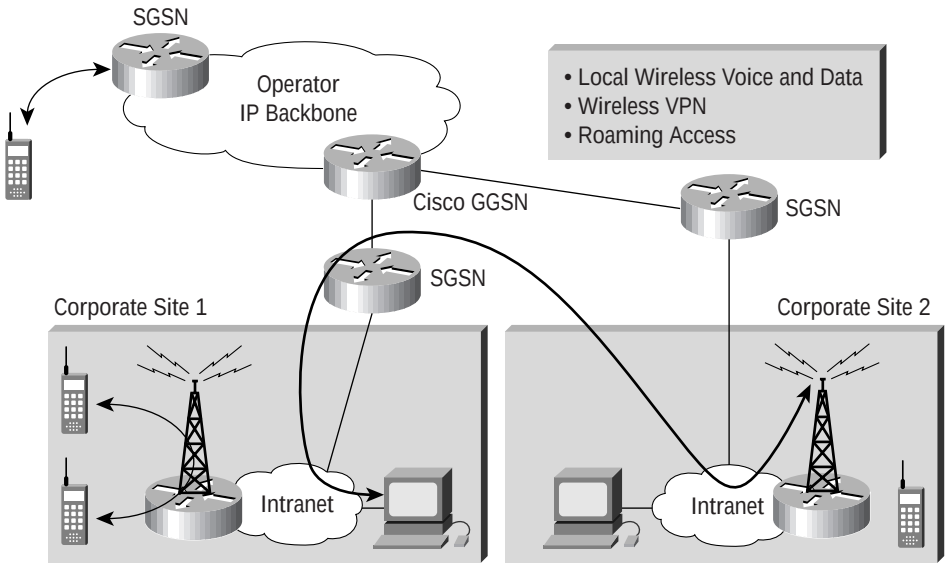
Figure 9 GGSN Deployed as Customer Premise Equipment (CPE)



5.2.4 Virtual Private Network Corporate Solutions

High scalable SGSN nodes could be used to create a GPRS corporate solution. Scalability, interworking features, and standard protocols are the key aspects that Cisco is introducing in all its innovative and advanced projects. Distributed solutions with intelligent devices can give operators a competitive advantage, especially in the small office/home office (SOHO) business. (see Figure 10).

Figure 10 GPRS Solution for Multi-site Corporation



6 GPRS Data Communication

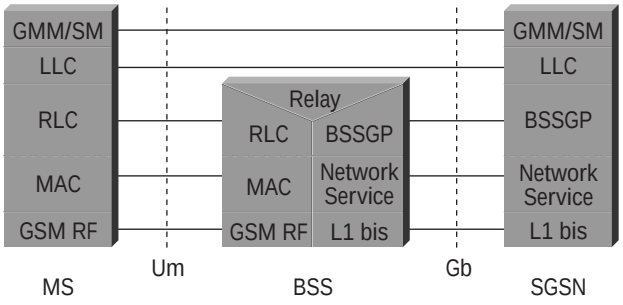
Some cooperation still exists between elements of the current GSM services and GPRS. On the physical layer, resources can be reused and some common signaling issues exist. In the same radio carrier, there can be time slots (TSs) reserved simultaneously for circuit-switched and GPRS use. The most optimum resource utilization is obtained through dynamic sharing between circuit-switched and GPRS channels. During the establishment of a circuit-switched call, there is enough time to preempt the GPRS resources for circuit-switched calls that have higher priority.

6.1 GPRS Service

The GPRS provides a bearer service from the edge of a data network to a GPRS MS. The GPRS protocol layering is illustrated in Figure 11. The physical radio interface consists of a flexible number of TDMA time slots (from 1 to 8) and thus provides a theoretical raw data rate of 171 kbps. A Media Access Control (MAC) utilizes the resources of the physical radio interface and provides a service to the GPRS Logical Link Control (LLC) protocol between the MS and the serving GSN (SGSN). LLC is a

modification of a High-Level Data Link Control (HDLC)-based Radio Link Protocol (RLP) with variable frame size. The two most important features offered by LLC are the support of point-to-multipoint addressing and the control of data frame retransmission. From the standpoint of the application, GPRS provides a standard interface for the network layer.

Figure 11 GPRS Protocol Layering



Source: ETSI

6.2 Data Routing

One of the main issues in the GPRS network is the routing of data packets to/from a mobile user. The issue can be divided into two areas: data packet routing and mobility management.

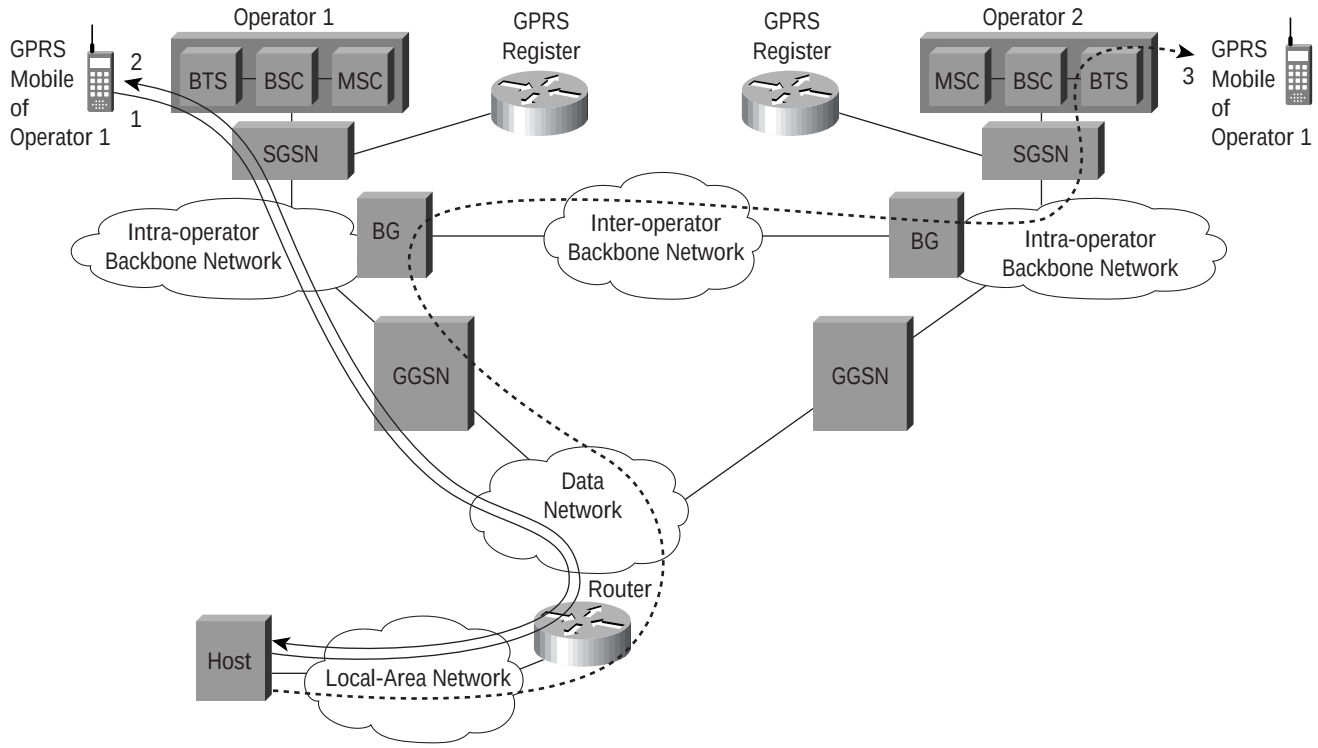
6.2.1 Data Packet Routing

The main functions of the GGSN involve interaction with the external data network. The GGSN updates the location directory using routing information supplied by the SGSNs about the location of a MS and routes the external data network protocol packet encapsulated over the GPRS backbone to the SGSN currently serving the MS. It also decapsulates and forwards external data network packets to the appropriate data network and collects charging data that is forwarded to a charging gateway.

In Figure 12, three different routing schemes are illustrated: mobile-originated message (path 1), network-initiated message when the MS is in its home network (path 2), and network-initiated message when the MS has roamed to another GPRS operator's network (path 3). In these examples, the operator's GPRS network consists of multiple GSNs (with a gateway and serving functionality) and an intra-operator backbone network.

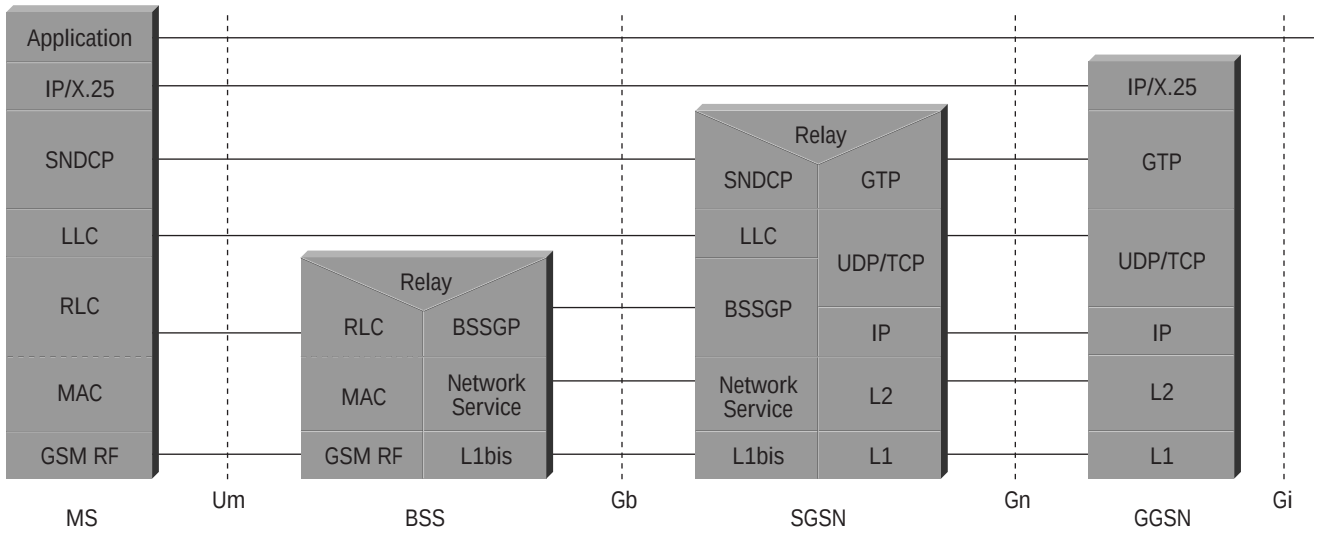
GPRS operators will allow roaming through an inter-operator backbone network. The GPRS operators connect to the inter-operator network via a boarder gateway (BG), which can provide the necessary interworking and routing protocols (for example, Border Gateway Protocol [BGP]). It is also foreseeable that GPRS operators will implement QoS mechanisms over the inter-operator network to ensure service-level agreements (SLAs). The main benefits of the architecture are its flexibility, scalablility, interoperability, and roaming.

Figure 12 Routing of Data Packets between a Fixed Host and a GPRS MS



The GPRS network encapsulates all data network protocols into its own encapsulation protocol, called the GPRS Tunneling Protocol (GTP), as shown in Figure 12. This is done to ensure security in the backbone network and to simplify the routing mechanism and the delivery of data over the GPRS network.

Figure 13 GPRS Network Protocol Stack

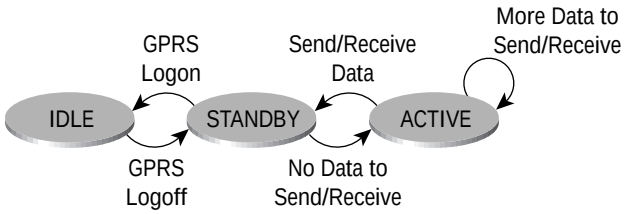


Source: ETSI

6.3 GPRS Mobility Management

The operation of the GPRS is partly independent of the GSM network. However, some procedures share the network elements with current GSM functions to increase efficiency and to make optimum use of free GSM resources (such as unallocated time slots). (See Figure 13.)

Figure 14 States of GPRS in a Mobile Station



An MS has three states in the GPRS system: idle, standby, and active (Figure 13). The three-state model represents the nature of packet radio relative to the GSM two-state model (idle or active).

Data is transmitted between a MS and the GPRS network only when the MS is in the active state. In the active state, the SGSN knows the cell location of the MS. However, in the standby state, the location of the MS is known only as to which routing area it is in. (The routing area can consist of one or more cells within a GSM location area.)

When the SGSN sends a packet to a MS that is in the standby state, the MS must be paged. Because the SGSN knows the routing area in which the MS is located, a packet paging message is sent to that routing area. After receiving the packet paging message, the MS gives its cell location to the SGSN to establish the active state.

Packet transmission to an active MS is initiated by packet paging to notify the MS of an incoming data packet. The data transmission proceeds immediately after packet paging through the channel indicated by the paging message. The purpose of the packet paging message is to simplify the process of receiving packets. The MS has to listen to only the packet paging messages, instead of all the data packets in the downlink channels, reducing battery use significantly.

When an MS has a packet to be transmitted, access to the uplink channel is needed. The uplink channel is shared by a number of MSs, and its use is allocated by a BSS. The MS requests use of the channel in a packet random access message. The transmission of the packet random access message follows Slotted Aloha procedures. The BSS allocates an unused channel to the MS and sends a packet access grant message in reply to the packet random access message. The description of the channel (one or multiple time slots) is included in the packet access grant message. The data is transmitted on the reserved channels.

The main reasons for the standby state are to reduce the load in the GPRS network caused by cell-based routing update messages and to conserve the MS battery. When a MS is in the standby state, there is no need to inform the SGSN of every cell change—only of every routing area change. The operator can define the size of the routing area and, in this way, adjust the number of routing update messages.

In the idle state, the MS does not have a logical GPRS context activated or any Packet-Switched Public Data Network (PSPDN) addresses allocated. In this state, the MS can receive only those multicast messages that can be received by any GPRS MS. Because the GPRS network infrastructure does not know the location of the MS, it is not possible to send messages to the MS from external data networks.

A cell-based routing update procedure is invoked when an active MS enters a new cell. In this case, the MS sends a short message containing information about its move (the message contains the identity of the MS and its new location) through GPRS channels to its current SGSN. This procedure is used only when the MS is in the active state.

When an MS in an active or a standby state moves from one routing area to another in the service area of one SGSN, it must again perform a routing update. The routing area information in the SGSN is updated and the success of the procedure is indicated in the response message.

The inter-SGSN routing update is the most complicated of the three routing updates. In this case, the MS changes from one SGSN area to another, and it must establish a new connection to a new SGSN. This means creating a new logical link context between the MS and the new SGSN, as well as informing the GGSN about the new location of the MS.

7 Glossary

2G	Second generation; generic name for second generation of digital mobile networks (such as GSM, and so on)
3G	Third generation; generic name for next-generation mobile networks (Universal Telecommunications System [UMTS], IMT-2000; sometimes GPRS is called 3G in North America)
3GPP	3G Partnership Project
BG	Border gateway
BGP	Border Gateway Protocol
bps	Bits per second
BSC	Base Station Controller
BTS	Base transceiver station
CS	Circuit switched
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
EDGE	Enhanced data rates for GSM evolution; upgrade to GPRS systems that requires new base stations and claims to increase bandwidth to 384 kbps
ETSI	European Telecommunications Standards Institute
Gb	Interface between a SGSN and a BSS
Gc	Interface between a GGSN and a HLR
Gd	Interface between a SMS-GMSC and a SGSN, and between a SMS-IWMSC and a SGSN
Gf	Interface between a SGSN and an EIR
GGSN	Gateway GPRS Support Node
Gi	Reference point between GPRS and an external packet data network
GIWU	GSM interworking unit
GMSC	Gateway mobile services switching center
Gn	Interface between two GSNs within the same PLMN
Gp	Interface between two GSNs in different PLMNs
GPRS	General Packet Radio Service; upgrade to existing 2G digital mobile networks to provide higher-speed data services
Gr	Interface between a SGSN and a HLR
Gs	Interface between a SGSN and a MSC/VLR
GSM	Global System for Mobile Communications; most widely deployed 2G digital cellular mobile network standard

GSN	GPRS Support Node (xGSN)
GTP	GPRS Tunneling Protocol
GW	Gateway
HDLC	High-Level Data Link Control
HLR	Home location register
HSCSD	High-speed circuit-switched data; software upgrade for cellular networks that gives each subscriber 56K data
IP	Internet Protocol
ISP	Internet service provider
L2TP	Layer two Tunneling Protocol
LLC	Logical Link Control
MAC	Medium Access Control
MM	Mobility management
MS	Mobile station
MSC	Mobile services switching center
NAS	Network access server
OA&M	Operations, administration, and management
OSS	Operations Support System
PCU	Packet control unit
PDA	Personal digital assistant
PDN	Packet data network
PDP	Packet Data Protocol
PLMN	Public Land Mobile Network; generic name for all mobile wireless networks that use earth base stations rather than satellites; the mobile equivalent of the PSTN
PSPDN	Packet Switched Public Data Network
PSTN	Public Switched Telephone Network
PVC	Permanent virtual circuit
QoS	Quality of service
RADIUS	Remote Authentication Dial-In User Service
RLP	Radio Link Protocol
SGSN	Serving GPRS Support Node
SLA	Service-level agreement
SMS	Short message service
SMSC	Short message service center
SS7	Signaling System Number 7
TCP	Transmission Control Protocol
TE	Terminal equipment

TDMA	Narrowband digital TDMA standard; uses same frequencies as AMPS, thus is also known as D-AMPS or digital AMPS
TS	Time slot
Um	Interface between the MS and the GPRS fixed network part
VAS	Value-added services
VLR	Visitor location register
VPN	Virtual private network
WAP	Wireless access Protocol; important protocol stack (Layers 4 through 7 of the OSI model), used to send simplified Web pages to wireless devices; uses IP but replaces TCP and Hypertext Transfer Protocol (HTTP) with UDP and WTP, and requires pages to be written in WML rather than in HTML

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