# GPRS—General packet radio service

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**By adding GPRS to the GSM network, operators can offer efficient wireless access to external IP-based networks, such as the Internet and corporate intranets. What is more, operators can profit from the rapid pace of service development in the Internet world, offering their own IP-based services using the GPRS IP bearer, thereby moving up the Internet value chain and increasing profitability.**

**End-users can remain connected indefinitely to the external network and enjoy instantaneous transfer rates of up to 115 kbit/s. Users who are not actually sending or receiving packets occupy only a negligible amount of the network's critical resources. Thus, new charging schemes are expected to reflect network usage instead of connection time.**

**Ericsson's implementation of GPRS enables rapid deployment while keeping entry costs low—the two new nodes that are added to the network can be combined and deployed at a central point in the network. The rest of the GSM network solely requires a software upgrade, apart from the BSC, which requires new hardware.**

**The authors describe Ericsson's implementation of GPRS. In particular, they explain the role of the two new GPRS support nodes and needed changes to Ericsson products in the PLMN.**

**TRADEMARKS**



## Introduction

General packet radio service (GPRS) is a standard from the European Telecommunications Standards Institute (ETSI) on packet data in GSM systems. GPRS has also been accepted by the Telecommunications Industry Association (TIA) as the packet-data standard for TDMA/136 systems. By adding GPRS functionality to the public land mobile network (PLMN), operators can give their subscribers resource-efficient access to external Internet protocol-based (IP) networks.

GPRS offers air-interface transfer rates up to 115 kbit/s—subject to mobile terminal capabilities and carrier interference. Moreover, GPRS allows several users to share the same air-interface resources and enables operators to base charging on the amount of transferred data instead of on connection time. In the initial release, GPRS uses the same modulation as GSM (GMSK). The subsequent evolution of packet-based services in GSM introduces EDGE technology.[1]

GPRS introduces two new nodes (Figure 1) for handling packet traffic:

- the serving GPRS support node (SGSN); and
- the gateway GPRS support node (GGSN).

These nodes interwork with the home location register (HLR), the mobile switching center/visitor location register (MSC/VLR) and base station subsystems (BSS).

The GGSN, which is the interconnection point for packet data networks, is connected to the SGSN via an IP backbone. User data—for example, from a GPRS terminal to the Internet—is sent encapsulated over the IP backbone.

The SGSN, in turn, is connected to the BSS and resides at the same hierarchical level in the network as the MSC/VLR. It keeps track of the location of the GPRS user, performs security functions and handles access control—that is, to a large extent, it does for the packet data service what the MSC/VLR does for circuit-switched service.

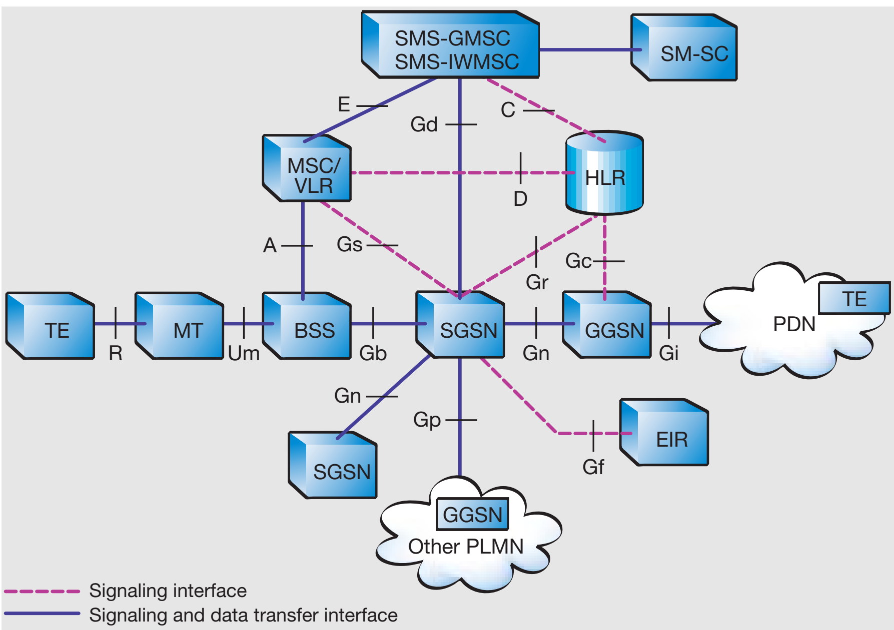
In the GPRS standard, three new types of mobile terminal have been defined:

- Class A terminal, which supports simultaneous circuit-switched and packet-switched traffic;
- Class B terminal, which supports either circuit-switched or packet-switched traffic (simultaneous network attachment) but does not support both kinds of traffic simultaneously; and
- Class C terminal, which is attached either as a packet-switched or circuit-switched terminal.

The terminal types are further differentiated by their ability to handle multi-slot operation.

Since class A and class B terminals support both circuit-switched and packet-

**Figure 1**
**The GPRS reference model.**



**BOX A, ABBREVIATIONS**

| | |
|---|---|
| APN | Access point name |
| BCCH | Broadcast common control channel |
| BGP | Border gateway protocol |
| BGW | Billing gateway |
| BSC | Base station controller |
| BSS | Base station subsystem |
| BTS | Base transceiver station |
| CDR | Call data record |
| CHAP | Challenge handshake authentication protocol |
| C/I | Carrier-to-interference ratio |
| CORBA | Common object request broker architecture |
| DNS | Domain name server |
| ETSI | European Telecommunications Standards Institute |
| GGSN | Gateway GPRS support node |
| GPRS | General packet radio service |
| GSM | Global system for mobile communication |
| GSN | GPRS support node |
| GTP | GPRS tunneling protocol |
| GUI | Graphical user interface |
| HLR | Home location register |
| HTML | Hypertext markup language |
| HTTP | Hypertext transfer protocol |
| IETF | Internet Engineering Task Force |
| IMEI | International mobile equipment identity |
| IMSI | International mobile subscriber identity |
| IP | Internet protocol |
| IPSec | IP security |
| ISP | Internet service provider |
| LA | Location area |
| MAC | Medium access control |
| MSC | Mobile switching center |
| O&M | Operation and maintenance |
| OSPF | Open shortest path first |
| OSS | Operations support system |
| OTP | Open telecom platform |
| PAP | Password authentication protocol |
| PCU | Packet control unit |
| PDCH | Packet data channel |
| PDP | Packet data protocol |
| PLMN | Public land mobile network |
| PXM | Packet eXchange Manager |
| QoS | Quality of service |
| RA | Routing area |
| RACH | Random access channel |
| RADIUS | Remote authentication dial-in user service |
| RIP | Routing internal protocol |
| RLC | Radio link control |
| SGSN | Serving GPRS support node |
| SMS | Short message service |
| SNMP | Simple network management protocol |
| SOG | Service order gateway |
| TFI | Temporary flow indicator |
| TIA | Telecommunications Industry Association |
| TMOS | Telecommunications management and operations support |
| TRX | Transceiver |
| VLR | Visitor location register |

switched traffic, the network may combine mobility management. For instance, location updates can include information relating to both services.

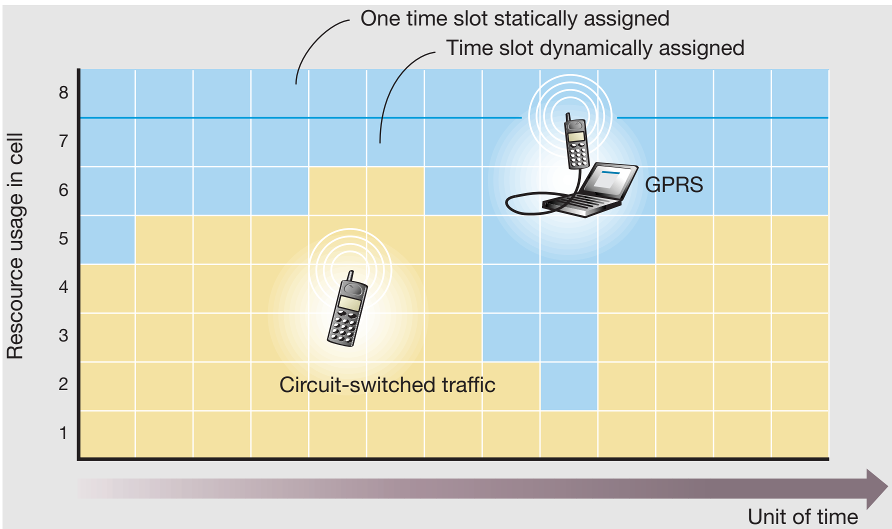
To support efficient multiplexing of packet traffic to and from mobile terminals, a new packet data channel (PDCH) has been defined for the air interface. One PDCH is mapped onto a single time slot, thereby utilizing the same physical channel structure as ordinary circuit-switched GSM channels.

Four different channel-coding schemes have been defined for GPRS to make optimum use of varying radio conditions.

All radio resources are managed from the BSC, where the pool of physical channels for a given cell can be used as either circuit-switched GSM channels or packet data channels. By means of packet multiplexing, the allocated PDCHs can be shared by every GPRS user in the cell. The number of PDCHs in a cell can be fixed or dynamically allocated to meet fluctuating traffic demands. Thus, physical channels not currently in use by the circuit-switched service can be made available to GPRS traffic (Figure 2).

More than one time slot can be allocated to a user during packet transfer. Uplink and downlink resources to connections are allocated separately on a case-by-case basis, which reflects the asymmetric behavior of packet data communication.

**Figure 2**
**In this example, one time slot is statically assigned to GPRS; all other time slots are defined as dynamic GPRS resources.**



**BOX B, PACKET-SWITCHED TRANSMISSION OVER THE AIR INTERFACE**

User data packets are segmented, coded and transformed into radio blocks. Each radio block is further interleaved over four standard GSM normal bursts—that is, over the same basic vehicle that carries coded, circuit-switched speech across the air interface.

When errors occur, data packets can be retransmitted at the radio block level. The set of bursts that results from a single user data packet is marked with a temporary flow identifier (TFI), which is used on the receiving side to reassemble the user data packet.

A new set of logical channels has been defined for GPRS traffic. This set includes control channels and packet data traffic channels. A physical channel allocated for GPRS traffic is called a packet data channel (PDCH). One or more physical channels in a cell can be statically or dynamically assigned for PDCHs. Static PDCHs are always available, whereas dynamic PDCHs are provided on a case-by-case basis.

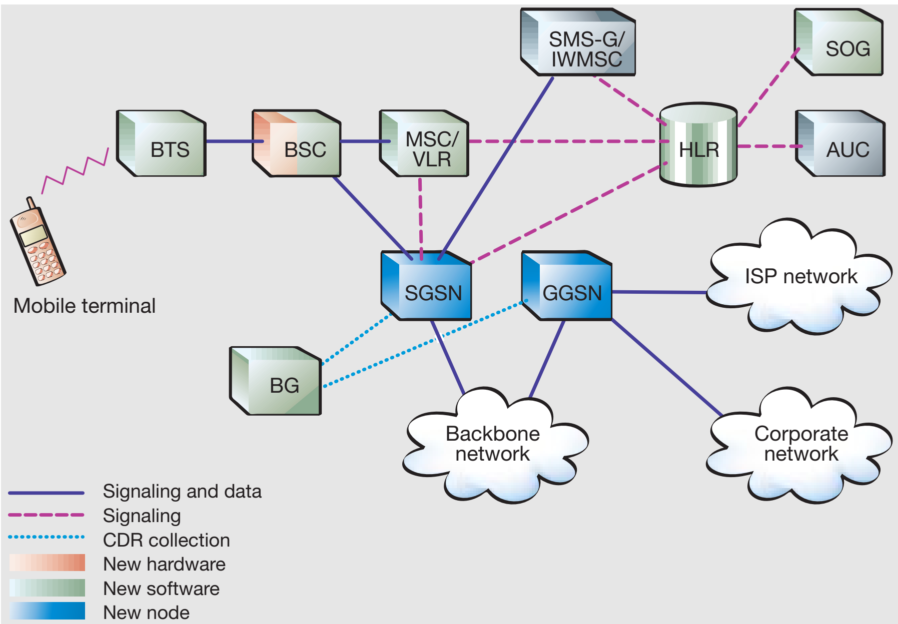
The PDCH consists of a multiframe pattern that runs on time slots assigned to GPRS. This is basically a predefined pattern of GPRS control channels and data traffic channels that keeps repeating itself. In cells defined as having only dynamic GPRS resources and which only run circuit-switched channels, the GPRS terminals use the circuit-switched control channels until one or more PDCH are assigned. Certain circuit-switched mobility-management procedures may also use GPRS control channels (for example, for location update).

Several mobile terminals can dynamically share the pool of packet data channels in a cell, and several PDCHs can be used simultaneously for a single connection. Thus, a user data packet can be transmitted over multiple packet data channels and reassembled at the other end (Figure 4).

The network side controls the allocation of resources. To start packet transmission on the uplink, the mobile terminal requests resources. The network tells the terminal which PDCHs to use. The network also sends a flag value which, when it occurs on the corresponding downlink, tells the mobile terminal to begin transmitting.

To start packet transmission on the downlink, the network sends an assignment message to the mobile terminal, indicating which PDCHs will be used and the value of the TFI assigned to the transfer. The mobile terminal monitors the downlink PDCHs and identifies its packets via the TFI.

**Figure 3**
**Impact of GPRS on an existing Ericsson PLMN.**




# Ericsson's implementation of GPRS

Ericsson's implementation of GPRS for GSM complies with the ETSI standard and supports open interfaces. The implementation enables fast deployment while keeping entry costs low (Figure 3):

- The two new support nodes—the SGSN and GGSN—can be combined into one physical node and deployed at a central point in the network.
- Apart from the BSC, which requires a hardware upgrade, the existing GSM network solely requires software upgrades to support GPRS.

## Two new nodes

### *GPRS support nodes*

The GPRS support nodes (GSN) are based on Ericsson's AXB 250 platform, a new, general-purpose, high-performance, packet-switching platform. The AXB 250 combines features usually associated with data communication (compactness and high functionality) with features from telecommunications (robustness and scalability). Designed for nonstop operation, the platform incorporates duplicated hardware and modular software. Thus, individual modules of the platform can be upgraded without disturbing traffic. The AXB 250 platform is robust and embodies advanced functions for capturing software faults, isolating hardware faults, and protecting against overload. The platform is based on industry standards and standard software components, including

- a UNIX operating system;
- C and Java programming languages;
- the common object request broker architecture (CORBA) interface; and
- the hypertext transfer protocol (HTTP) and the simple network management protocol (SNMP).

Hardware redundancy and the open telecom platform (OTP)—which is specific Ericsson middleware—support carrier-class features, such as high reliability, system recovery, a real-time database, and minimum downtime. The OTP, which is a generic system for fault-tolerant, real-time applications, provides a platform and a set of tools for easily and accurately generating datacom or telecom applications. It is entirely scalable, from low-end, PC-based testing and administrative applications to very large, multiprocessor, $n+m$ redundant systems.

Applications can be designed on a small system and ported to a variety of computer environments.[2]

All operation and maintenance (O&M) activities directed toward the GSNs are handled through a Java-based graphical user interface (GUI), called the Packet eXchange Manager (PXM), which is an element manager based on the thin-client concept. This means that all GUI software, such as files written in the hypertext markup language (HTML) and Java applets, is stored on the GSN, and that a presentation layer (Java) is downloaded and run on the client. Consequently, the GUI always conforms with the software of the node that handles traffic. The client can run on any computer with an Internet browser that supports Java.

Alarm and event management can be integrated into Ericsson's telecommunications management and operations support (TMOS) or into external management systems that use the SNMP.

The GSN also supports traditional telecom performance-management features, such as performance measurements and event recordings.

A router function has been integrated into the GSN. Intranetwork routing protocols and external gateway protocols include the routing information protocol (RIP), open shortest path first (OSPF), and the border gateway protocol (BGP). Several packet-filtering options are also available. IPSec functionality ensures secure transmission between the GSNs as well as between the PLMN and external networks.

### *Serving GPRS support node*

The SGSN, which is based on the

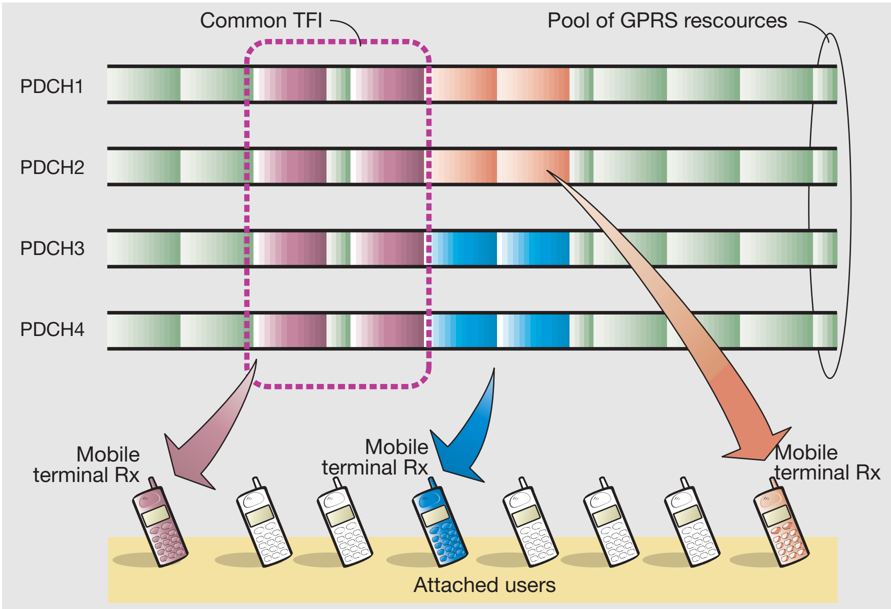



**Figure 4**
**GPRS users share the pool of resources in a cell.**

**BOX C, GPRS ATTACH**

*GPRS attach* and *PDP context activation* must be executed in order for GPRS users to connect to external packet data networks.
The mobile terminal makes itself known to the network by means of GPRS attach—GPRS attach corresponds to IMSI attach, which is used for circuit-switched traffic. Once the terminal is attached to the network, the network knows its location and capabilities. If the unit is a class A or class B terminal, then circuit-switched IMSI attach can be performed at the same time (Figure 5)

1. The mobile terminal requests that it be attached to the network. The terminal's request, which is sent to the SGSN, indicates its multi-slot capabilities, the ciphering algorithms it supports, and whether it wants to attach to a packet-switched service, a circuit-switched service, or to both.
2. Authentication is made between the terminal and the HLR.
3. Subscriber data from the HLR is inserted into the SGSN and the MSC/VLR.
4. The SGSN informs the terminal that it is attached to the network.

(See also Box D, *PDP context activation*).

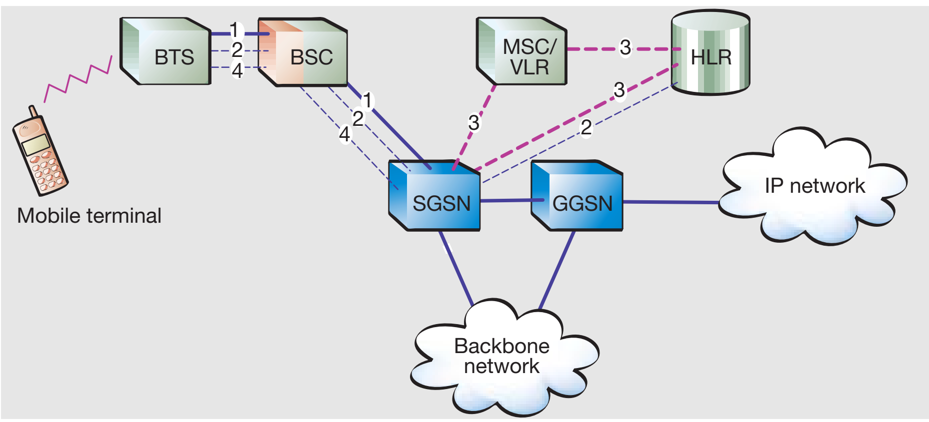



**Figure 5**
**GPRS attach.**

## BOX D, PDP CONTEXT ACTIVATION

Before the mobile terminal can communicate with an external packet data network, the packet data protocol (PDP) context must be activated.

The PDP context describes the characteristics of the connection to the external packet data network—type of network, network address, access point name (APN), QoS, radio priority, and so on. (Figure 6).

1. The mobile terminal requests PDP context activation.
2. The SGSN validates the request based on subscription information received from the HLR during GPRS attach.
3. The APN is sent to the domain name server (DNS) in the SGSN to find the IP address of the relevant GGSN.
4. A logical connection is created between the SGSN and the GGSN (GTP tunnel).
5. The GGSN assigns a dynamic IP address to the mobile terminal—from the range of IP addresses allocated to the PLMN or externally, from a remote authentication dial-in user service (RADIUS) server (a fixed IP address from the HLR could also be used). A RADIUS client is included in the GGSN to support password authentication protocol (PAP) and challenge handshake authentication protocol (CHAP) authentication to external networks with RADIUS servers.

At this stage, communication between the user and the external packet data network can commence.

AXB 250 platform, serves every GPRS subscriber that is physically located within the SGSN service area. In the PLMN, it resides at the same hierarchical level as the MSC/VLR. The main functions of the SGSN are

- to perform mobility management for GPRS terminals (attach/detach, user authentication, ciphering, location management, and so on);
- to support combined mobility management for class A and class B mobile terminals by interworking with the MSC/VLR;
- to manage the logical link to mobile terminals (the logical link carries user packet traffic, SMS traffic, and layer 3 signaling between the network and the GPRS terminal);
- to route and transfer packets between mobile terminals and the GGSN;
- to handle packet data protocol (PDP) con-

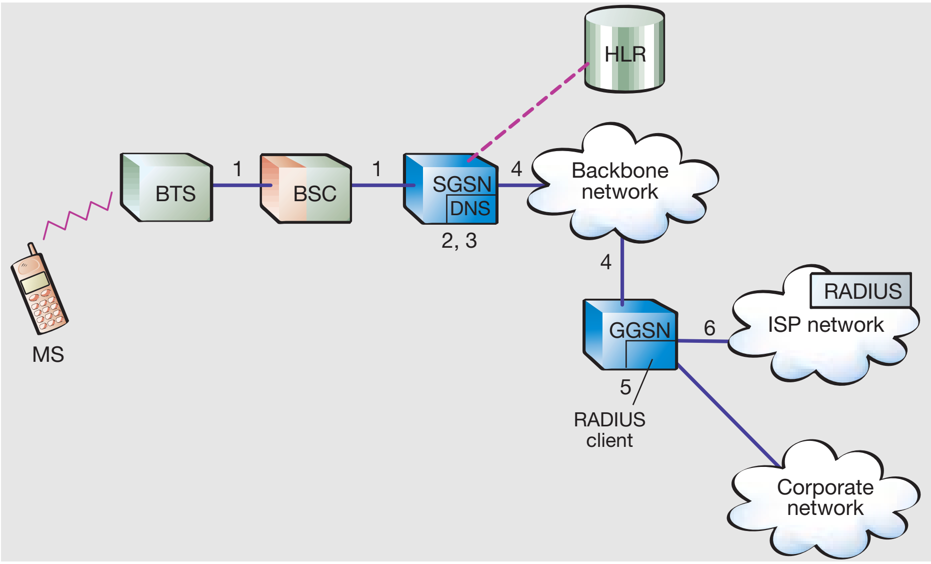



Figure 6
PDP context activation.

texts (the PDP context defines important parameters, such as the access point name, quality of service, the GGSN to be used, and so on, for connection to the external packet data network);
- to interwork with the radio resource management in the BSS; and
- to generate charging data.

*Gateway GPRS support node*

Like the SGSN, the GGSN is a new component (also based on the AXB 250 platform) in the PLMN. It accommodates the interface to external IP-based networks. The access-server functionality in the GGSN is defined according to standards from the Internet Engineering Task Force (IETF). The main functions of the GGSN are
- to function as a border gateway between the PLMN and external networks;
- to set up communication with external packet data networks;
- to authenticate users to external packet networks;
- to route and tunnel packets to and from the SGSN; and
- to generate charging data.

## Changes to a PLMN with Ericsson products

*Cell plan*

GPRS introduces a new set of logical channel types that have been optimized for packet data. The physical radio resources in a cell may be dedicated to GPRS or shared with the circuit-switched service, in which case this service takes precedence. If dedicated resources have not been assigned in a cell, then GPRS broadcast and control signaling is handled via ordinary control channels (BCCH, RACH, and so on).

GPRS does not use location areas (LA). Instead, a routing-area (RA) concept has been introduced.

In the first GPRS release, and in cases where GPRS traffic does not constitute a significant part of network traffic, operators are advised to use the same cell parameters and borders as for their circuit-switched systems. Later, as GPRS traffic grows, the GPRS service and the circuit-switched service might need different cell parameters and borders.

GPRS can be introduced by defining either shared or dedicated resources on existing transceivers (TRX). New transceivers and frequencies can also be set aside specifically for GPRS.

*Billing and customer administration systems*

With the introduction of GPRS, current customers' subscriptions will be enhanced and new customer categories will appear—possibly including those with GPRS-only subscriptions. These and other changes will have an impact on the operator billing and customer administration (BCA) systems.

The call detail records (CDR) generated by the SGSN and the GGSN indicate to which external packet network the connection was set up, the volume of data that was transferred, the quality of service offered, the date and time of connection, and the duration of the session. This information, which differs from what CDRs of circuit-switched services currently provide, will affect existing billing systems. In all likelihood, operators will not base charges for GPRS services on the duration of a session, as is the case with circuit-switched services. Instead, charges will be based on a flat fee or on volumes of data transferred. Operators may also want to offer subscribers of both circuit-switched and packet-switched services a single, consolidated invoice with itemized charges for each service.

To moderate the impact on billing systems, Ericsson's billing gateway (BGW) can be connected between the SGSN and the GGSN (which generate CDRs) and the billing systems. The functionality of the billing gateway entails
- storing CDRs during long GPRS sessions (sessions last for as long as the PDP context is active);

**BOX E, SECURITY**

Several features have been included in Ericsson's implementation of GPRS to provide security, confidentiality and user integrity:
- User authentication (GSM style) prevents illegitimate users from using the network.
- Ciphering of the path between the mobile terminal and the SGSN protects the link against eavesdropping.
- The GPRS tunneling protocol (GTP) encapsulates user packets in the IP backbone.
- IPSec functionality provides secure connections between the SGSN and GGSN in the PLMN.
- IPSec provides secure connections to external packet data networks.
- Packet filtering in the GGSN and SGSN provide firewall functionality, which protects against network intruders.

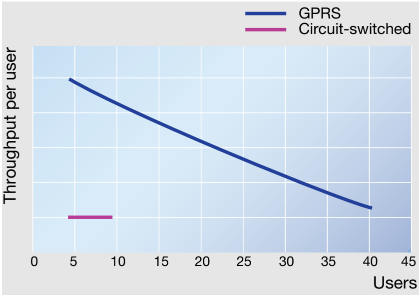



**Figure 7**
**Idealized comparison of GPRS and circuit-switched data services.**

- matching CDRs—to consolidate information from several CDRs generated during one session;
- rating volume-based CDRs; and
- translating new CDR types into formats that can be handled by existing billing systems.

*BSS*

To support GPRS, the base station controller (BSC) requires new hardware and software. In terms of hardware, the BSC requires a packet control unit (PCU) to handle GPRS packets. In particular, the PCU is responsible for the radio link control (RLC) and the medium access control (MAC) layers over the air interface. It also manages the transfer of user data packets between mobile terminals and the SGSN.

Regarding the BTS, Ericsson's RBS2000 and RBS200 product families solely require a software upgrade.

*HLR*

To support GPRS, the software in the home location register must be upgraded. The upgrade adds functionality for

- interconnecting to the SGSN—to function as an HLR for the GPRS service;
- supporting the transfer of SMS over GPRS; and
- supporting combined mobility management.

*MSC/VLR*

As with the HLR, software in the MSC/VLR must be upgraded to support GPRS. The upgrade enables the MSC/VLR to be connected to the SGSN, to support integrated mobility management for class A and class B terminals.

## Conclusion

GPRS enables GSM operators to offer efficient mobile access to external packet-switched networks, such as the Internet and corporate intranets. Several users can share the same network resources at the same time and enjoy transfer rates of up to 115 kbit/s.

To support GPRS, two new nodes—the SGSN and the GGSN—must be added to the GSM network.

Ericsson has developed a complete family of products for GPRS:

- The SGSN and GGSN are based on the AXB 250, a new packet-switching platform;
- Apart from the BSC, existing nodes in the network solely require a software upgrade to support GPRS. The BSC requires new hardware and software.

**BOX F, GPRS EFFICIENCY**

Figure 7 shows an idealized comparison of GPRS and circuit-switched data services for typical Internet browsing. In this context, throughput is the average throughput that a user experiences as he or she downloads information from the Internet. In the case of GPRS, fewer active users implies that each user has access to more bandwidth. As the number of active users grows, the bandwidth allocated to each user decreases. Compare this to circuit-switched service, where fixed bandwidth is allocated to a limited number of users.

Compared with circuit-switched connections, GPRS offers superior performance to applications like Internet browsing. Due to bursty user behavior (users suddenly require lots of bandwidth, then nothing, then lots of bandwidth, and so forth), GPRS can serve more users than ordinary circuit-switched services. On the other hand, GPRS offers non-bursty applications the same level of service—in terms of throughput—as circuit-switched data. Obviously, in evaluating efficiency, the user traffic model plays a central role.

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