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.

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.

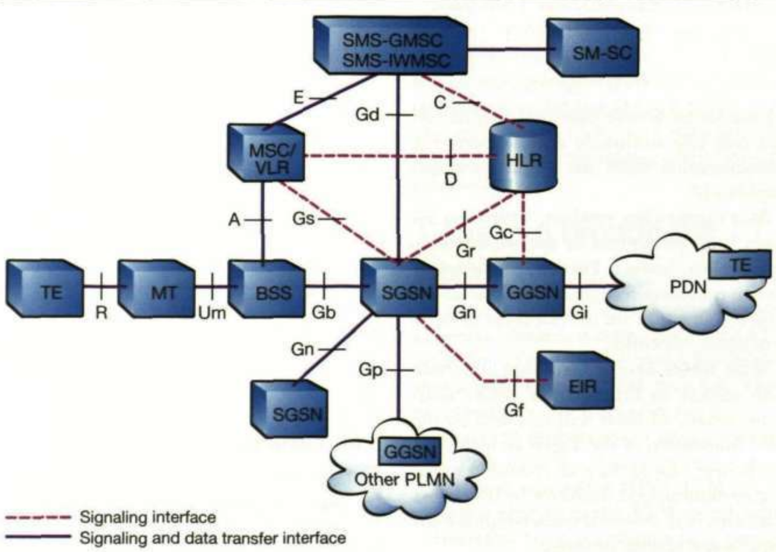
In the GPRS standard, three new types of mobile terminal have been defined:

- 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.

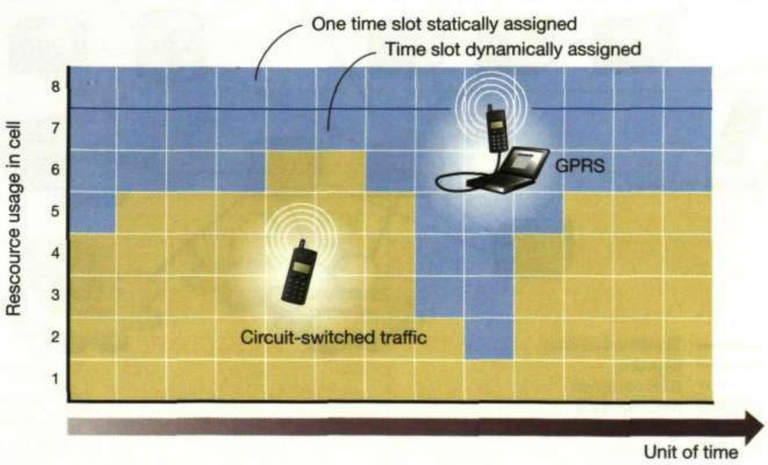
To support efficient multiplexing of packet traffic to and from mobile terminals, a new packet data channel (PDCH) has been defined for the air interface. One PDCH is mapped onto a single time slot, thereby utilizing the same physical channel structure as ordinary circuit-switched GSM channels.

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.

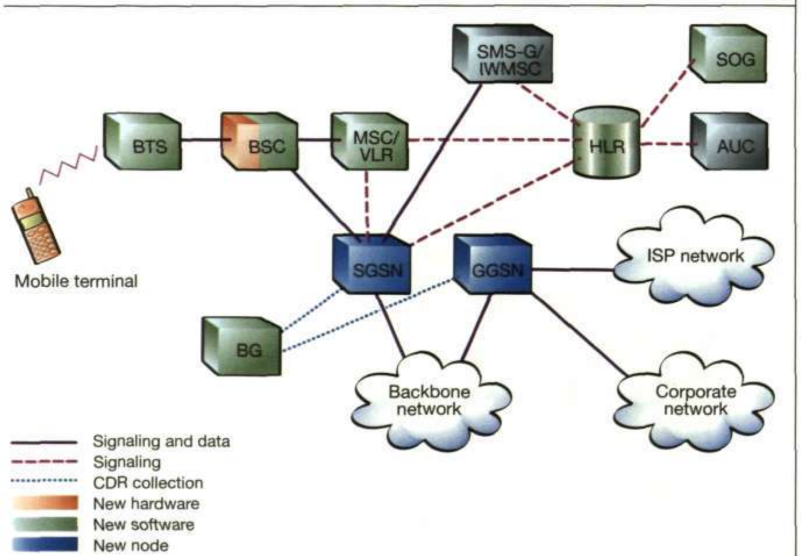
The PDCH consists of a multiframe pattern that runs on time slots assigned to GPRS. This is basically a predefined pattern of GPRS control channels and data traffic channels that keeps repeating itself. In cells defined as having only dynamic GPRS resources and which only run circuit-switched channels, 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

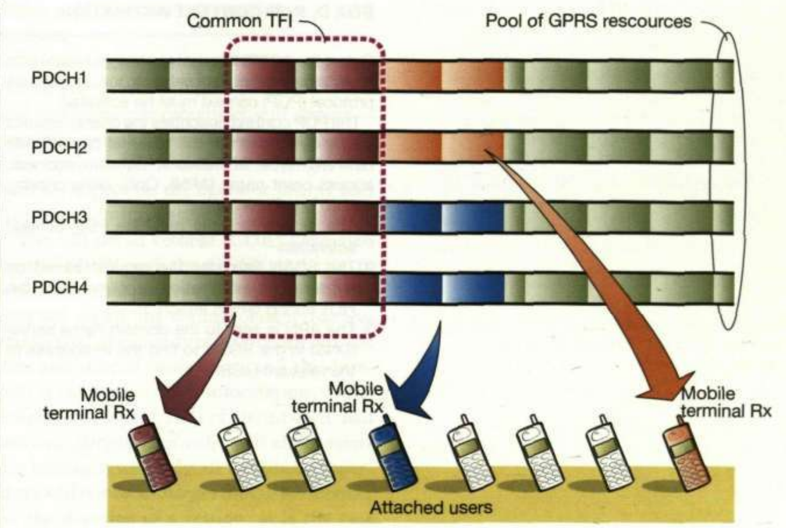


Figure 4
GPRS users share the pool of resources in a cell.

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*).

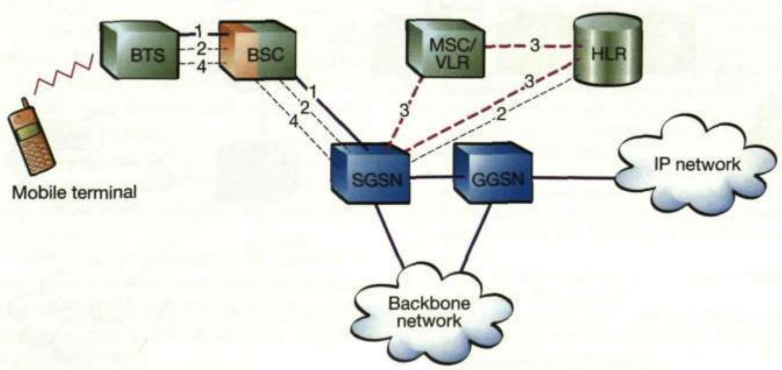


Figure 5
GPRS attach.

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).

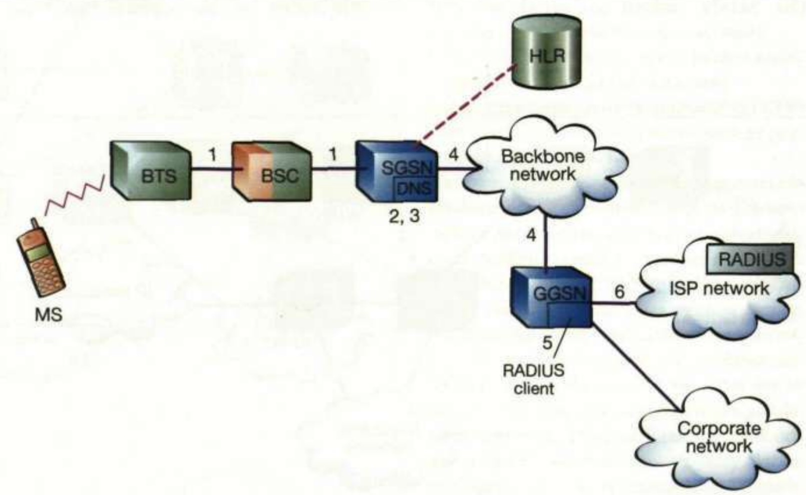
1. The mobile terminal requests PDP context activation.
2. The SGSN validates the request based on subscription information received from the HLR during GPRS attach.
3. The APN is sent to the domain name server (DNS) in the SGSN to find the IP address of the relevant GGSN.
4. A logical connection is 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.



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