# Data Services and GPRS

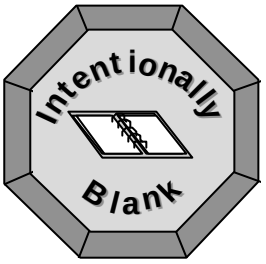
## Chapter 14

This chapter is designed to provide the student with an overview of the data transmission capabilities and services of Ericsson's GSM and GPRS systems.

## OBJECTIVES:

Upon completion of this chapter the student will be able to:

- Describe the data transmission services which GSM offers
- Describe a GSM data traffic case
- Describe the data transmission services which GPRS offers
- Describe a GPRS data traffic case.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# 14: Data Services and GPRS

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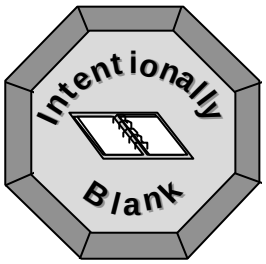


# INTRODUCTION

With the use of data communications, and the internet in particular, there has been an increasing demand for improved data handling capabilities. In recent years the data rates of fixed modems has increased from 9.6kbits/s to 56kbits/s, and the recommended minimum speed is now 28.8kbits/s. GSM phones have been capable of only 9.6kbits/s, and have not been able to effectively compete with fixed networks for data communication purposes.

With Ericsson's GSM systems, a data rate of 48kbits/s is now possible. This gives GSM network operators the possibility to offer new competitive data applications that attract and maintain new end-users.

It is possible to sent and receive data to and from many network types, including:

Public Switched Telephony Network (PSTN)

Integrated Services Digital Network (ISDN)

Circuit Switched Public Data Network (CSPDN)

Packet Switched Public Data Network (PSPDN)

As GSM is limited in data rate capability a new enhancement to GSM has been introduced, known as GPRS (General Packet Radio Service). GPRS offers the subscriber data rates of up to 170kbit/s and will work on existing GSM network to give IP connectivity. In this chapter we will look at both GPRS and GSM data traffic cases and GPRS.

# DATA CONNECTION TYPES

## DTI IMPLEMENTATION

Data services in Ericsson's GSM systems are provided by the hardware device Data Transmission Interface (DTI) and the software of the subsystem Data Transmission Subsystem (DTS).

The basic types of telecommunications connection that the DTI handles are, circuit switched. The circuit is set-up from end to end and is maintained for the duration of the call, regardless of whether it is being used or not. This is suitable for speech calls.

Data can be sent with either of the above methods. For calls using a modem, DTI (Data Transmission Interface) will be used for data speed conversion.

High-Speed Circuit Switched Data (HSCSD) enables up to four time slots for one user connection. The timeslots do not need to be in consecutive order. HSCSD supports the following types of data transmission connections:

- **Transparent:** by adding error correction bits to the basic data, a more reliable connection is ensured. However, the basic data rate is restricted to a maximum of 38.4kbits/s.

- **Non-transparent:** in contrast with transparent connections, this form does not add information to the basic data and is therefore less reliable. However, higher basic data rates are possible - up to 48kbits/s.

The following tables identify the exact data rates capable with each of these connections:

| Time Slots | End-user Data Rate (kbits/s) |
|---|---|
| 1 | 4.8 |
| 2 | 9.6 |
| 3 | 14.4 |
| 4 | 19.2 |

*Table B-1 Transparent data using half-rate channel*

| Time Slots | End-user Data Rate (kbits/s) |
|---|---|
| 1 | 9.6 |
| 2 | 19.2 |
| 3 | 28.8 |
| 4 | 38.4 |

*Table B-2 Transparent data using full-rate channel*

| Time Slots | End-user Data Rate (kbits/s) |
|---|---|
| 1 | 12 |
| 2 | 24 |
| 3 | 36 |
| 4 | 48 |

*Table B-3 Non-transparent data using full-rate channel*

Within standard GSM network all connections are circuit switched. In order to access a PSPDN, a connection to Packet Assembler/Disassembler (PAD) is needed.

# IMPLEMENTATION IN ERICSSONS GSM SYSTEMS

The DTI (Data Transmission Interface) implements the GSM Inter-Working Function (IWF) for data communications. It performs data handling functions such as data rate conversion and provides the functions necessary for data interworking between the GSM network and other networks, including the following:

- **Traffic to/from PSTN:** this involves modem and fax calls. For connections to the PSTN a modem is selected by the DTI to perform the necessary rate and format conversions.
- **Traffic to/from ISDN:** the entire set of data communications towards ISDN is available, since the MSC is capable of signaling and mapping basic service information between the ISDN and the GSM network.
- **Traffic to/from PSPDN:** the packet services use the bit-oriented synchronous service in GSM. Supported user data rates are 2.4, 4.8, and 9.6 kbits/s. This service consists of two establishment phases. The MSC/VLR establishes the call to a Packet Handler (PH) or to an Access Unit (AU), while the second phase establishes the call to the X.25 terminal in-band
- **Traffic between Mobiles:** the data traffic inside the PLMN has to pass through the DTI to handle the protocol used for rate adaptation in the radio path.
- **HSCSD:** High Speed Circuit Switched Data (HSCSD) allows the connection of 2, 3, or 4 timeslots on one radio channel each carrying 9.6 kbits/s. PSTN connections supporting V.34 modems (up to 28.8 kbits/s) and ISDN connections using rate adaptation are possible.
- **HDLC Encapsulation on ISDN:** the Interworking Function (IWF) supports High level Data Link Control (HDLC) encapsulation in order to handle Point to Point Protocol (PPP) and X.75 protocol links via the ISDN networks. This will allow a maximum data rate of 9.6 kbits/s (38.4 kbits/s using HSCSD) excluding start and stop bits which are included in UDI calls using V.110 protocol.

- **Bearer Services:** with a bearer service, the GSM network provides a transmission path for data between two access points and also a user-network interface. The network will be responsible for delivering in one interface what was received in the other. Interworking attributes may be defined for supporting bearer services over transit networks.

  These Bearer Services will enable a subscriber to run applications like:

  – E-mail
  – Database access
  – File transfer
  – Digital communication with an ISDN terminal
  – Access to a Packet Assembly/Disassembly (PAD) port in PSPDN, providing access to X.25 services

# DATA CALL TRAFFIC CASE

## *HSCSD DURING A CALL*

Each MS is assigned a multislot class which, when sent to the network, identifies the number of time slots which the MS can handle simultaneously.

During call set-up, by default, the network chooses the maximum rate possible, limited by the MSs multislot class and by a user-set maximum number of time slots.

The number of time slots in use during a call is dynamic and can be changed by any of the following events:

- **User action:** the user may choose to decrease or increase the number of simultaneous time slots that they are using. The user may wish to reduce their bandwidth due to costs or because they do not need it for some time during a call (e.g. when browsing a directory) and may wish to increase bandwidth later in the call (e.g. for file transfer).

- **Handover:** the network attempts to assign the same number of time slots in the new cell. If this is not available, the network reduces the number being used and informs the MS to do so also.

- **Cell congestion:** the network may choose either to prioritize incoming calls or reduce the number of time slots, which the HSCSD user is using.

The network reduces the number of time slots, in the handover or cell congestion cases, if a time slot becomes available at a later stage, the network may assign it to the HSCSD user.

## EXAMPLE: DATA CALL TO PSPDN

As explained previously, each MSC/VLR must have a dedicated DTI to handle data calls. The MSC/VLR is always in control of the data call and can execute changes in the resources despite the MS mobility.

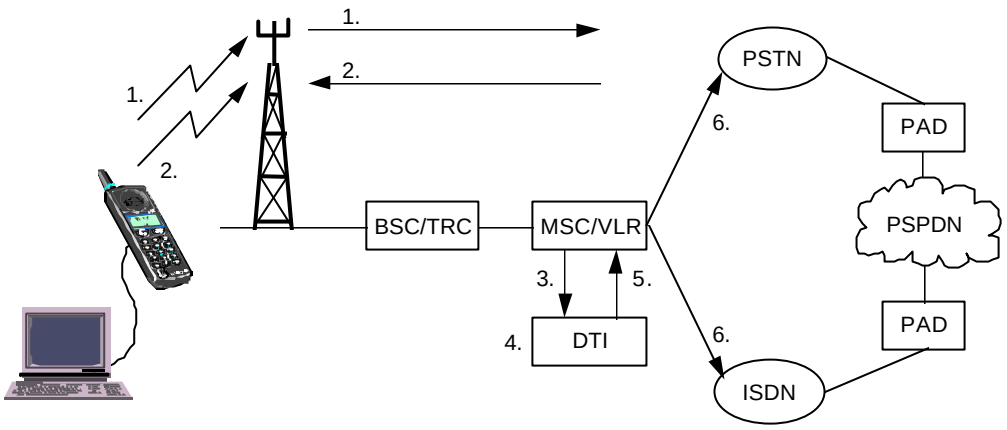



*Figure 14-1 Data call*

1. An MS initiates a data call. In the call set-up message, the MSs multislot class is included along with the Bearer Capability (BC) requested. The BC includes the bearer service type (fax, data) and the requested transmission rate.
2. A connection between the MS and the network is set-up, as in a normal call, and authentication is performed.
3. The MSC/VLR analyzes the BC. The B–number and the BC are transferred to the DTI.
4. The DTI is configured to perform the required service (i.e. rate adaptation, fax or modem service).
5. The DTI re-routes the call to the MSC/VLR.
6. The MSC/VLR routes the call to the destination network. (PSPDN is used as an example in the figure above.) The connection to this network may be via an existing network such as the PSTN or ISDN.

# GPRS SYSTEM

Ericsson's GPRS (General Packet Radio Service) system is an additional service to the GSM system and supports end users that wish to access the Internet or a corporate LAN, using a packet data MS as the connecting device. The GPRS system provides a basic solution for Internet Protocol (IP) communication between Mobile Stations and Internet service hosts (IH) or a corporate LAN. This is done with:

- Efficient use of scarce radio resources
- A flexible service, with volume based (or session duration based) billing
- Fast set up and access time
- Simultaneous GSM and GPRS services, coexistance without disturbances.

GPRS is a packet switching technology. The circuit is set up from end to end when it is necessary to transmit or receive information. With each new packet a different connection may be used. This is better suited to applications that have bursty type of transmissions, for example, internet browsing.

The solution for IP communication between MS and IH permits services beyond those that GSM can provide.

The MS can consist of one Mobile Terminal (MT) which is a GSM telephone, and one Terminal Equipment (TE), which is a computer that is connected to the MT. The MS can also be a MT and TE integrated into the one piece of equipment.

GPRS data transfer is based on the Internet Protocol (IP). The packet data transmission is thus carried out on an end-to-end basis, including air interface. By introducing the GPRS system into the GSM system, it is possible to co-ordinate, attach, authenticate and handle subscriber and terminal data for both circuit-switched and packet-switched communication.

The packet data function does not interfere with the circuit-switched services offered by GSM. Data packets sent from the MSs can use different radio channels for different packets during transmission. An

MS can be used for both circuit-switched or packet-switched communication or for either packet-switched and circuit-switched communication.

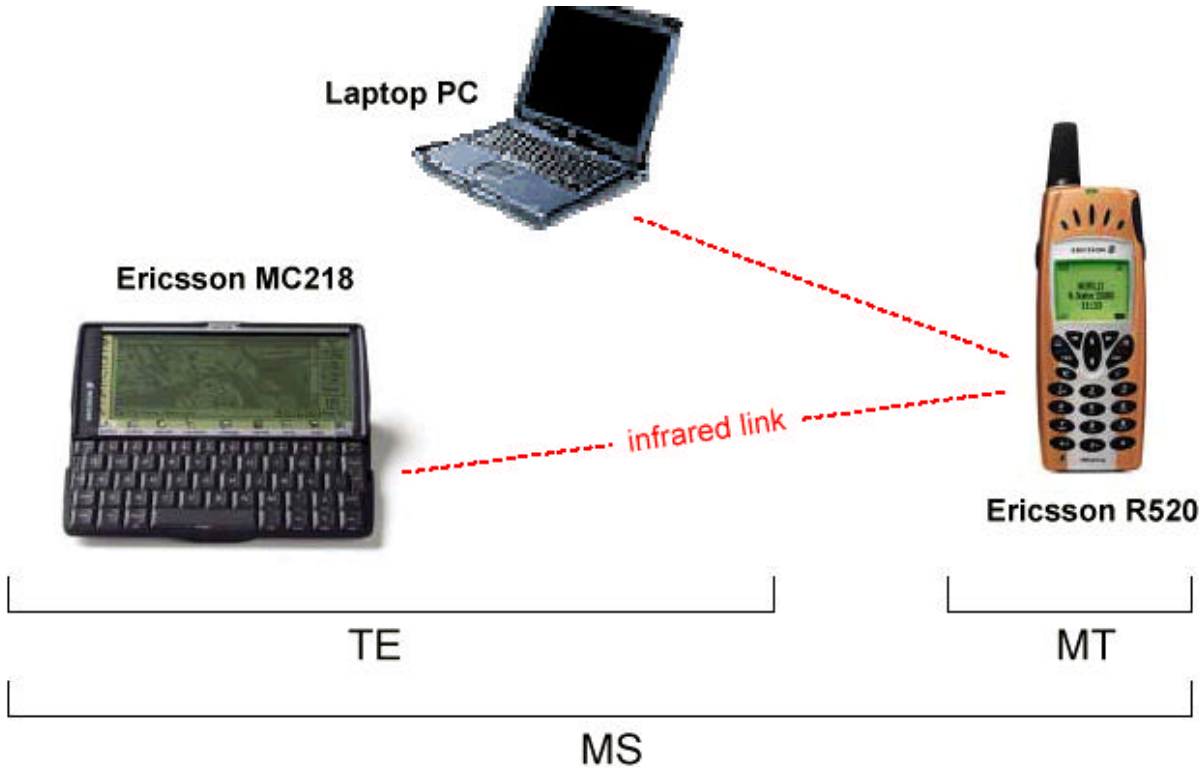



*Figure 14-2 Terminal Equipment (TE) and Mobile Terminal (MT) = Mobile Station (MS)*

## GPRS

The parts of the Ericsson GPRS system that carry out the switching part of the packet data are called the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node. The SGSN provides packet routing to and from the geographical SGSN service area.

The GGSN makes up the interfaces towards the external IP networks. The SGSN and GGSN are physically separated from the circuit-switched part of the Ericsson GSM System. The other parts of the Ericsson GPRS architecture utilize current GSM network elements.

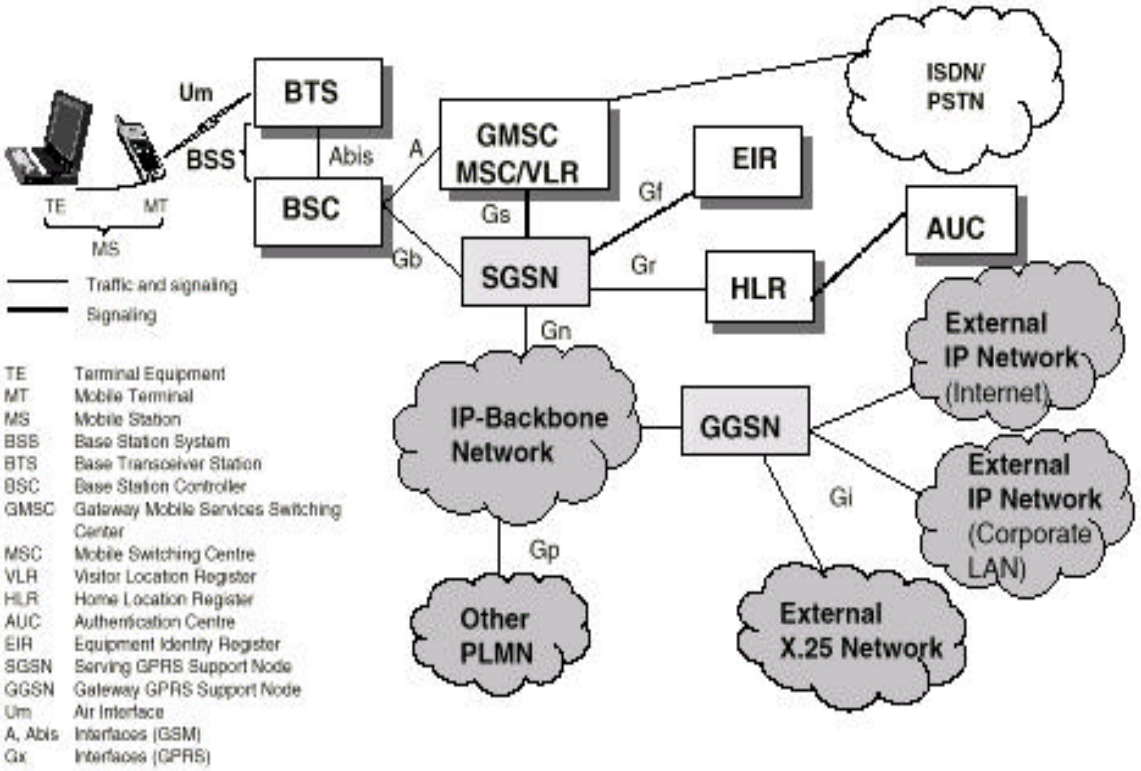



*Figure 14-3 GPRS logical Architecture*

An overview of the system components is shown in the above diagram and briefly explained below.

## MOBILE STATIONS

Depending on the MS and the network capabilities, GPRS MS can operate in three different modes:

- Class A mode of operation: Allows an MS to have a circuit-switched connection at the same time that it is involved in a packet transfer.

- Class B mode of operation: Allows an MS to be attached to both CS and PS, but it can not use both services at the same time. However, an MS that is involved in a packet transfer can receive a page for circuit-switched traffic. The MS can then suspend the packet transfer for the duration of the circuit-switched connection and afterwards resume the packet transfer.

- Class C mode of operation: Allows an MS only to be attached to one service at the time. An MS that only supports GPRS and not circuit-switched traffic will always work in class C mode of operation.

## BASE STATION SUBSYSTEM (BSS)

The Base Station System (BSS) consists of a Base Station Controller (BSC) and a Base Transceiver Station (BTS). The BTS is the radio equipment, which transmits and receives information over the air to let the BSC communicate with the MS in the BSCs service area.

A group of BTSs is controlled by a BSC. The BTS must contain GPRS-specific software.

The BSC provides all radio-related functions. The BSC can set up, supervise and disconnect circuit-switched and packet-switched calls. It is a high capacity switch that provides functions including handover, cell configuration data and channel assignment.

The BSC must be equipped with GPRS hardware, Packet Control Unit (PCU) and software when used for GPRS. One or several BSCs are served by an MSC and a number of BSCs are served by an SGSN.

## MOBILE SERVICES SWITCHING CENTER (MSC)

The Mobile services Switching Center (MSC) performs the telephony switching functions of the GSM circuit-switched system, like the SGSN switches the GSM packet-switched traffic. It controls calls to and from other telephony and data systems, such as the Public Switched Telephone Network (PSTN), Integrated Services Digital Network (ISDN), Public Land Mobile Network (PLMN), Public Data Networks, and possibly some private networks.

The SGSN Routing Area (RA) is a subset of the MSC Location Area (LA). An MSC Location Area is a group of BSS cells. The system uses the LAs to search for subscribers in the active state. A LA is the part of the network in which an MS may move around without reporting its location to the network.

## HOME LOCATION REGISTER (HLR)

The Home Location Register (HLR) is the database that holds subscription information for every person who has bought a subscription from the GSM/GPRS operator. The HLR stores information for CS and for PS communication. Information found in the HLR includes supplementary services, authentication parameters,

Access Point Name (APN) such as the subscribers Internet Service Provider and whether a static IP address is allocated to the MS.

In addition, the HLR includes information about the location of the MS.

For GPRS, subscriber information is exchanged between HLR and SGSN. Note that the authentication triplets for GPRS are retrieved directly from the HLR to the SGSN, i.e. it does not pass the MSC/VLR as it does for CS GSM.

The information going from HLR to SGSN has been set up by the operator for the subscriber. This information transfer is done when the operator changes the subscriber information, or when a new SGSN needs to have data for a subscriber after attach or roaming.

The old SGSN is also informed of the roaming. The information going from SGSN to HLR is the routing information that is transferred upon MS action e.g. attach or roaming. For a roaming MS the HLR may be in a different PLMN than the SGSN serving the MS.

## *VISITOR LOCATION REGISTER (VLR)*

The Visitor Location Register (VLR) database contains information about all MSs that are currently located in the MSC location area or SGSN routing area respectively. The SGSN actually contains the VLR functionality for packet-switched communication. Similarly, the circuit-switched VLR is an integrated component of the Ericsson MSC.

The VLR contains temporary subscriber information needed by the MSC or SGSN to provide services for visiting subscribers. When an MS roams into a new MSC location area or SGSN routing area, the VLR of that MSC or SGSN requests and stores data about the MS from the HLR. If the MS makes a call at another time, the necessary information for that call setup will be available immediately.

## SERVING GPRS SUPPORT NODE (SGSN)

The SGSN is a primary component in the GSM network using GPRS and is a new component in GSM. The SGSN forwards incoming and outgoing IP packets addressed to/from a MS that is attached within the SGSN service area.

The SGSN provides packet routing and transfer to and from the SGSN service area. SGSN serves all GPRS subscribers that are physically located within the geographical SGSN service area. A GPRS subscriber may be served by any SGSN in the network, all depending on the location. The traffic is routed from the SGSN to the BSC, via the BTS to the MS.

SGSN also provides:

- Ciphering and authentication
- Session management
- Mobility management
- Logical link management toward the MS
- Connection to HLR, MSC, BSC, GGSN and other nodes
- Output of billing data

## GATEWAY GPRS SUPPORT NODE

Like the SGSN, the Gateway GPRS Support Node (GGSN) is a primary component in the GSM network using GPRS and is a new component.

- The GGSN provides the interface toward the external IP packet networks. The GGSN therefore contains access functionality that interfaces with external ISP (Internet Service Provider) functions like routers and RADIUS (Remote Access Dial-In User Service) servers, which are used for security purposes. From the external IP networks point of view, the GGSN acts as a router for the IP addresses of all subscribers served by the GPRS network. The GGSN thus exchanges routing information with the external network.

- GPRS session management and communication setup towards an external network.
- Functionality for associating the subscribers with the right SGSN.
- Output of billing data. The GGSN collects billing information for each MS, related to the external data network usage. Both the GGSN and the SGSN collect billing information on usage of the GPRS network resources

## EQUIPMENT IDENTITY REGISTER (EIR)

The EIR is a database containing mobile equipment identity information, which helps to block calls from stolen, unauthorized, or defective MSs.

## AUTHENICATION CENTER (AUC)

The AUC is a GSM-specified entity that provides triplets to the authentication and ciphering process used within GSM. The authentication for GPRS and for GSM subscribers is the same. The change in security for GPRS is related only to ciphering. This change does not require an update for AUC.

# GPRS TRAFFIC CASES

In order to receive or transmit data the end user needs to perform a two step procedure. GPRS attach (step 1) and PDP context activation (step 2).

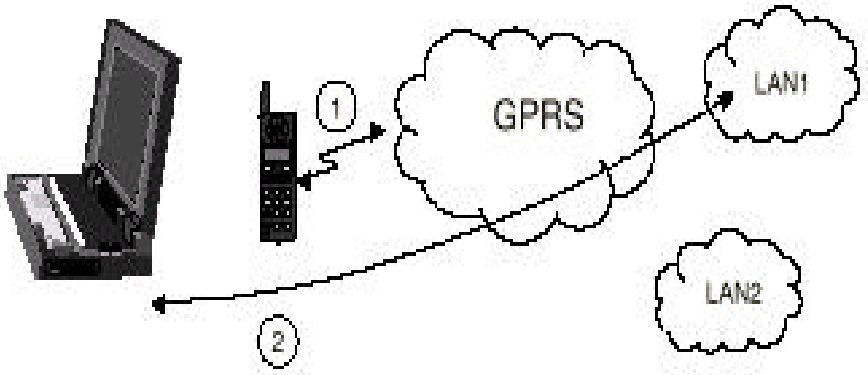



*Figure 14-4: GPRS Attach (1) and PDP context Activation (2)*

## *GPRS ATTACH*

At GPRS attach, a logical link is established between the MS and the SGSN. Similar to a GSM attach in that you "power on" an MS, but in a GPRS network.

## *PDP CONTEXT ACTIVATION*

In order to send and receive GPRS data the MS performs PDP context activation after the GPRS attach. The PDP context activation makes the MS known in the concerned GGSN and communication to external networks is made possible.

The PDP context activation, from the end user's perspective corresponds to "logging on" to an external network, i.e. his corporate LAN, his ISP or to the Service LAN provided by the GPRS operator.

The difference from using a dial-up connection over circuit switched is that in GPRS the end user can have several PDP contexts activated simultaneously if the terminal supports several IP-addresses.

At MS detach all PDP contexts for the MS are deactivated.

A logical link between the MS and SGSN is established through the GPRS attach. The next step is a PDP context activation. This makes it possible to reach an external network (LAN). Figure 14-5 illustrates the steps in the procedure of PDP context activation. Each step is explained in the following list.

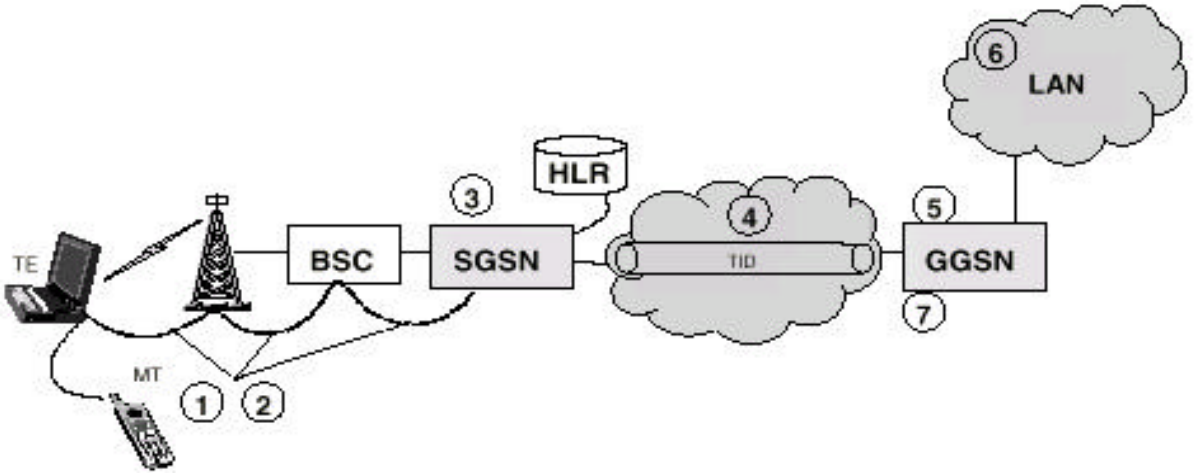



*Figure 14-5 PDP Context Activation*

1) MS sends PDP context activation request to SGSN.

2) Security functions may be executed between MS and SGSN.

3) SGSN validates request.

4) SGSN will

- Check subscription
- Check quality of service (needed for charging)
- Send Access Point Name (APN) to GGSN
- Create a TID, Tunnel IDentity
- Create a logical link to the GGSN, a GTP (GPRS

Tunneling Protocol) tunnel

5) GGSN contacts an external network (LAN) and ask for an IP-number

7) The server in the external network sends the IP-number to GGSN.

8) GGSN sends the IP-number back to the MS

After step 8 a connection between the MS and the external network is established.

The subscriber is now free to download data from any external network.

## *UPDATE PROCEDURES*

A Routing Area (RA) is a subset of the Location Area (LA) and is specific to GPRS systems.

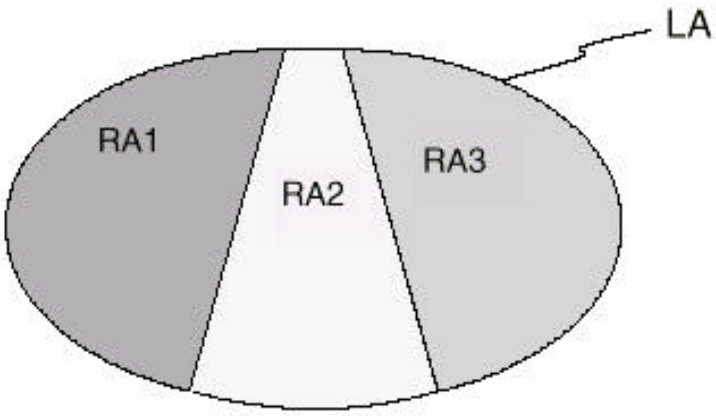



*Figure 14-6 Routing Area= RAC + LAI*

*RAC = Routing Area Code, LAI = Location Area Identification*

Three different scenarios can appear when the MS enters a new cell and possibly a new routing area. They are

- Cell update
- Routing area update
- Combined routing area and location area update

## CELL UPDATE

A cell update takes place when the MS enters a new cell inside the current RA, if the MS is in "ready state" (the phone is powered on and actively downloading information from the external network).

If the RA is changed also, a RA update takes place instead of the cell update. The MS performs the cell update by sending a message up to the SGSN containing the MS identity. The SGSN records the MS change of cell and the following traffic to the MS will be conveyed over the new cell.

## ROUTING AREA UPDATE

A routing area update takes place when any of the following three activities occur:

- The MS has entered a new routing area
- The periodic RA update timer has expired
- A suspended MS (Class B) due to an incoming circuit-switched call may require to do a routing area update request after the CS call has been released.

The procedure is initiated by a Routing Area Update Request from the MS to the SGSN. The updates can either be an Intra SGSN Routing Area Update (when the SGSN has the required information about the MS) or an Inter SGSN Routing Area Update (when the new SGSN gets information about MS from the old SGSN).

## COMBINED RA/LA UPDATE PROCEDURE

A combined RA/LA update takes place in a network when the MS enters a new RA or when a GPRS attached MS performs IMSI attach. The procedure is initiated by a Routing Area Update Request indicating that a LA update must also be conducted. The SGSN forwards the LA update to the VLR.

# ENABLING TECHNOLOGIES

As previously described GPRS enables the subscriber to have IP connectivity. As such we refer to GPRS and similar technologies as enablers or enabling technologies.

Examples of other enabling technologies include:

Bluetooth: Makes it possible to have wireless data services all the way to mobile and user applications.

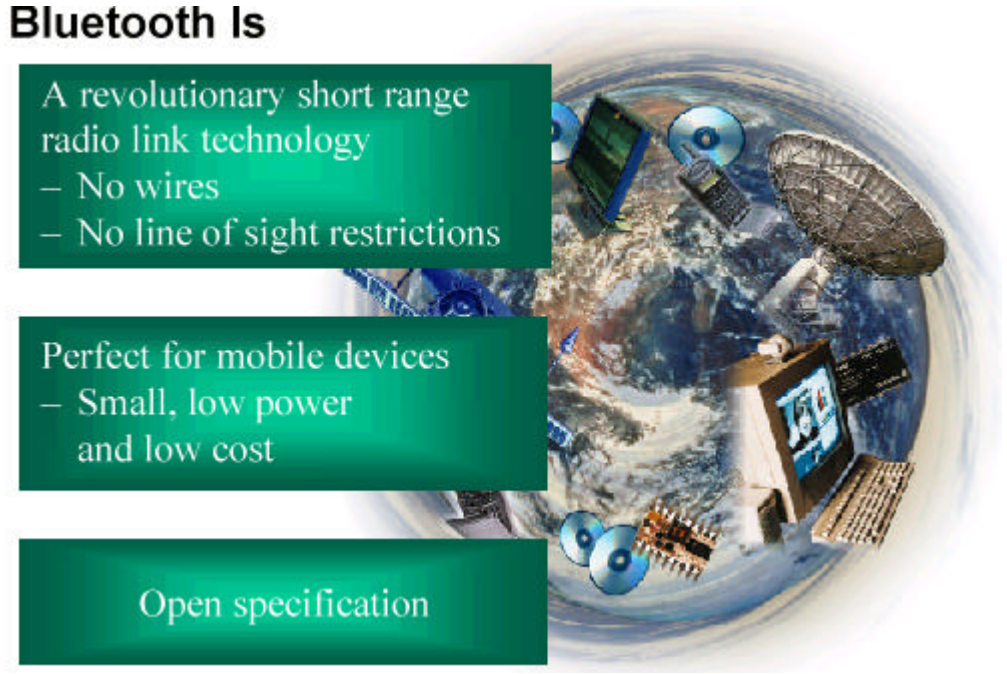
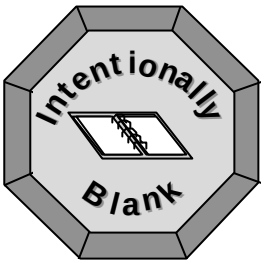



*Figure 14-6 Bluetooth*

- EPOC: Symbian is the provider of this Open Operating System. EPOC is a scalable, low power, low price OS which is open for third party applications.

- WAP (Wireless Application Protocol): Brings Internet content and advanced telephony services to digital cellular phone users. Optimised for narrowband bearers and hand held devices with limited capability.

Together, these technologies make it possible to access Internet content instantly in a hassle free way.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