Chapter 2 Data services in GSM system

Part 2 General Packet Radio Service (GPRS)

What GPRS is:

- Packet-switched high speed mobile data
- An efficient approach to upgrade the existing GSM system to a packet-switched system (2.5G)
- Remains online when turned on.
What GPRS is not:

- The Internet in your pocket
- Unlimited mobile bandwidth
- The ultimate goal of high speed mobile data

The business perspective of GPRS

Transmission rates:

<table>
<thead>
<tr>
<th></th>
<th>1 Timeslot</th>
<th>2 Timeslots</th>
<th>8 Timeslots</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-1:</td>
<td>8.0 kbit/s</td>
<td>16.0 kbit/s</td>
<td>64.0 kbit/s</td>
</tr>
<tr>
<td>CS-2:</td>
<td>12.0 kbit/s</td>
<td>24.0 kbit/s</td>
<td>96.0 kbit/s</td>
</tr>
<tr>
<td>CS-3:</td>
<td>14.4 kbit/s</td>
<td>28.8 kbit/s</td>
<td>115.2 kbit/s</td>
</tr>
<tr>
<td>CS-4:</td>
<td>20.0 kbit/s</td>
<td>40.0 kbit/s</td>
<td>160.0 kbit/s</td>
</tr>
</tbody>
</table>
Applications of GPRS

- Fast Internet access and e-mail transfer
- Mobile leased-line provisioning
- New services:
  - Toll road services
  - Burglar alarm systems
  - Navigation systems

Some GPRS details

- Resource limitations:
  - Network operators will start with a 2:1 configuration per cell: 2 timeslots in downlink direction, 1 timeslot in uplink direction can be allocated to GPRS
  - Are there enough IP address for all mobile subscribers?

- Shared medium:
  - Existing voice services will still require the bulk of the resources
  - Infrastructure upgrade will take time
Obstacles for mobile packet switching

- Instantaneous but short-time seizure and release
  - Especially in case of bursty transactions
- Data packet headers will add overhead
  - Important issue for a mobile network environment with scarce air interface resources
- Synchronization of network usage in uplink direction
  - Distinguish between initial access and network usage during a transaction
- Power control
- Handover
- Propagation delay

Requirements for a GPRS network (1)

- Cost efficiency
  - Reuse as much hardware of existing GSM infrastructure as possible
- Provide support for multiple packet data protocols
  - Current GPRS supports IP, PPP and IHOSS
- Support the transfer of short messages (SMS)
- Provide for different charging options
  - Duration, volume, content, etc.
PPP: Point to point protocol

- Used for the establishment of dial-up connections over serial links to the Internet
  - LCP: link control protocol. Establishment of layer 2 point-to-point connections and configuration of the connection parameters
  - PAP, CHAP: password authentication protocol, challenge handshaking authentication protocol. Authentication between terminal and host
  - NCP, IPCP: network control protocol, Internet protocol control protocol. Establishment and configuration of network layer protocol.

IHOSS

- IHOSS: Internet hosted octet stream service
- Together with OSP (OSP:IHOSS), provides a character-based transmission pipe between the MS and GGSN. Within the GGSN, a relay function maps the octet stream to a transport protocol on the Internet side
- OSP: Octet Stream Protocol
- PAD: Packet Assembler/Disassembler

Requirements for a GPRS network (2)

- Long term investment
  - Operators want to make sure that GPRS hardware is future-proof to allow for a later migration to EDGE (Enhanced Data Rates for Global Evolution) or IMT-2000

- Compatibility to alternative air interface technologies
  - In order to support IS-136+ and UWC (Universal Wireless Communications)

- The GPRS network shall provide broadband mobile access to the Internet
Implications for the GPRS network

- Leave the GSM base station subsystem (BSS) almost unchanged
- Add a packet-switched core network to the GSM-network switching subsystem (NSS)

A small extension within BSS:
- The packet control unit (PCU) is added to
  - Interface data packets to the unchanged GSM-BSS
  - Control and manage most of the radio related functions of GPRS
Different locations of PCU

An entirely new GPRS core network is required:

- GPRS core network consists of:
  - Serving GPRS support node (SGSN)
  - Gateway GPRS support node (GGSN)
  - Border gateway (BG)
Functions of the serving GPRS support node (SGSN) (1)

- SGSN is a packet-switch
  - SGSN needs to route incoming data to the right destination

- Data compression
  - SGSN applies data compression according to RFC 1144 and V. 42bis. Note that RFC 1144 can only be used to compress the header of TCP/IP data units

- Ciphering
  - In contrast to genuine GSM, where the BTS takes care of speech and data encryption, in GPRS the SGSN is responsible

Functions of the serving GPRS support node (SGSN) (2)

- Being the ultimate peer for the mobile station
  - Within the GPRS core network, SGSN is the main partner for the mobile station

- Mobility management
  - SGSN keeps track of a subscriber’s location down to the routing area and, in ready state, even down to the BTS level

- Charging
  - SGSN needs to collect charging information related to the usage of its corresponding network, and in particular, the usage of the air interface
Functions of the serving GPRS support node (SGSN) (3)

- **Handoff/cell change**
  - In case of a cell change during an ongoing packet data transfer, SGSN needs to take care that unacknowledged packets are routed to the new cell and, in case of a change of SGSN, that the new SGSN receives the unacknowledged packets and all new packets.

Functions of the gateway GPRS support node (GGSN)

- **Gateway to external packet data networks**
  - The GGSN interconnects a PLMN to external packet data networks.

- **Anchor function during packet data transactions**
  - The GGSN will remain the anchor point for external packet data networks even after the SGSN has changed due to cell change.

- **Charging**
  - Contrary to SGSN, GGSN collects charging information based on the usage of external network resources.
Functions of the border gateway (BG)

- Message screening /security
  - All transactions that involve the usage of the external PLMNs are screened by the BG to provide a maximum level of security for a network operator.

Geographical considerations

- SGSN is dedicated to a limited area
  - As SGSN is supporting a limited number of BSSs, it is limited to the very area that is covered by these BSSs. In that respect, SGSN can be compared with the circuit-switched MSC.

- GGSN is dedicated to the PLMN
Mobile stations in GPRS

- For GPRS, three different categories have been defined:
  - Class A: the mobile station can simultaneously perform circuit-switched and GPRS transactions
  - Class B: the mobile station can monitor circuit-switched and packet-switched services but cannot operate both simultaneously
  - Class C: the mobile station is limited to the monitoring and operation of either GPRS or circuit-switched services
52-multiframe is used in GPRS

Some features of 52-multiframe:

- 12 radio blocks for the different packet data channels (PDCH)
- Each radio block consists of 4 consecutive appearances of the same timeslot within 4 consecutive TDMA-frames
- Resource allocation in uplink and downlink is done on block level
- 2 TDMA frames are reserved for Timing Advance (TA) Control (to correct for propagation delay differences)
- 2 idle (I) TDMA frames for interference measurements
Packet data channels (PDCHs) are logical channels:

- PDCHs are mapped on one or more timeslots of one or more carriers
- PDCHs use the 52-multiframe structure
- PDCHs can be allocated dynamically by the system
- PDCH is an overall description for a whole bunch of new logical channels

Overview

No dedicated signaling channel in GPRS
Names and functions of the various PDCHs (1)

- **PBCCH** (Packet broadcast control channel)
  - PBCCH is used to broadcast GPRS-related information about a cell to all GPRS-enabled mobile stations that are currently camping on that cell. Contrary to BCCH, PBCCH can be configured on each timeslot of each ARFCN (frequency carrier).

- **PRACH** (packet random access channel)
  - PRACH is used to convey the initial network access message from the mobile station to the network (PCU). PRACH is the only uplink PCCCH.

- **PAGCH** (Packet access grant channel)
  - PAGCH is used to convey the assignment of dedicated uplink or downlink resources to a mobile station. PAGCH belongs to the group of PCCCHs.

Names and functions of the various PDCHs (2)

- **PCCCH** (packet common control channel)
  - PCCCH includes PRACH, PAGCH, PPCH and PNCH. Note that packet-related control information can also be transmitted on CCCH if there is no PCCCH allocated in a cell.

- **PPCH** (packet paging channel)
  - PPCH is used to transmit a paging message for GPRS or circuit-switched services to the mobile station. Additionally, PPCH can be used to send a downlink resource allocation to the mobile station.

- **PNCH** (packet notification channel)
  - PNCH is used to notify a mobile station about upcoming Point-to-multipoint (PTM) transaction.
Names and functions of the various PDCHs (3)

- **PDTCH (packet data traffic channel)**
  - PDTCH is the bearer for all packet data that is being transferred in uplink and downlink directions. The GPRS mobile station may transmit and receive simultaneously on one or more PDTCHs. Contrary to the circuit-switched TCH, PDTCH is unidirectional.

Names and functions of the various PDCHs (4)

- **PACCH (packet associated control channel)**
  - PACCH is the only PDCH that is available in both directions during a unidirectional GPRS transaction. PACCH is used to transmit RLC/MAC control information between PCU and the mobile station.

- **PTCCH (packet timing advance control channel)**
  - For this control channel, a distinction needs to be made for PTCCH/U (uplink) and PTCCH/D (downlink). PTCCH is only applicable in the 52-multiframe positions 12 and 38 in uplink and downlink direction.
Timing advance control in GPRS

- Three alternatives for timing advance control:
  - Dedicated mode
  - Continuous timing advance update procedure
  - Timing advance update using polling and access bursts

- Dedicated mode:
  - This method is only applicable in case of uplink TBFs (temporary block flow)
  - During uplink TBF, the mobile station will send data blocks to the BTS
  - The BTS uses TSC within the received bursts to determine the updated TA-value
  - The updated TA-values will be sent back to the mobile station in a dedicated control message

Timing advance control: continuous timing advance update procedure (1)

- PTCCH/U is divided into 16 subchannels within 8 52-multiframes
- The 16 subchannels can be assigned to 16 different active stations
- Each PTCCH/U subchannel repeats every 416 TDMA-frames (1.92s)
- The active mobile stations will transmit one access burst with TA=0 to the BTS once per eight 52-multiframes within “their” subchannel
Timing advance control: continuous timing advance update procedure (2)

- Based on the PTCCH/U transmission, the network can calculate the timing advance value.
- The updated TA-values can be conveyed to up to 16 different mobile stations in the TA-message.
- The TA-message is carried within 4 consecutive PTCCH/D frames (CS-1). The format of the TA-message is given below.

Timing advance control: continuous timing advance update procedure (3)
Timing advance update procedure using polling and access bursts

- A PACK_POLL_REQ message is sent to the mobile station, specifying one uplink radio block.
- The mobile station will use this uplink block to send a PACK_CTRL_ACK message to the BTS.
- This PACK_CTRL_ACK message is formatted as 4 identical access bursts (either 8 or 11 bit). The access bursts are sent with TA=0.
- Dependent on the time of arrival, the BTS can determine the TA and transmit this new value in a dedicated control message to the mobile station.