General Packet Radio Service (GPRS)

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Content

- Network Architecture
- Network Components
- Channels
- Mobility Management
- Quality of Service

Jump to Packet World and Higher Speeds

- GSM subscribers have used the 9.6-kb/s circuit-switched (CS) symmetric ''pipe'' for data transfer.
- Due to the Internet and electronic messaging, a couple of enhancements have been introduced.
- First, channel coding is optimised. By doing this the effective bit rate has increased from 9.6 kb/s up to 14 kb/s
- Second, to put more data through the air interface, several traffic channels can be used instead of one.
- This arrangement is called ''High Speed Circuit Switched Data'' (HSCSD).

- In an optimal environment an HSCSD user may reach data transfer using 40–50 kb/s data rates
- Technically, this solution is quite straightforward.
- Unfortunately, it wastes resources and some end-users may not be happy with the pricing policy of this facility
- Another issue is the fact that most of the data traffic is asymmetric in nature; that is,
  - Typically a very low data rate is used from the terminal to the network direction (uplink) and higher data rates are used in the opposite direction (downlink).

General Packet Radio Service (GPRS) Network

- GPRS network architecture is **based** on that of GSM
- Two **new nodes** are added for handling packet data
  - Serving GPRS Support Node (SGSN)
  - Gateway GPRS Support Node (GGSN)

Packet Switching Vs. Circuit Switching

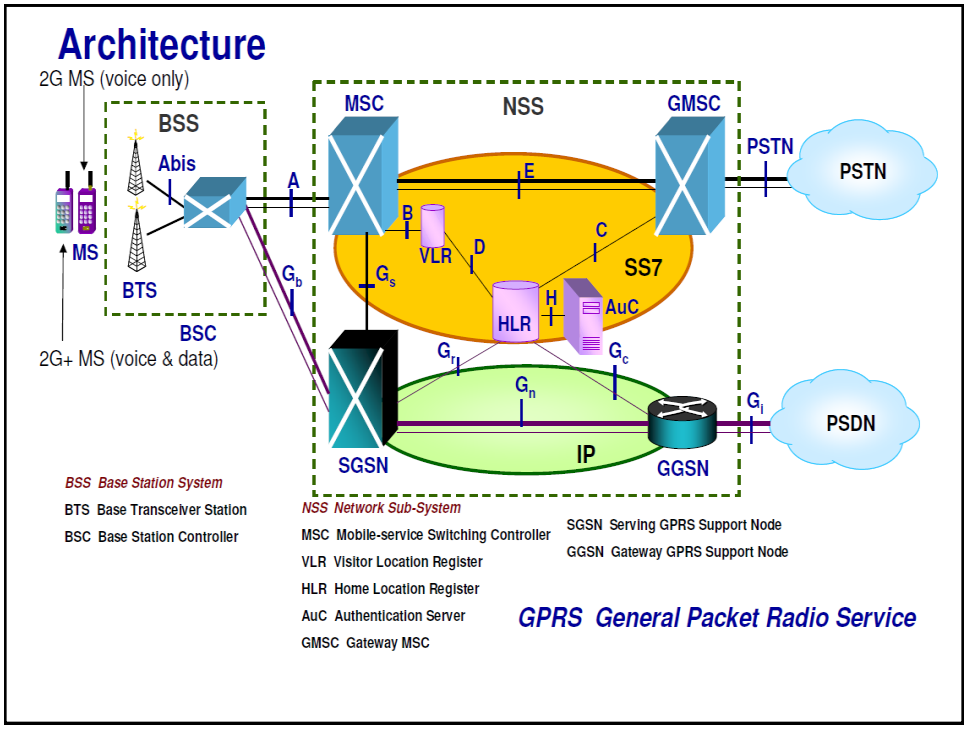
item	C-s	P-s
Call setup	required	Not needed
Dedicated physical path	Yes	no
Each packet follows the same path	yes	no
Packets arrive in order	yes	no
Is a switch crash fatal	yes	no
Bandwidth available	fixed	dynamic
When can congestion occur	At setup time	On every packet
Store and forward transmission	no	yes
Potentially wasted bandwidth	Yes	no

Circuit Switched Data (CSD)

- **Before GPRS**
  - A channel is allocated to user for duration of connection
- Inefficient use of resources
- Time-based billing
- Resources allocated to communication
- **In GPRS**
- Resources are allocated to user only for the time it takes to send each packet
- A channel may be shared by many users
- User pays by the packet
- Ideal for “data” traffic

High Data Rate

- Radio channel width = 200 kHz
- Radio channel carries digital data stream = 271 kbps
- This is divided into 8 time slots each carrying 34 kbps
- After correction data rate per time slot = 14 kbps
- GPRS can combine up to 8 time slots giving data rate of 114 kbps



The different interfaces between different network elements

FYI

- G_b (between PCU and SGSN) is a frame relay-based interface using BSS GPRS protocol (BSSGP).
- G_r (between HLR and SGSN) is an SS7-based interface using MAP.
- G_s (between MSC/VLR and SGSN) is an SS7-based interface using Signaling Connection Control Part (SCCP).
- G_d (between SMSC and SGSN) is an SS7-based interface using MAP.
- G_n (between GGSN and SGSN or between SGSN and SGSN) is an IP-based interface using the GPRS Tunneling Protocol (GTP).
- G_c (between HLR and GGSN) is an SS7-based interface using MAP.
- G_a (between SGSN and CGF, or between CGF and GGSN) is an SS7-based interface using MAP.

Hardware & Software Upgrades

Element	Software	Hardware
MS	Upgrade Required	Upgrade Required
BTS	Upgrade Required	No Change
BSC	Upgrade Required	PCU Interface
TRAU	No Change	No Change
MSC/VLR	Upgrade Required	No Change
HLR	Upgrade Required	No Change
SGSN	New	New
GGSN	New	New

Note: TRAU (Transcoder/Rate Adapter Unit) frames carry voice and control information in a GSM network.

PCU: Packet Control Unit

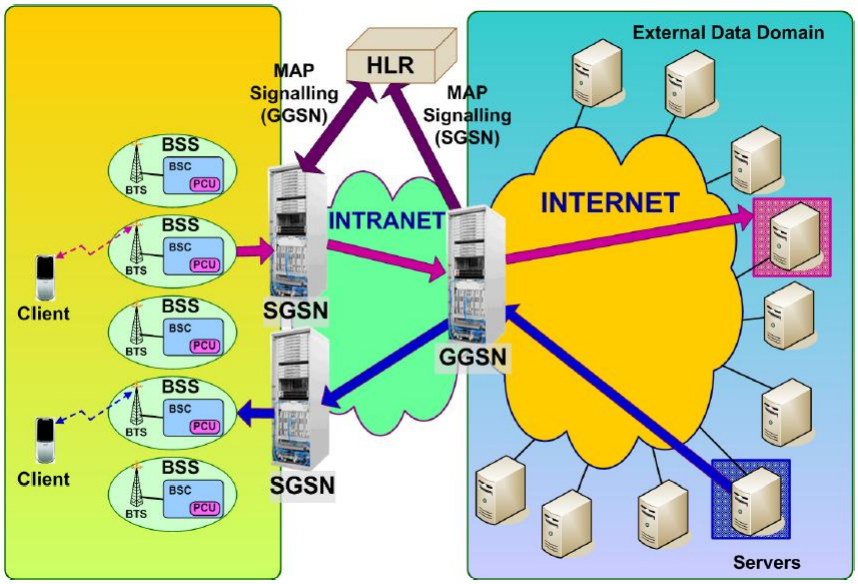
IP and X.25

- One of the requirements in the original GPRS design was to provide a system that was able to support IP and X.25 data in the same way
- Consequently, GPRS backbone was not fully optimized for IP data
- A general purpose tunneling protocol was designed

GPRS Support Node (GSN)

- GSN is a new class of network nodes to enable GPRS to integrate with existing GSM architectures
- There are two categories of GSN
  - Serving GPRS Support Nodes (SGSN)
  - Gateway GPRS Support Nodes (GGSN)
- Responsible for delivery and routing of data packets between MS and external PDN

What is an SGSN/GGSN



Serving GPRS Support Node (SGSN)

- The SGSN is responsible for delivery of packets to/from mobile stations within its service area
- Detect and Register new GPRS MS in its serving area
- The location register of the SGSN stores location information (e.g., current cell, current VLR) and user profiles (e.g., IMSI, address(es) used in the packet data network) of all GPRS users registered with this SGSN
- Packet Routing, Transfer & Mobility Management
- Authentication, Maintaining user profiles

Gateway GPRS Support Node (GGSN)

- GGSN represents the gateway towards the IP network.
- It executes all the functions necessary for inter- working
- i.e. Interfaces GPRS backbone network & external packet data network
- It converts the **GPRS packets coming from the SGSN into the IP format and sends them out on the corresponding packet data network**
- In the other direction, PDP addresses of incoming data packets are converted to the GSM address of the destination user
- The re-addressed packets are sent to the responsible SGSN
  → For this purpose, the **GGSN stores** the current SGSN address of the user and his/her profile in its location register.
- The GGSN also **performs authentication and charging functions**

GPRS Backbone

- Intra-PLMN (*public land mobile network*) Backbone Network
  - Private IP-based network of the GPRS provider
  - Connects GSNs of the same PLMN
- Inter-PLMN backbone networks
  - Connects GSNs of different PLMNs
  - Requires roaming agreement between GPRS network providers
- GSNs encapsulate the PDN (***Packet Data Network)*** packets and transmit (Tunnel) using the GPRS Tunneling Protocol (GTP).

Home Location Register (HLR)

- Shared database with GSM
  - Is enhanced with GPRS subscriber data and routing information
- For all users registered with the network, HLR keeps:
  - user profile, current SGSN and Packet Data Protocol (PDP) address(es) information
- SGSN exchanges information with HLR
  - e.g., informs HLR of the current location of the MS
- When MS registers with a new SGSN, the HLR sends the user profile to the new SGSN

Visitor Location Register (VLR)

- VLR is responsible for a group of location areas. It stores data of only those users in its area of responsibility
- MSC/VLR can be enhanced with functions and register entries that allow efficient coordination between GPRS and GSM services
  - combined location updates

GPRS Terminal Types

- **Type A**
  - Can support circuit (GSM) and packet (GPRS) calls **concurrently**
- **Type B:**
  - This type of phone can support circuit or packet modes but not at the same time. It can be registered for both…i.e. an IP address and a PSTN number
- **Type C**
  - This type of phone can only be registered for packet **OR** circuit but not both

GPRS Air Interface Um

- Is one of the central aspects of GPRS
  - Concerned with communication between MS and BSS at the physical, MAC and RLC (***Radio Link Control)*** layers
  - The Physical channel dedicated to packet data traffic is called a packet data channel (PDCH)
- Capacity on Demand:
  - Allocation/De-allocation of PDCH to GPRS traffic is dynamic
  - BSC controls resources in both directions
  - No conflicts on downlink
  - Conflicts on uplink are resolved using slotted ALOHA

Physical channels

- Defined by timeslot (0-7) and radio frequency channel
- Shared Basic Physical Sub Channel (SBPSCH)
  - Shared among several users (maximum 8)
  - Uplink Stage Flag (USF) controls multiple access
- Dedicated Basic Physical Sub Channel (DBPSCH)
  - One user
- Packet Data Channel (PDCH)
  - Dedicated to packet data traffic from logical channels
    - Control
    - User data

GPRS Logical Channels

Group	Channel	Function	Direction
Packet Data Traffic	PDTCH	Data Traffic	MS ⟺ BSS
Packet Broadcast Control Channel	PBCCH	Broadcast Channel	MS ⟸ BSS
Packet Common Control Channel	PRACH	Random Access	MS ⟹ BSS
	PAGCH	Access Grant	MS ⟸ BSS
	PPCH	Paging	MS ⟸ BSS
	PNCH	Notification	MS ⟸ BSS
Packet Dedicated Control Channels	PACCH	Associated Control Timing Advance	MS ⟺ BSS
	PTCCH	Control	MS ⟺ BSS

Logical Channels

- Mapped by the MAC to physical channels
- Control channels for control, synchronization and signaling
  - Common
  - Dedicated
  - Broadcast
- Packet Traffic channels
  - Encoded speech
  - Encoded data

Control Channels

1. Packet Common Control Channel (PCCCH)

- Paging (PPCH)
- Random Access (PRACH)
- Grant (PAGCH)
- Packet Notification (PNCH)

2. Packet Dedicated Control Channel (PDCCH)

❑ Operations on Dedicated Basic Physical Sub Channel (DBPSCH)

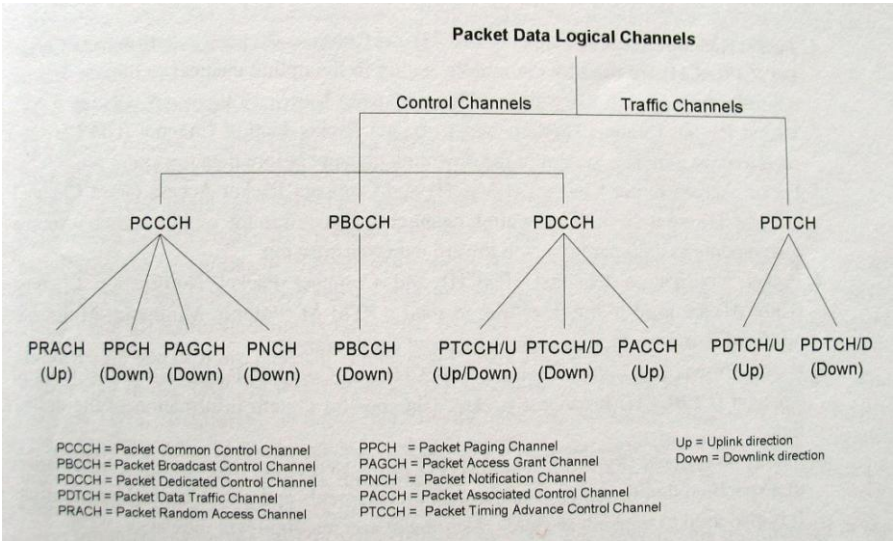
- Slow Associated Control Channel (SACCH)
  - ➢ Radio measurements and data
  - ➢ SMS transfer during calls
- Fast Associated Control Channel (FACCH)
  - ➢ For one Traffic Channel (TCH)
- Stand-alone Dedicated Control Channel (SDCCH)

3. Packet Broadcast Control Channel (PBCCH)

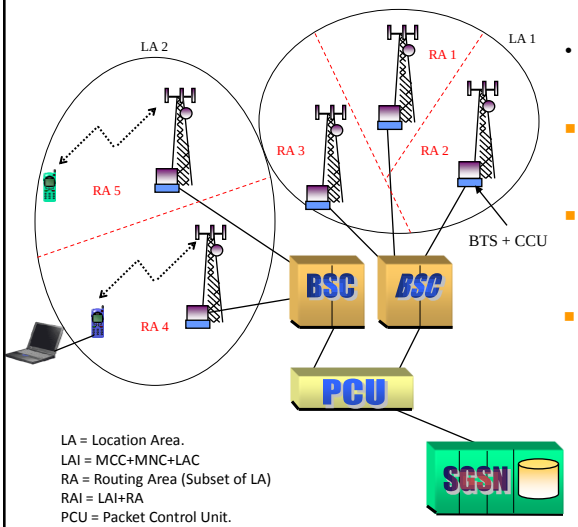
- Frequency correction channels
- Synchronisation channel (MS freq. vs. BS)
- Broadcast control channel for general information on the base station
- Packet broadcast channels
  - Broadcast parameters that MS needs to access network for packet transmission

4. Packet Traffic Channels

- Traffic Channels (TCH)
- Encoding of speech or user data
- Full rate/half rate
- Occur on both SBPSCH and DBPSCH
- Modulation techniques
  - GMSK
  - 8-PSK



Base Station Subsystem

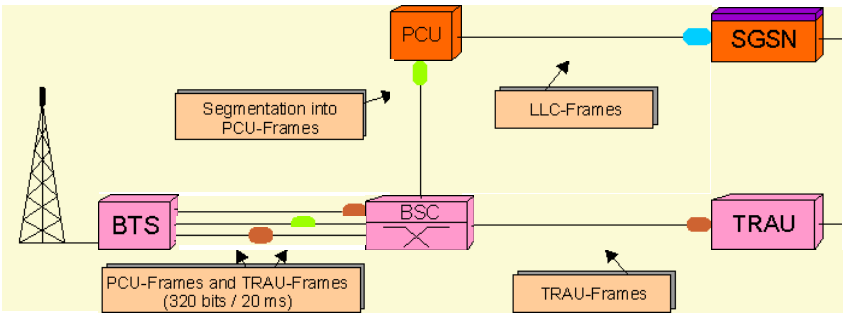


LA = Location Area.
LAI = MCC+MNC+LAC
RA = Routing Area (Subset of LA)
RAI = LAI+RA
PCU = Packet Control Unit.
CCU = Channel Codec Unit.

- In GPRS, LA is divided into RA. Each RA contains one or more cells.
- In a RA, the RAI is broadcasted as System Information.
- When an MS is crossing an RA border the MS will initiate an RA update procedure.
- New elements (CCU , PCU) are added to the BSS in order to support new coding schemes introduced by GPRS.

PCU (Packet Control Unit)

- Interface the new GPRS core network to the existing GSM BSS.
  - Converting packet data coming from the SGSN in so called PCU-frames that have the same format as TRAU-frames. These PCU-frames are transparently routed through the BSC and towards the BTS. The BTS needs to determine the respective coding scheme and other options before processing a PCU-frame.
- Takes over all GPRS radio related control functions from the BSC.



GPRS Mobility Management (GMM)

- GMM are used to keep track of the current location of an MS and to initiate security procedures
- GMM is a function that is mainly handled between the mobile station and the SGSN. However, the HLR is also involved.
- There are various scenarios defined in GPRS to update a subscriber's location within the network. The most important ones are:
  - Routing Area Update (Intra-SGSN and Inter-SGSN)
  - GPRS Attach and Detach
  - Cell Update (only while in GMM-Ready State)

GPRS Attach/Detach

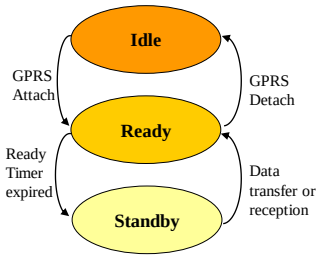
- MS must register with an SGSN before it can use GPRS services

1) The network checks user authentication
2) It then copies user profile from HLR to SGSN
3) It then assigns a Packet Temporary Mobile Subscriber Identity (P-TMSI) to the mobile

- This is a GPRS attach procedure
- GPRS detach is when the GPRS terminal disconnects from the network

GMM States

- Idle Mode. (MS off or not attached yet.).
  - If the MS is on, the MS will listen to the network, but not make any updating of where the MS is. It is not possible to page an MS.
- Ready Mode. (MS is able to send and receive data).
  - Cell updating is necessary.
  - If no activity within the timer (Default = 44s) the MS will fall back to a stand-by state.
  - NOTE: an MS can be forced back to standby mode due to lack of recourses.
- Standby Mode. (MS is listening to the Network).
  - Only RA update and periodic update is necessary.
  - It is possible to page the MS.



GPRS Attach

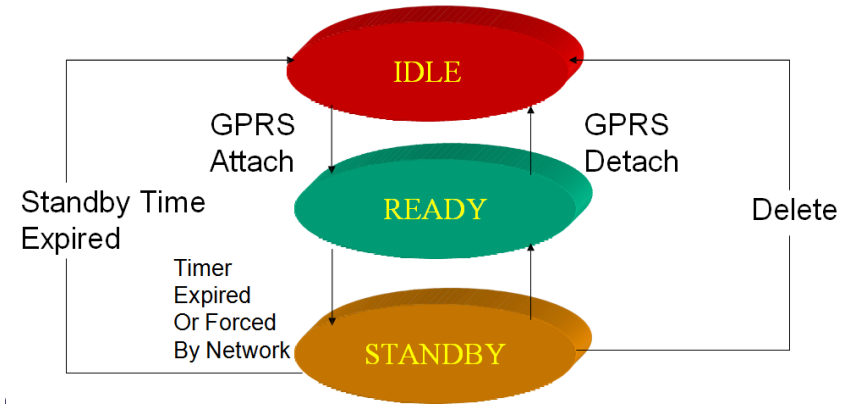
- Packet-switched core network recognizes three states:
  - IDLE, READY, STANDBY

- GPRS Attach procedure is used to log an MS onto the network when changing from IDLE to READY mode
  - MS can now send & receive data
  - Call & routing area updates are performed

- A timer switches from READY to STANDBY if no data is transferred for a certain time
- An MS sending data automatically switches from STANDBY to READY

GPRS Detach

- Logging off from the network - MS returns to IDLE state



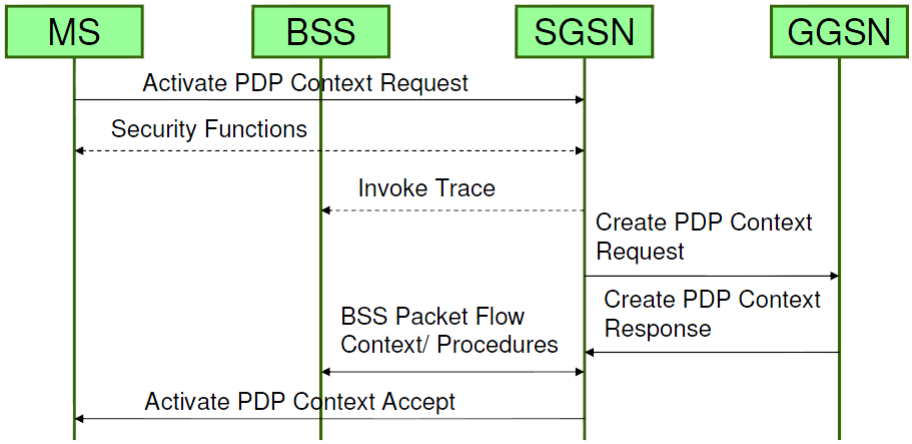
PDP Address

- An MS must apply for one or more addresses used in the PDN before data packets can be exchanged
- An address is called a Packet Data Protocol (PDP) address

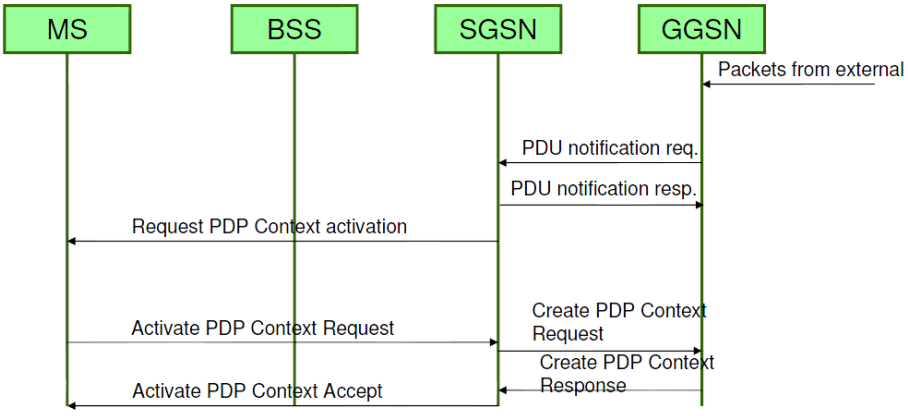
PDP Context

- For each session, a PDP context is created, containing:
  - PDP Type (e.g. IP v6)
  - PDP Address assigned to MS
  - GGSN address of the access point to the PDN
- This is stored in the MS, SGSN and GGSN
- MS is now able to tx and rx packets from the network

MS Initiated PDP Context



GGSN Initiated PDP Context



Location Management

- In **Idle** state, no location updates are made
- In **Standby** state, SGSN will only be informed when Routing Area changes (RA consists of several cells, a Location Area of several RAs)
- An MS in **Ready** state informs its SGSN of every change of cell
  - MS makes a "Routing Area Update request"
  - To find current cell of an MS, paging must be performed within RA

GPRS QoS

- Each GPRS subscription is associated with one QoS profile (HLR)
- Consists of four parameters:

1. Precedence:
- operator defined priority; three classes

2. Delay:
- includes radio access delay (uplink) or radio scheduling delay (downlink), radio transit delay, GPRS-network transit delay; up to four classes supported

3. Reliability:
- error/loss rates/probabilities; up to four classes supported

4. Throughput:
- specified by maximum bit rate and mean bit rate

GPRS QoS - SGSN's Role

- SGSN will negotiate QoS for the flow
  - Based on subscribed default in HLR, requested profile from MS and current availability of GPRS resources
  - SGSN performs admission control for each PDP context activation
  - SGSN can re-negotiate QoS with MN even during run time

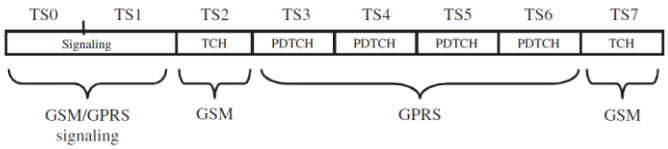
Quality of Service

- Four traffic classes
  - Conversational, streaming, interactive, background
    - they differ in delay sensitivity
- Conversational, streaming:
  - for carrying real-time flows
  - e.g. telephony and video
- Interactive, background:
  - for traditional Internet traffic

Timeslot Aggregation: If more than one timeslot is available when a subscriber wants to transmit or receive data, the network can allocate several timeslots (multislot) to a single subscriber

Mixed GSM/GPRS Timeslot Usage in a Base Station

- As GPRS is an addition to the GSM network, the eight timeslots available per carrier frequency on the air interface can be shared between GSM and GPRS.
- Therefore, the maximum GPRS data rate decreases as more GSM voice/data connections are needed.
- The network operator can choose how to use the timeslots
- Timeslots can be assigned statically, which means that some timeslots are reserved for GSM and some for GPRS.
- The operator also has the option of dynamically assigning timeslots to GSM or GPRS. If there is a high amount of GSM voice traffic, more timeslots can be used for GSM. If voice traffic decreases, more timeslots can be given to GPRS



Shared use of the timeslots of a cell for GSM and GPRS

Coding Schemes

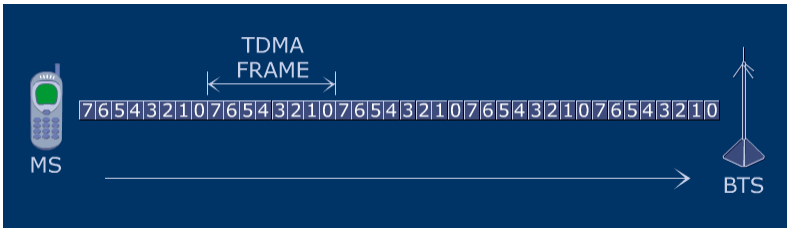
- Another way to increase the data transfer speed besides timeslot aggregation is to use different coding schemes.
- If the user is at close range to a base station, the data transmitted over the air is less likely to be corrupted during transmission than if the user is farther away and the reception is weak.

Channel Coding

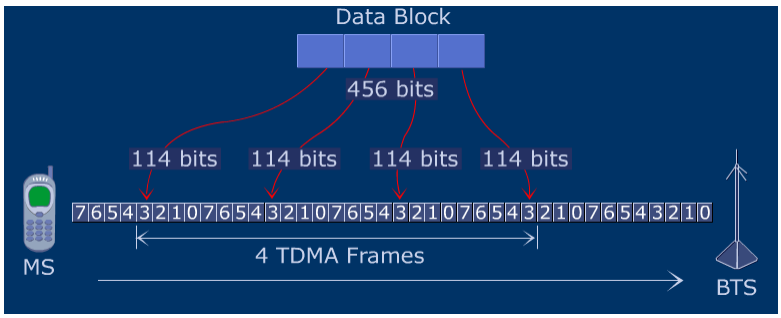
Channel Coding Scheme	Data Bits in Radio Block	Data Rate per Time Slot in kb/s on Radio Layer	Max. Data Rate per 8 slots kb/s
CS-1	181	9.05	72.4
CS-2	268	13.4	107.2
CS-3	312	15.6	124.8
CS-4	428	21.4	171.2

Multi-frame structure

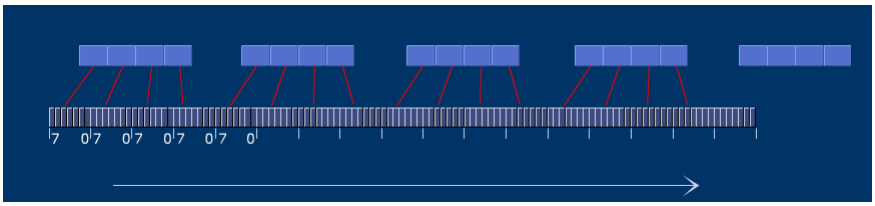
- Each radio carrier or radio channel is divided into eight equal length time slots
- This group of eight time slots is referred to as a frame or a TDMA frame

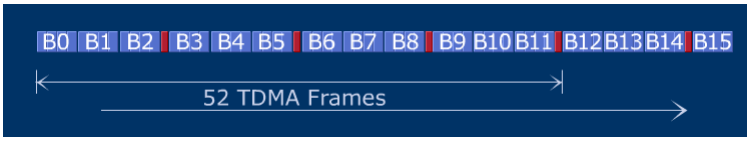


- A GSM data block as define by ETSI, contains 456 bits and requires four time slots to be transmitted
- With reference to a physical channel, a block can be regarded as a single time slot over for consecutive frames



- The data blocks are grouped together in threes (3x4 frames per block), with an idle frame separating each group.
- The complete sequence of 52 frames is known as a multi-frame
- Multi-frame contains four groupings (4x12 frames per block) plus idle frames





- Radio resources are allocated on a oer block basis
- So that a PDTCH will always be assigned the same time slot on each of the four frames within a block

http://www.ossidian.com/demo/gprs-eng-china/tut/tut07.swf

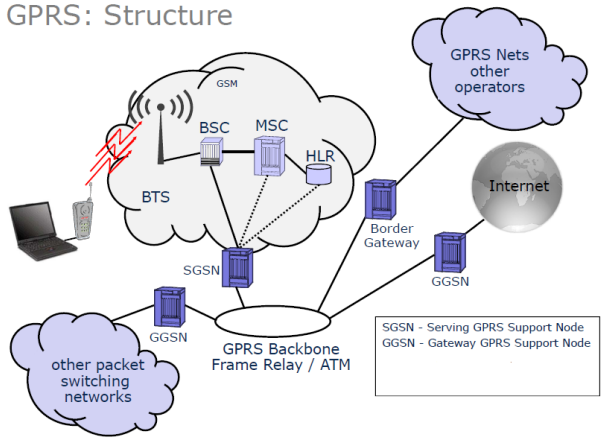
GSM VS. GPRS

1. Circuit - Switched voice and data service
2. Network nodes are switching centers(MSCs). Each MSC is in Charge of The MTs in its control area.
3. Gateway MSC
4. BSS

1. Packet – switched data services
2. Network nodes are IP routers enhanced with mobility management functionalities
3. GGSN
4. BSS enhanced with a PCU

Advantages of GPRS

- Good compatibility with GSM through the reuse of network infrastructure
- A solution already standardized on how to communicate with:
  - A packet data network on one side
  - A mobile/intelligent network based on MAP on the other



GPRS: Changes