2G(GSM)

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GSM

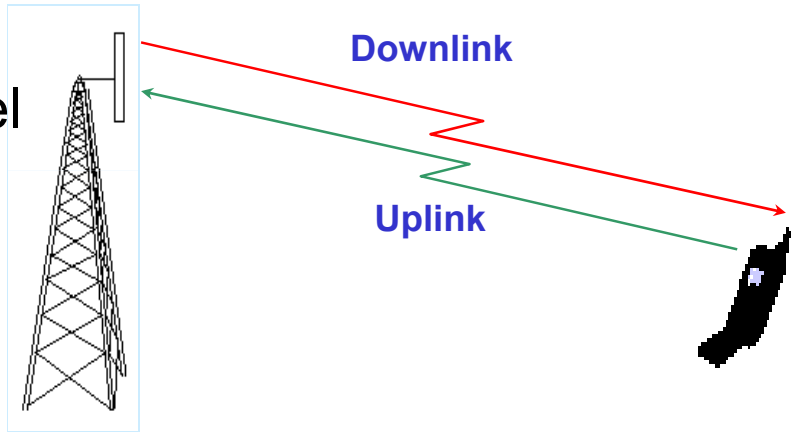
- Abbreviation for Global System for Mobile Communications
- Concurrent development in USA and Europe in the 1980's
- The European system was called GSM and deployed in the early 1990's

GSM Services

- Voice, 3.1 kHz
- Short Message Service (SMS)
  - 1985 GSM standard that allows messages of at most 160 chars. (incl. spaces) to be sent between handsets and other stations
  - Over 2.4 *billion* people use it; multi-billion $ industry
- General Packet Radio Service (GPRS)
  - GSM upgrade that provides IP-based packet data transmission up to 114 kbps
  - Users can “simultaneously” make calls and send data
  - GPRS provides “always on” Internet access and the Multimedia Messaging Service (MMS) whereby users can send rich text, audio, video messages to each other
  - Performance degrades as number of users increase
  - GPRS is an example of 2.5G telephony – 2G service similar to 3G

GSM Channels

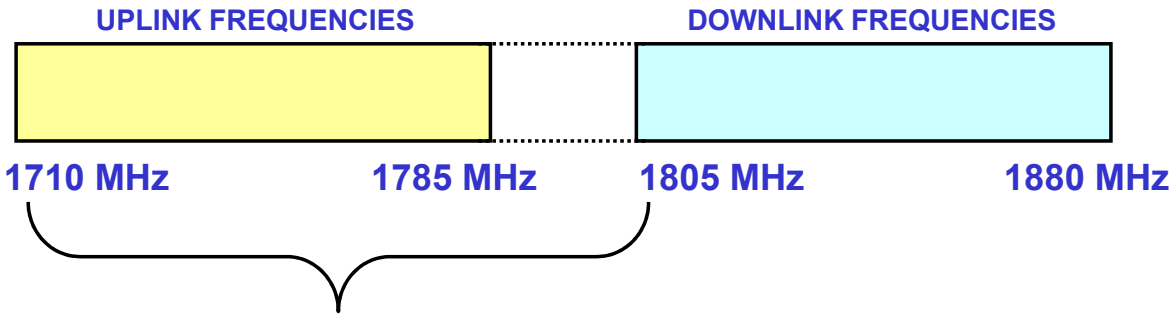
Channels



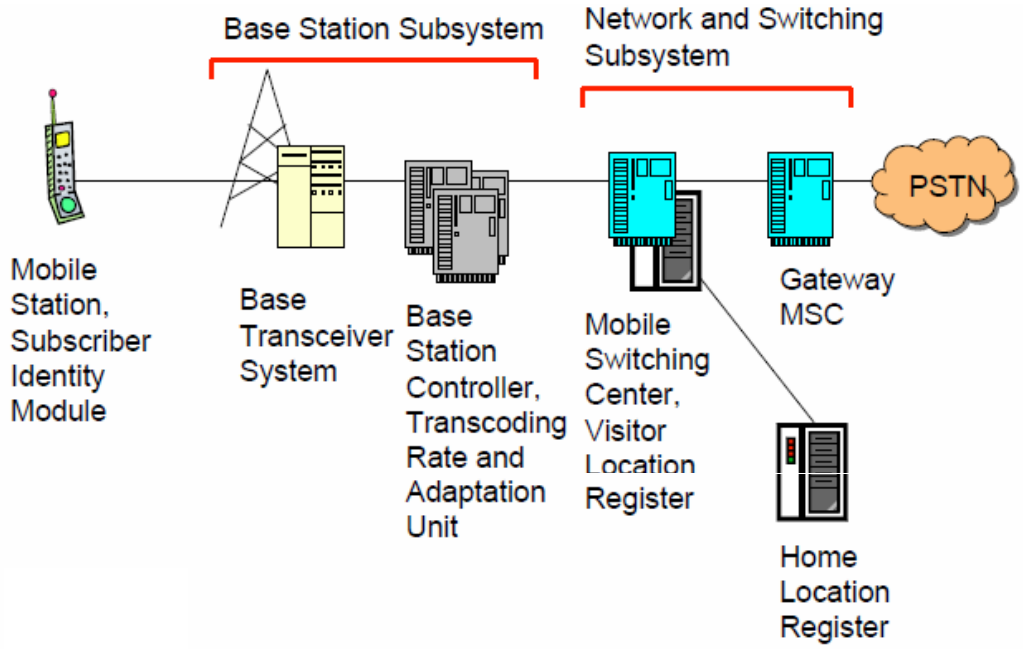
- Physical Channel: Each timeslot on a carrier is referred to as a physical channel
- Logical Channel: Variety of information is transmitted between the MS and BTS. Different types of logical channels:
  - Traffic channel
  - Control Channel

GSM Frequencies

- Originally designed on 900MHz range, now also available on 800MHz, 1800MHz and 1900 MHz ranges.
- Separate Uplink and Downlink frequencies
  - One example channel on the 1800 MHz frequency band, where RF carriers are space every 200 MHz



GSM Architecture

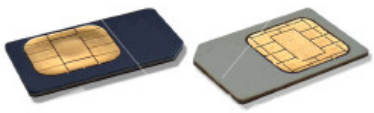


Mobile Station (MS)

- MS is the user's handset and has two parts
- Mobile Equipment
  - Radio equipment
  - User interface
  - Processing capability and memory required for various tasks
    - Call signalling
    - Encryption
    - SMS
  - Equipment IMEI number
- Subscriber Identity Module

Subscriber Identity Module

- A small smart card
- Encryption codes needed to identify the subscriber
- Subscriber IMSI number
- Subscriber's own information (telephone directory)
- Third party applications (banking etc.)
- Can also be used in other systems besides GSM, e.g., some WLAN access points accept SIM based user authentication



Base Station Subsystem

- Transcoding Rate and Adaptation Unit (TRAU)
  - Performs coding between the 64kbps PCM coding used in the backbone network and the 13 kbps coding used for the Mobile Station (MS)
- Base Station Controller (BSC)
  - Controls the channel (time slot) allocation implemented by the BTSes
  - Manages the handovers within BSS area
  - Knows which mobile stations are within the cell and informs the MSC/VLR about this
- Base Transceiver System (BTS)
  - Controls several transmitters
  - Each transmitter has 8 time slots, some used for signaling, on a specific frequency

Network and Switching Subsystem

- The backbone of a GSM network is a telephone network with additional cellular network capabilities
- Mobile Switching Center (MSC)
  - An typical telephony exchange (ISDN exchange) which supports mobile communications
  - Visitor Location Register (VLR)
    - A database, part of the MSC
    - Contains the location of the active Mobile Stations
- Gateway Mobile Switching Center (GMSC)
  - Links the system to PSTN and other operators
- Home Location Register (HLR)
  - Contain subscriber information, including authentication information in Authentication Center (AuC)
- Equipment Identity Register (EIR)
  - International Mobile Station Equipment Identity (IMEI) codes for e.g., blacklisting stolen phones

Home Location Register

- One database per operator
- Contains all the permanent subscriber information
  - MSISDN (Mobile Subscriber ISDN number) is the telephone number of the subscriber
  - International Mobile Subscriber Identity (IMSI) is a 15 digit code used to identify the subscriber
    - It incorporates a country code and operator code
  - IMSI code is used to link the MSISDN number to the subscriber's SIM (Subscriber Identity Module)
  - Charging information
  - Services available to the customer
- Also the subscriber's present Location Area Code, which refers to the MSC, which can connect to the MS.

Other Systems

- Operations Support System
  - The management network for the whole GSM network
  - Usually vendor dependent
  - Very loosely specified in the GSM standards
- Value added services
  - Voice mail
  - Call forwarding
  - Group calls
- Short Message Service Center
  - Stores and forwards the SMS messages
  - Like an E-mail server
  - Required to operate the SMS services

Location Updates

- The cells overlap and usually a mobile station can ‘see’ several transceivers (BTSes)
- The MS monitors the identifier for the BSC controlling the cells
- When the mobile station reaches a new BSC’s area, it requests an location update
- The update is forwarded to the MSC, entered into the VLR, the old BSC is notified and an acknowledgement is passed back

Handoff (Handover)

- When a call is in process, the changes in location need special processing
- Within a BSS, the BSC, which knows the current radio link configuration (including feedbacks from the MS), prepares an available channel in the new BTS
- The MS is told to switch over to the new BTS
- This is called a hard handoff
  - In a soft handoff, the MS is connected to two BTSes simultaneously

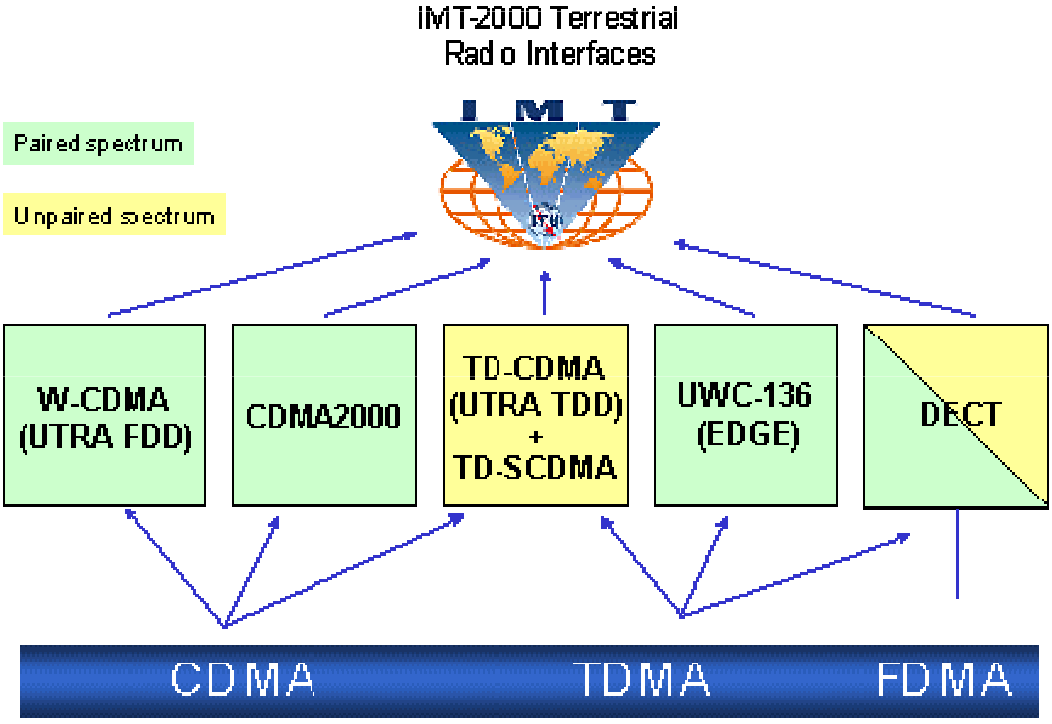
Roaming

- When a MS enters another operators network, it can be allowed to use the services of this operator
  - Operator to operator agreements and contracts
  - Higher billing
- The MS is identified by the information in the SIM card and the identification request is forwarded to the home operator
  - The home HLR is updated to reflect the MS's current location

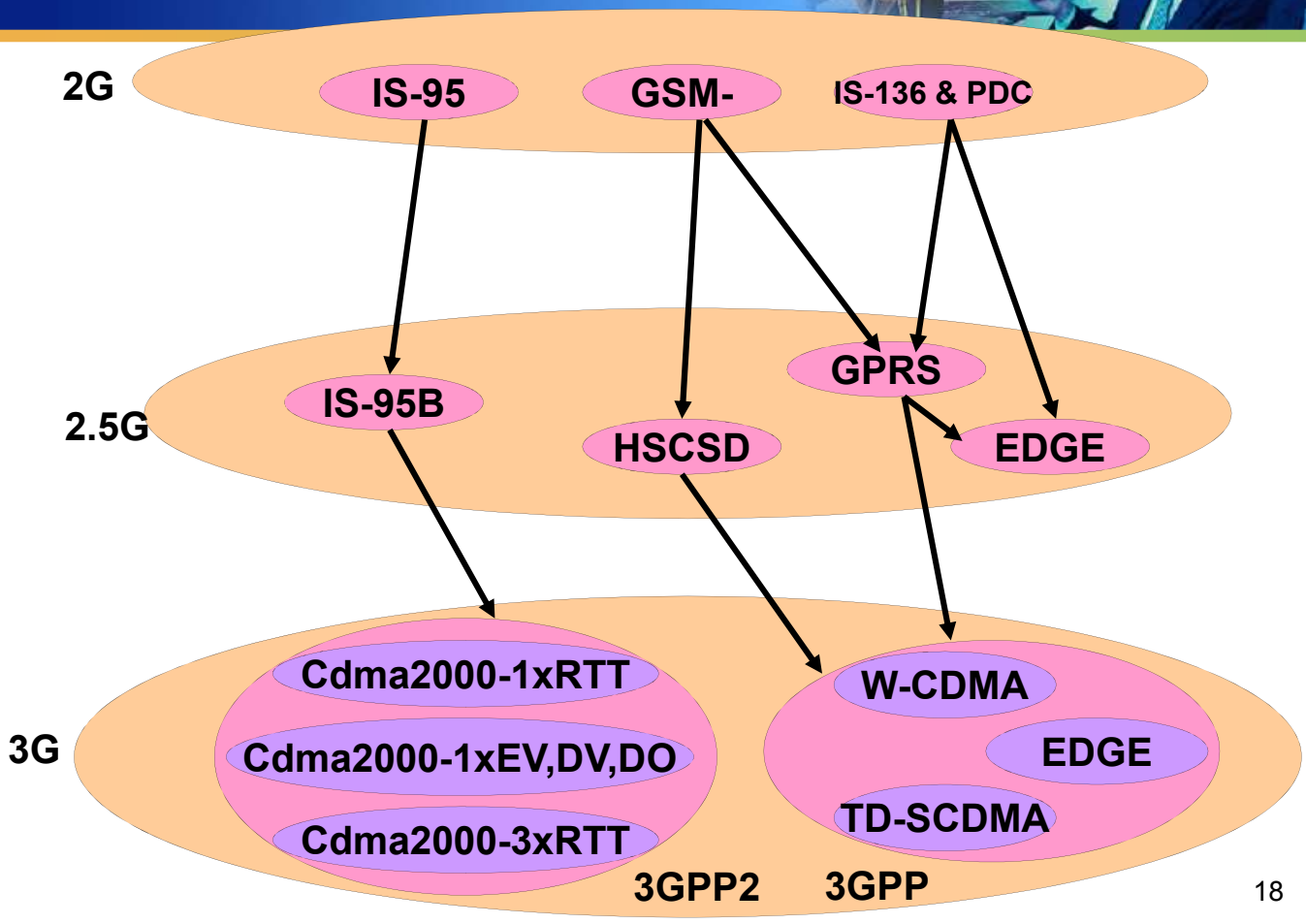
3G, 3.5G and 4G (LTE)

3G Overview

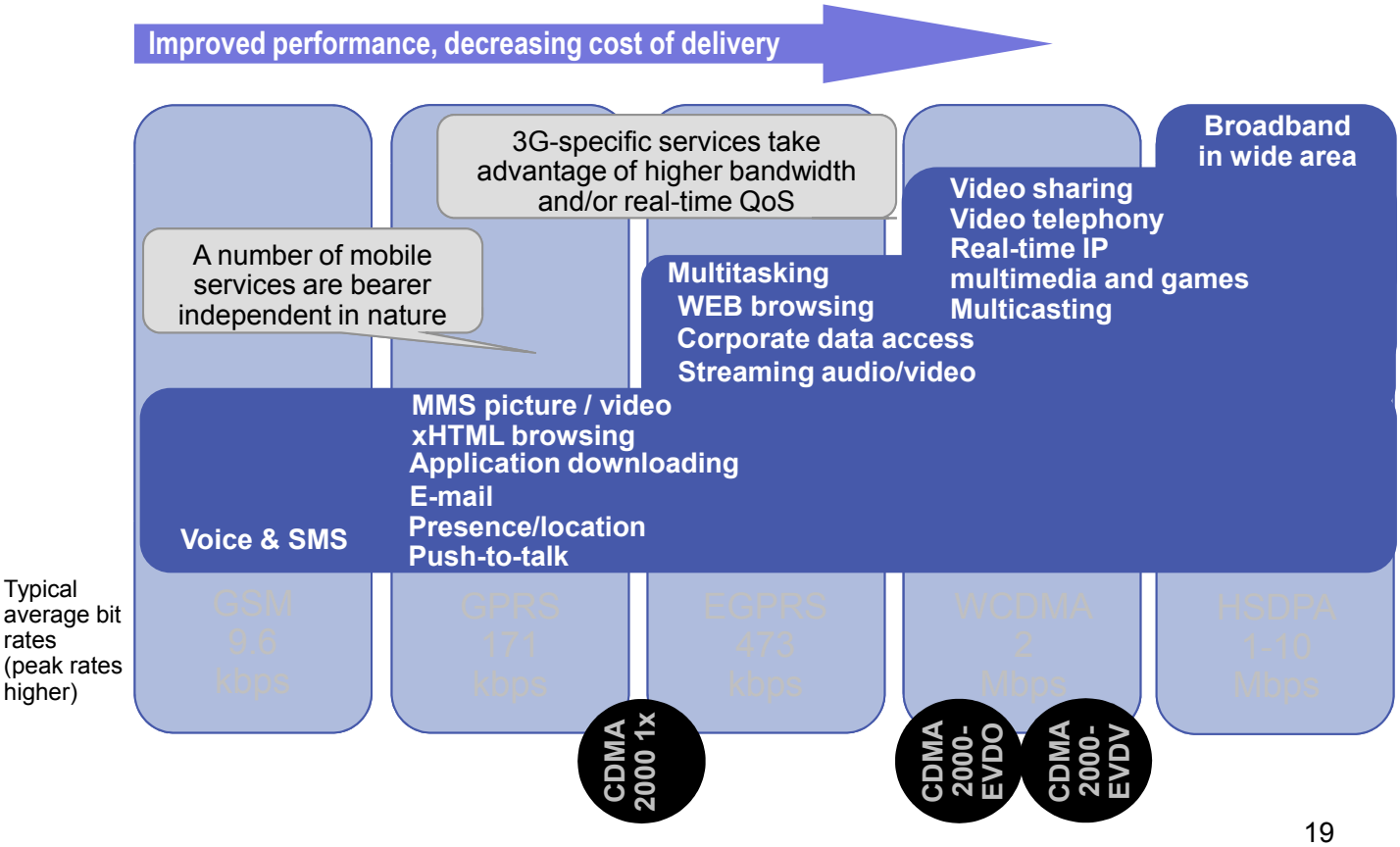
- 3G is created by ITU-T and is called IMT-2000



Evolution from 2G



Service Roadmap

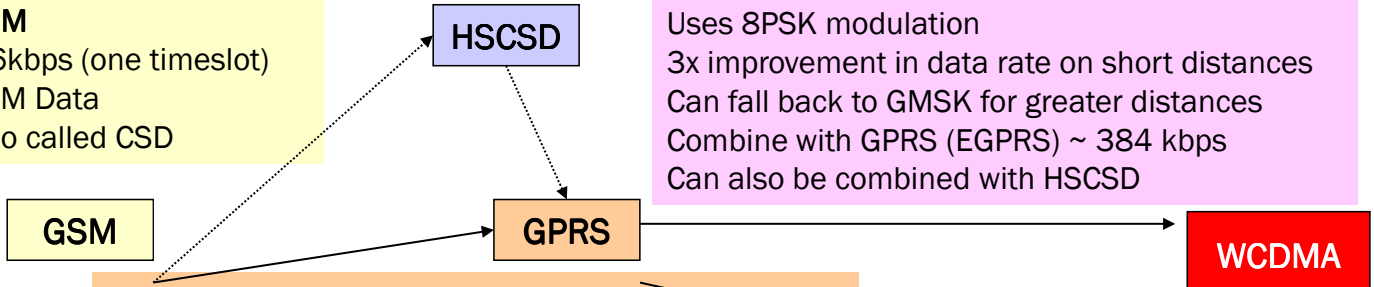


GSM Evolution to 3G

High Speed Circuit Switched Data
Dedicate up to 4 timeslots for data connection ~ 50 kbps
Good for real-time applications c.w. GPRS
Inefficient -> ties up resources, even when nothing sent
Not as popular as GPRS (many skipping HSCSD)

GSM
9.6kbps (one timeslot)
GSM Data
Also called CSD

Enhanced Data Rates for Global Evolution
Uses 8PSK modulation
3x improvement in data rate on short distances
Can fall back to GMSK for greater distances
Combine with GPRS (EGPRS) ~ 384 kbps
Can also be combined with HSCSD



General Packet Radio Services
Data rates up to ~ 115 kbps
Max: 8 timeslots used as any one time
Packet switched; resources not tied up all the time
Contention based. Efficient, but variable delays
GSM / GPRS core network re-used by WCDMA (3G)

GPRS (GENERAL PACKET RADIO SERVICE)

Contents

GPRS (General Packet Radio Service)

- a packet based communication service for mobile devices that allows data to be sent and received across a mobile telephone network

Benefit of GPRS

Speed
GPRS is packet switched. Higher connection speeds are attainable at around 56–118 kbps, a vast improvement on circuit switched networks of 9.6 kbps. By combining standard GSM time slots theoretical speeds of 171.2 kbps are attainable. However in the very short term, speeds of 20-50 kbps are more realistic.

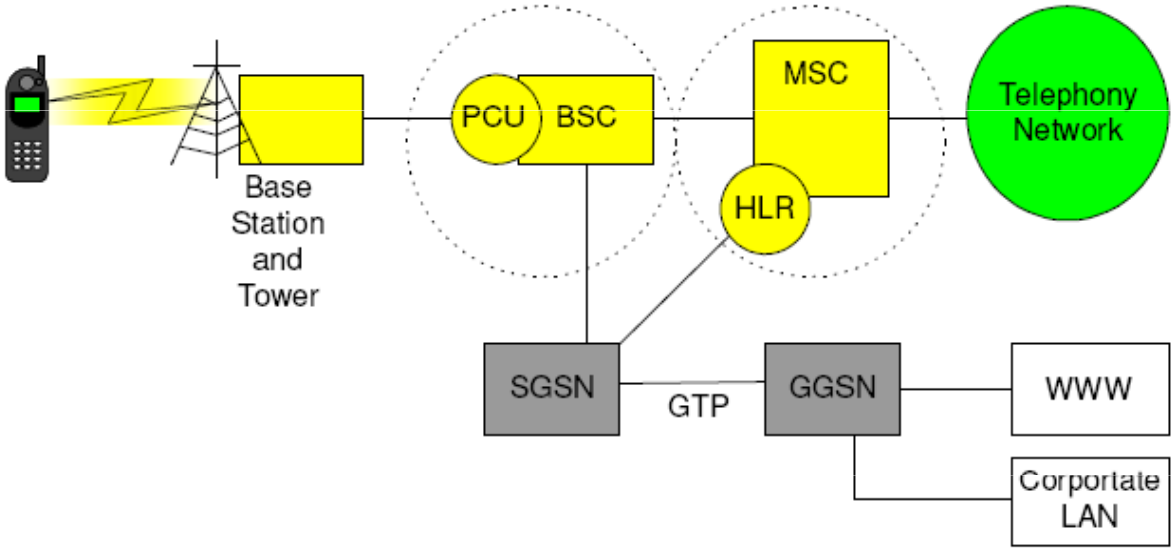
Always on connectivity
GPRS is an always-on service. There is no need to dial up like you have to on a home PC for instance. This feature is not unique to GPRS but is an important standard that will no doubt be a key feature for migration to 3G. It makes services instantaneously available to a device.

New and Better applications
Due to its high-speed connection and always-on connectivity GPRS enables full Internet applications and services such as video conferencing straight to your desktop or mobile device. Users are able to explore the Internet or their own corporate networks more efficiently than they could when using GSM. There is often no need to redevelop existing applications.

GSM operator Costs
GSM network providers do not have to start from scratch to deploy GPRS. GPRS is an upgrade to the existing network that sits along side the GSM network. This makes it easier to deploy, there is little or no downtime of the existing GSM network whilst implementation takes place, most updates are software so they can be administered remotely and it allows GSM providers to add value to their business at relatively small costs.

The GSM network still provides voice and the GPRS network handles data, because of this voice and data can be sent and received at the same time.

Simple GPRS Technical Overview



As mentioned earlier GPRS is not a completely separate network to GSM. Many of the devices such as the base transceiver stations and base transceiver station controllers are still used. Often devices need to be upgraded be it software, hardware or both. When deploying GPRS many of the software changes can be made remotely.

There are however two new functional elements which play a major role in how GPRS works. The Serving GPRS Support Node (SGSN) and the Gateway GPRS support node (GGSN). These 2 nodes are new to the network with the other changes being small if any.

Before explaining what these 2 new members of our network do it is important to ask how does the network differentiate between GSM (circuit) and GPRS (packet)?

In simple terms there are in practice two different networks working in parallel, GSM and GPRS. In any GSM network there will be several BSC's (Base Station Controllers). When implementing GPRS a software and hardware upgrade of this unit is required. The hardware upgrade consists of adding a Packet Control Unit (PCU). This extra piece of hardware differentiates data destined for the standard GSM network or Circuit Switched Data and data destined for the GPRS network or Packet Switched Data. In some cases a PCU can be a separate entity.

From the upgraded BSC there is a fast frame relay connection that connects directly to the newly introduced SGSN.

Serving GPRS Support Node

SGSN

- Functionally connected with BSC, physically can be at MSC or BSC site
- One for few BSCs or one (or few) per every BSC
- One SGSN can support BSCs of several MSC sites

- Main functions
  - Authenticates GPRS mobiles
  - Handles mobile's registration in GPRS network
  - Handles mobile's mobility management
  - Relays MO and MT data traffic
    - TCP/IP header compression, V.42bis data compression, error control MS- SGSN (ARQ)
  - Collect charging information of air interface usage

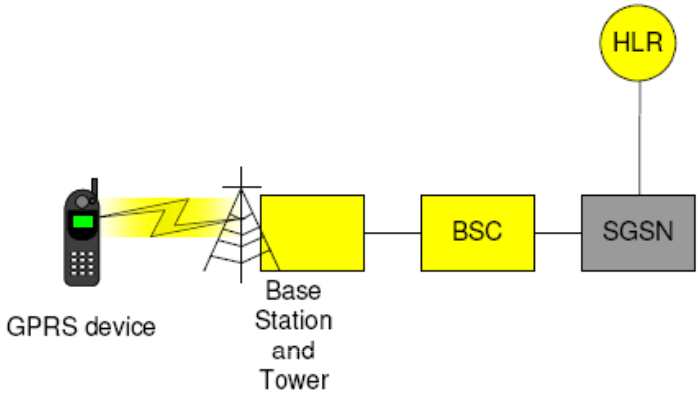
Gateway GPRS Support Node

GGSN

- Typically located at one of the MSC sites
- One (or few) per operator
- Main functions
  - Interface to external data networks
  - Resembles to a data network router
  - Forwards end user data to right SGSN
  - Routes mobile originated packets to right destination
  - Filters end user traffic
  - Collects charging information for data network usage
  - Data packets are not sent to MS unless the user has activated the PDP address

Allocating IP addressing

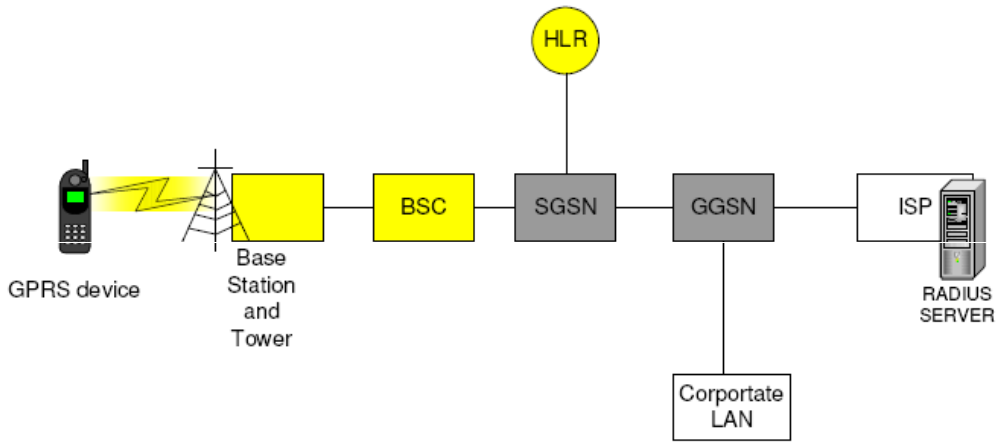
Fixed IP addressing:
Fixed IP addresses for mobile devices are not widely used due to shortages of Ipv4 addresses (see below). This information is stored in the HLR.



Allocating IP addressing (3)

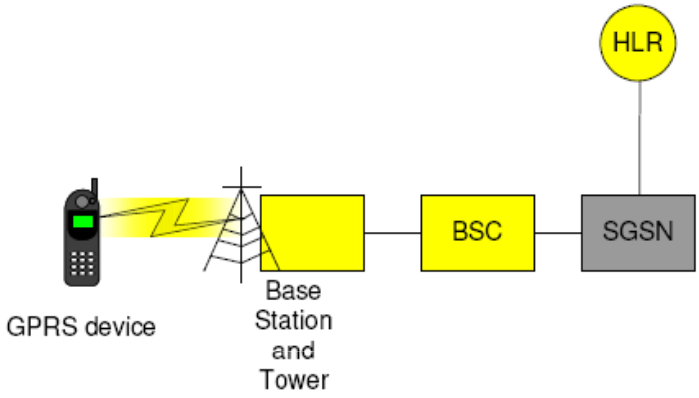
Dynamic IP addressing:
The second means of addressing is dynamic addressing. This is where a mobile device does not have its own IP address stored in the HLR. Instead the IP address is assigned to the GGSN domain.

The third method is also a type of dynamic IP addressing in which the IP address is assigned by RADIUS servers normally situated inside an IP network outside the mobile network, an example of this being when you dial up to an ISP from your home PC.



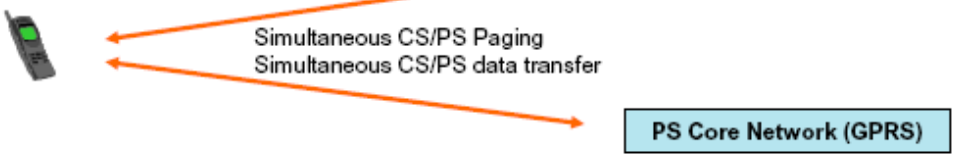
Allocating IP addressing (2)

Fixed IP addressing:
Fixed IP addresses for mobile devices are not widely used due to shortages of Ipv4 addresses (see below). This information is stored in the HLR.

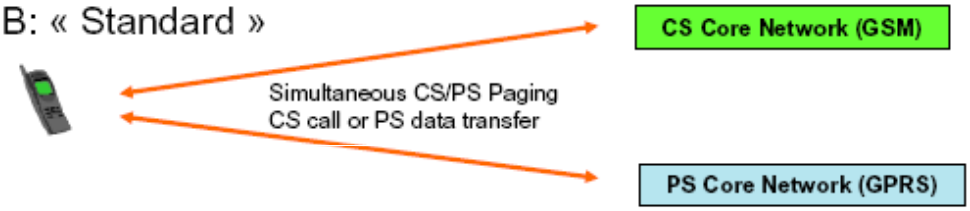


Three types of Mobile Classes

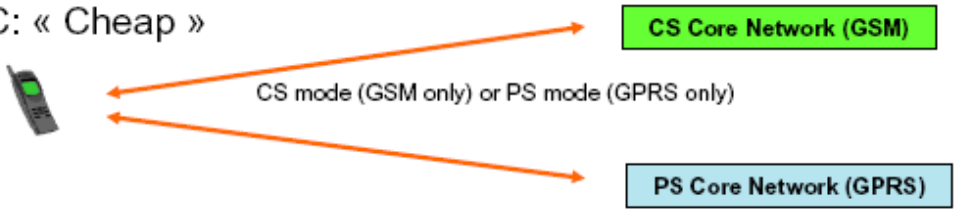
- CLASS A: « Rolls Royce »



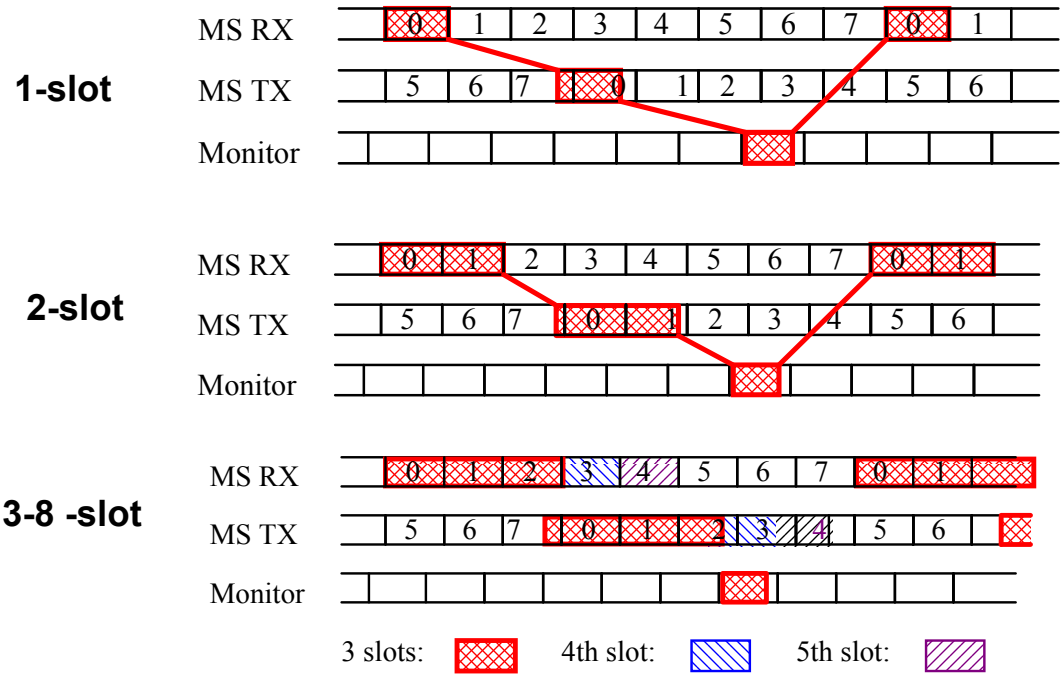
- CLASS B: « Standard »



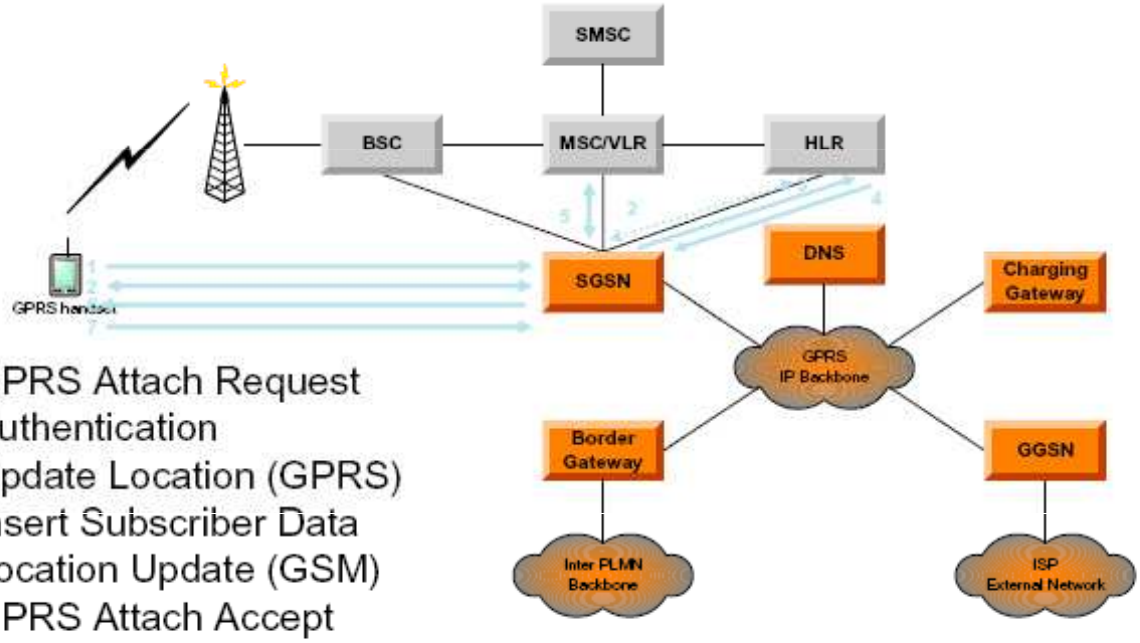
- CLASS C: « Cheap »



GPRS multislot capabilities

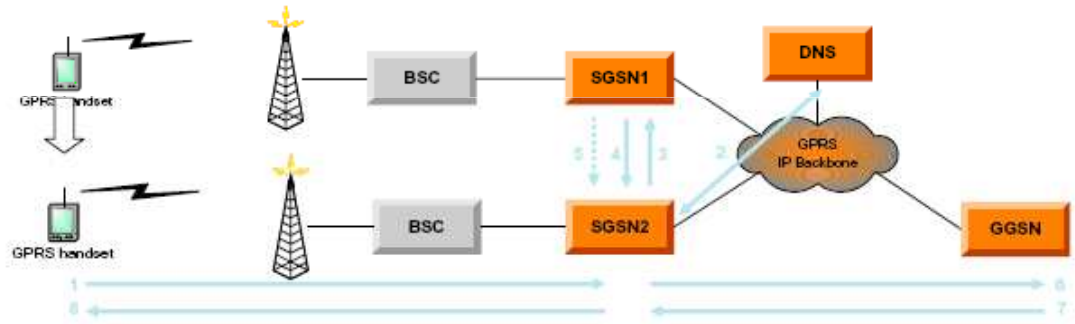


Mobility Management
GPRS Attach



1. GPRS Attach Request
2. Authentication
3. Update Location (GPRS)
4. Insert Subscriber Data
5. Location Update (GSM)
6. GPRS Attach Accept
7. Attach complete

Mobility Management
Routing Area Update



1. RA Update Request (old RAI)
2. DNS Query: IP @ for old RAI
3. SGSN Context Request
4. SGSN Context Response
5. Forward Packets
6. Update PDP Context Request: IP @ of new RAI
7. Update PDP Context Response
8. RA Update Accept

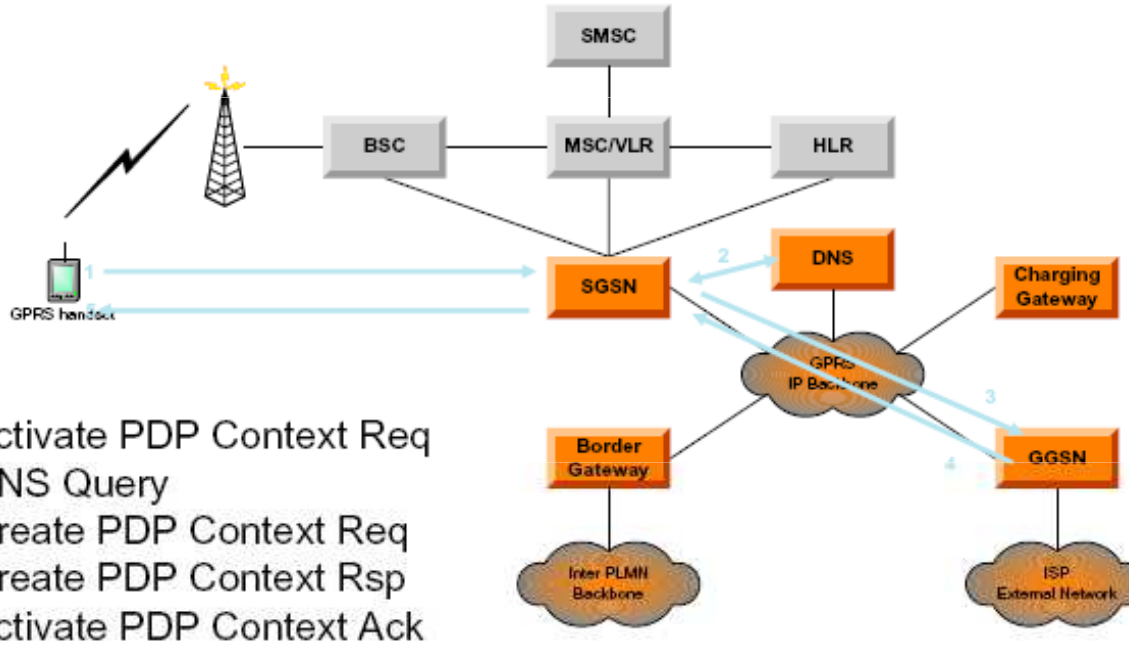
Session Management
Notion of PDP context

- Packet Data Protocol context:
  - set of information stored in mobile, SGSN and GGSN
  - allow packet data transfer between a certain type of network and the mobile

- PDP context contains:

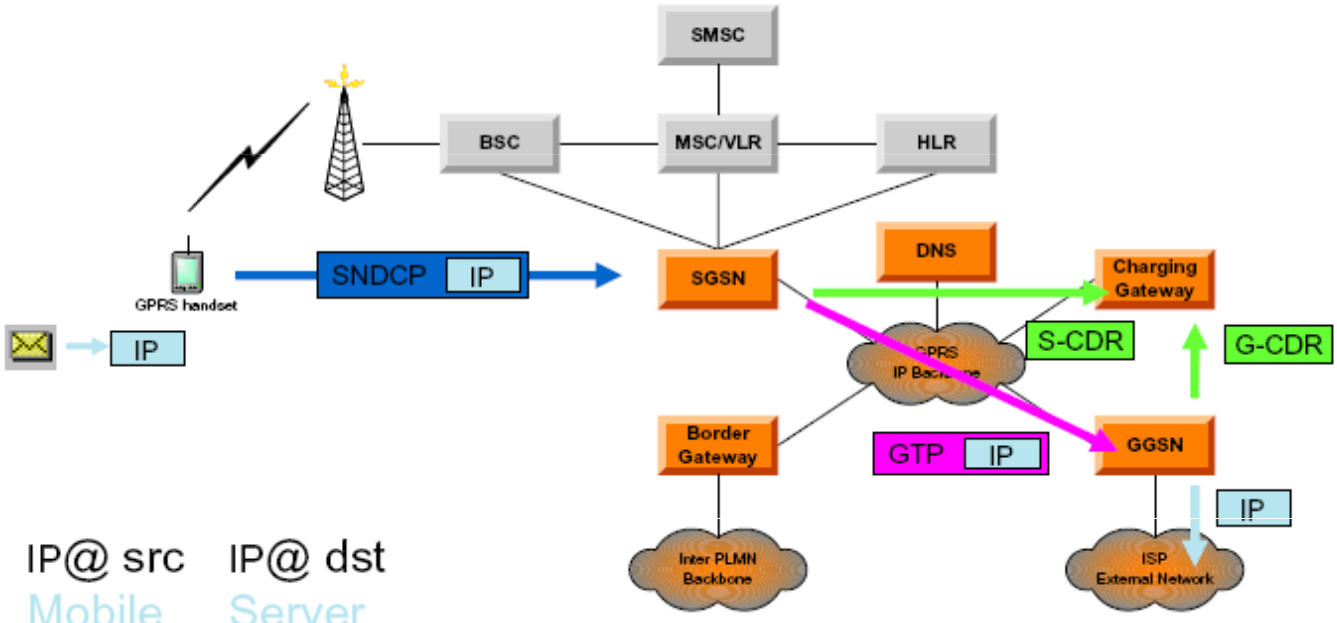
Main Field	Description
type of PDP network	IP, X25 ....
Mobile address	IP address or X.121 address for X25 network
SGSN address	IP address of the serving SGSN
NSAPI	Network Service Access Point
QoS Profile	Quality of service negociated for this PDP context
Access Point Name	APN (service) requested by the mobile (ie WAP, internet...)

Session Management
PDP Context Activation



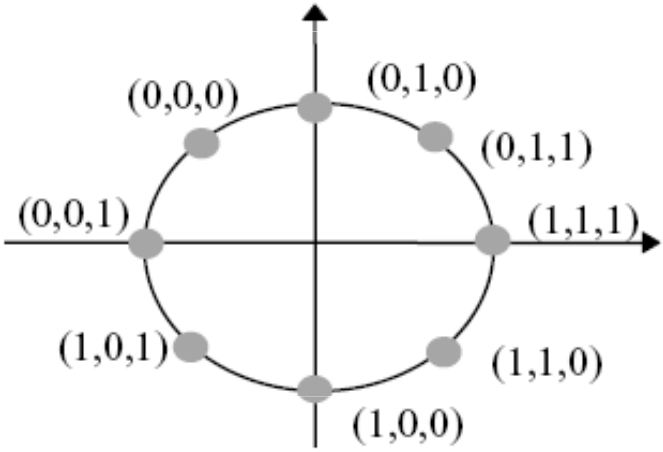
1. Activate PDP Context Req
2. DNS Query
3. Create PDP Context Req
4. Create PDP Context Rsp
5. Activate PDP Context Ack

Session Management
Data Transfer



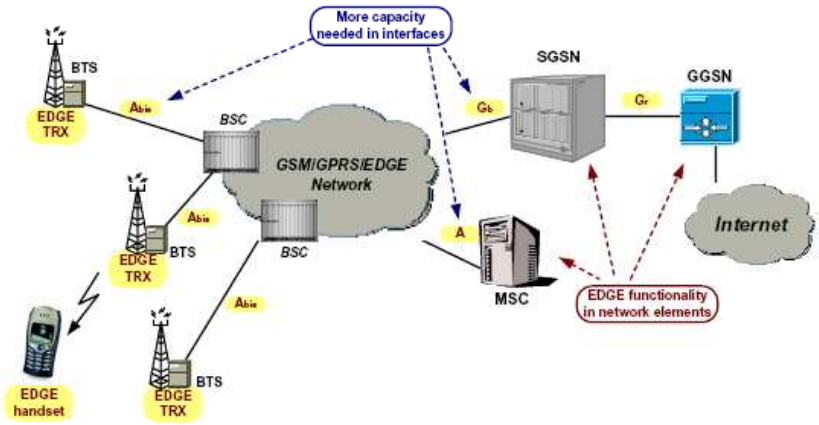
IP@ src IP@ dst
Mobile Server
SGSN GGSN

EDGE – evolution of GSM air interface
8PSK modulation to replace GMSK



	EDGE	*GSM*
Modulation	8-PSK, 3bit/sym	GMSK, 1 bit/sym
Symbol rate	270.833 ksps	270.833 ksps
Payload/burst	346 bits	114 bits
Gross rate/time slot	69.2 kbps	22.8 kbps

Objective: a **higher data throughput** thanks to a better spectral efficiency.



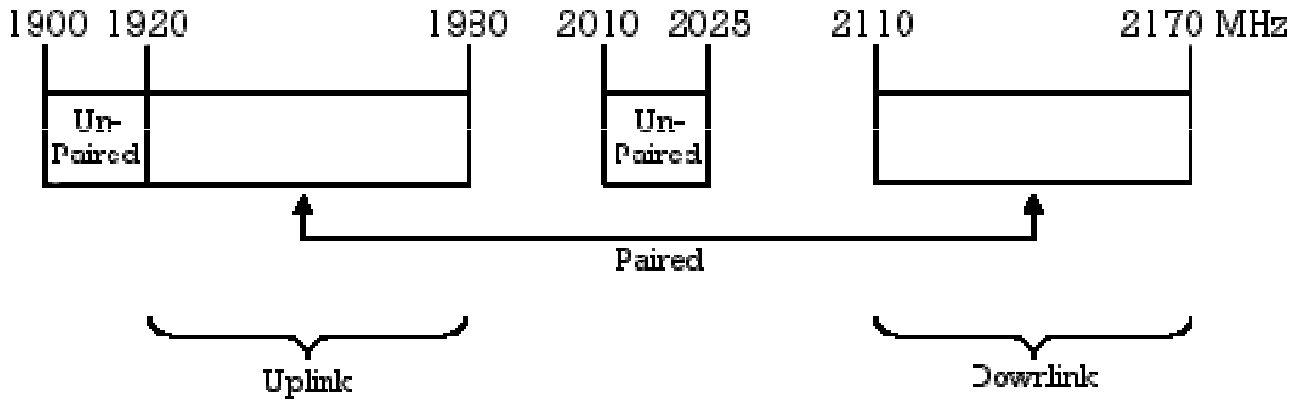
- EDGE capable TRX need to be added, old BTS might have to be changed, BSC/PCU shall support EDGE capability.
- Re-dimensioning of the interface according to the traffic growth.

UMTS

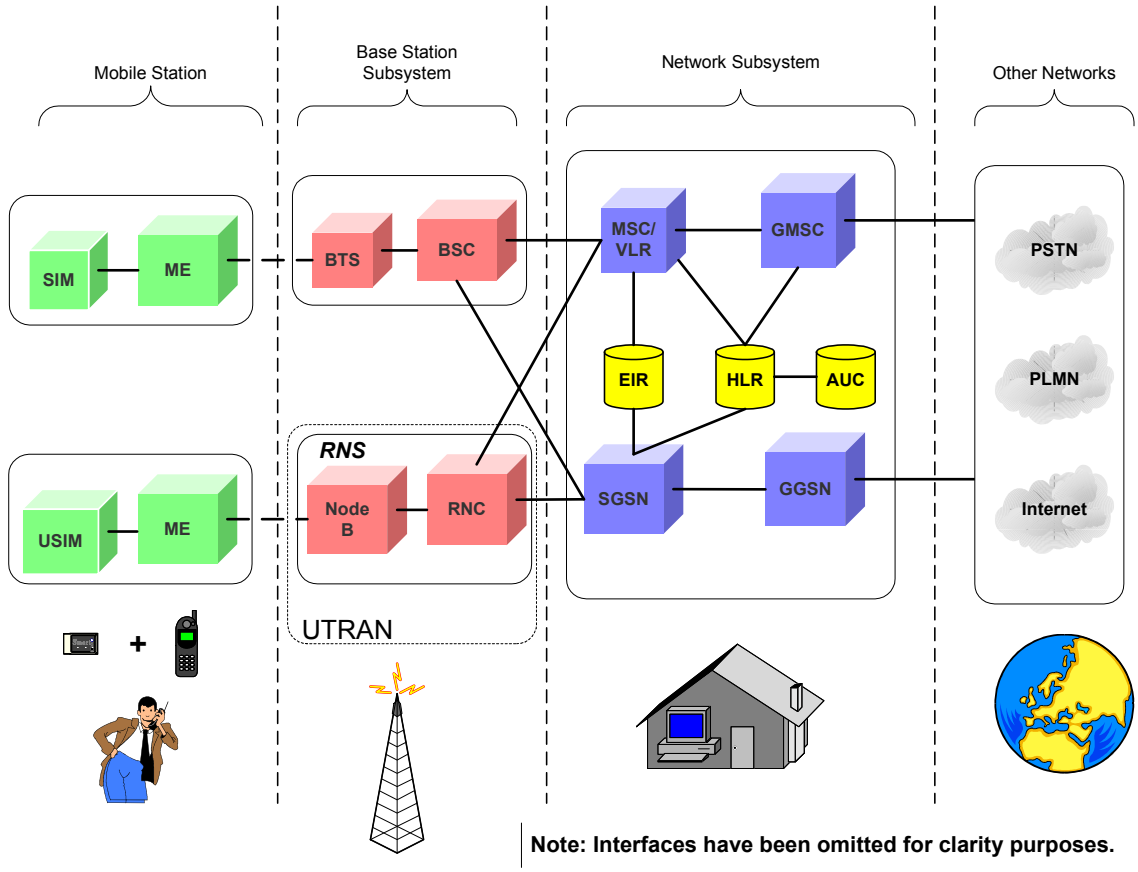
- Universal Mobile Telecommunications System (UMTS)
- UMTS is an upgrade from GSM via GPRS or EDGE
- The standardization work for UMTS is carried out by Third Generation Partnership Project (3GPP)
- Data rates of UMTS are:
  - 144 kbps for rural
  - 384 kbps for urban outdoor
  - 2048 kbps for indoor and low range outdoor
- Virtual Home Environment (VHE)

UMTS Frequency Spectrum

- UMTS Band
  - 1900-2025 MHz and 2110-2200 MHz for 3G transmission
  - In the US, 1710–1755 MHz and 2110–2155 MHz will be used instead, as the 1900 MHz band was already used.



UMTS Architecture



Note: Interfaces have been omitted for clarity purposes.

UMTS Network Architecture

- UMTS network architecture consists of three domains
  - Core Network (CN): Provide switching, routing and transit for user traffic
  - UMTS Terrestrial Radio Access Network (UTRAN): Provides the air interface access method for user equipment.
  - User Equipment (UE): Terminals work as air interface counterpart for base stations. The various identities are: IMSI, TMSI, P-TMSI, TLLI, MSISDN, IMEI, IMEISV

UTRAN

- Wide band CDMA technology is selected for UTRAN air interface
  - WCDMA
  - TD-SCDMA
- Base stations are referred to as Node-B and control equipment for Node-B is called as Radio Network Controller (RNC).
  - Functions of Node-B are
    - Air Interface Tx/Rx
    - Modulation/Demodulation
  - Functions of RNC are:
    - Radio Resource Control
    - Channel Allocation
    - Power Control Settings
    - Handover Control
    - Ciphering
    - Segmentation and reassembly

3.5G (HSPA)

High Speed Packet Access (HSPA) is an amalgamation of two mobile telephony protocols, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), that extends and improves the performance of existing WCDMA protocols

3.5G introduces many new features that will enhance the UMTS technology in future. 1xEV-DV already supports most of the features that will be provided in 3.5G. These include:

- Adaptive Modulation and Coding
- Fast Scheduling
- Backward compatibility with 3G
- Enhanced Air Interface

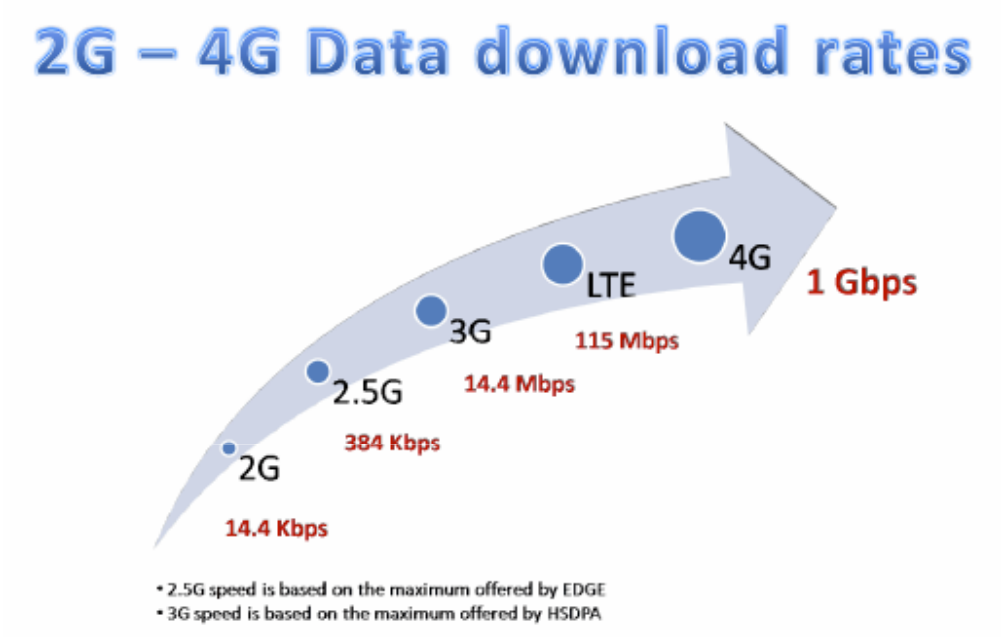
4G (LTE)

- LTE stands for Long Term Evolution
- Next Generation mobile broadband technology
- Promises data transfer rates of 100 Mbps
- Based on UMTS 3G technology
- Optimized for All-IP traffic

Advantages of LTE

for Network Operators	*for* End Users
High network throughput	Faster data downloads/uploads
Low latency	Improved response for applications
Plug & Play architecture	Improved end-user experience
Low Operating Costs	
All-IP network	
Simplified upgrade path from 3G networks	

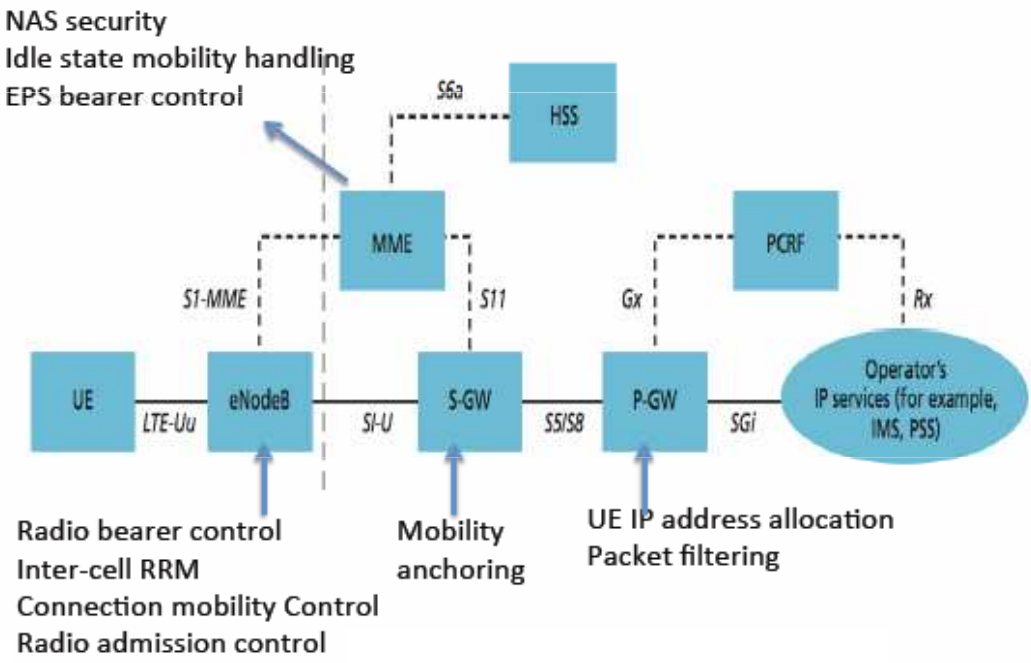
Comparison of LTE Speed



Major LTE Radio Technogies

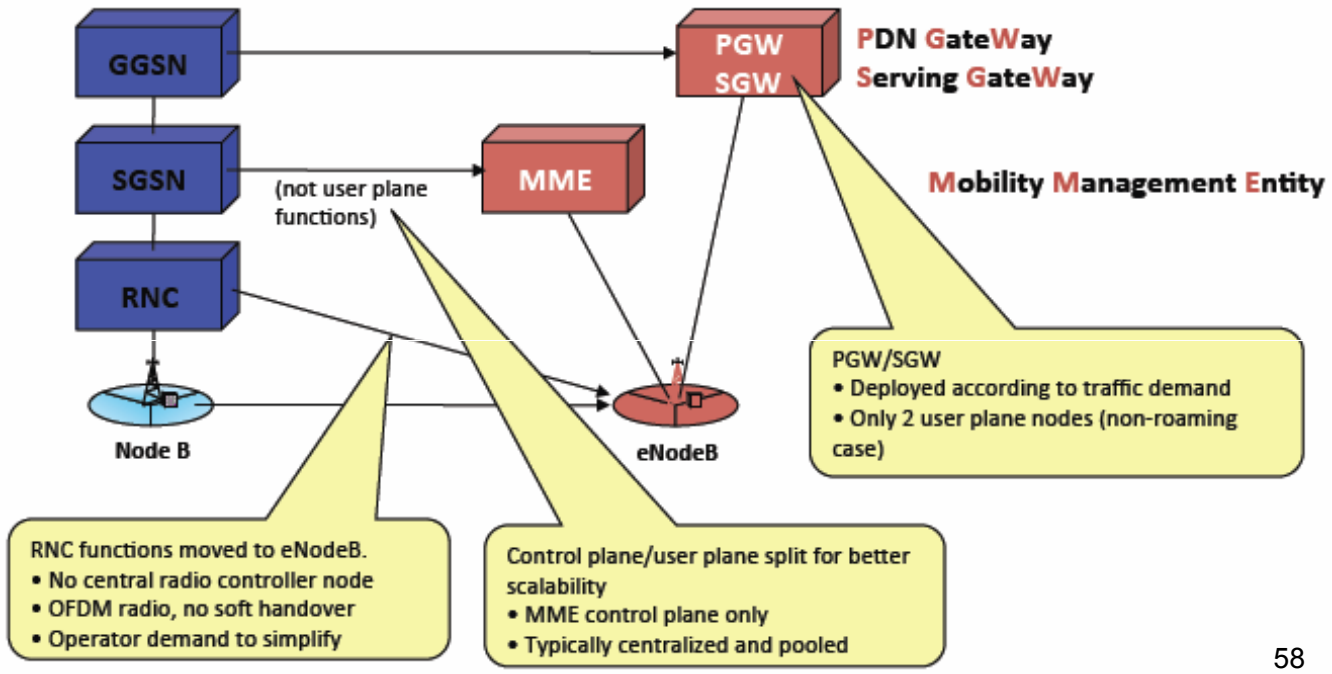
- Uses Orthogonal Frequency Division Multiplexing (OFDM) for downlink
- Uses Single Carrier Frequency Division Multiple Access (SC-FDMA) for uplink
- Uses Multi-input Multi-output(MIMO) for enhanced throughput
- Reduced power consumption
- Higher RF power amplifier efficiency (less battery power used by handsets)

LTE Architecture



LTE vs UMTS

- Functional changes compared to the current UMTS architecture



Context

HSPA Node B

HSPA Node B

pictures' source: Wikipedia

Can HSPA provide the same level of service to mobile users on public transport?