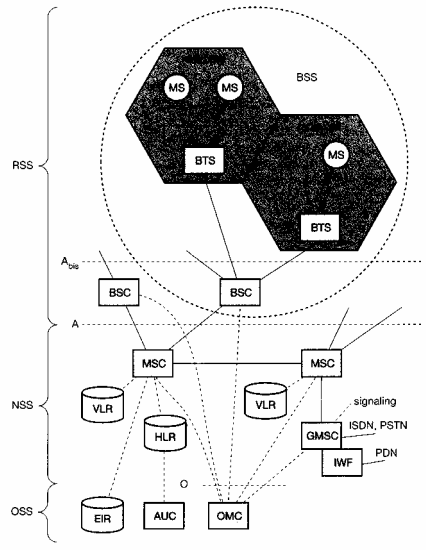
GSM system architecture

GSM system architecture

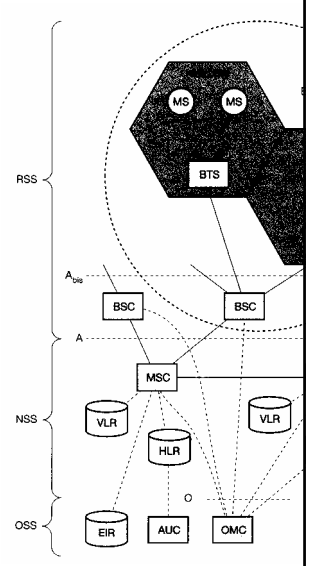
A GSM system consists of three subsystems.

– Radio SubSystem (RSS)
– Networking and Switching Subsystem (NSS)
– Operation SubSystem (OSS)



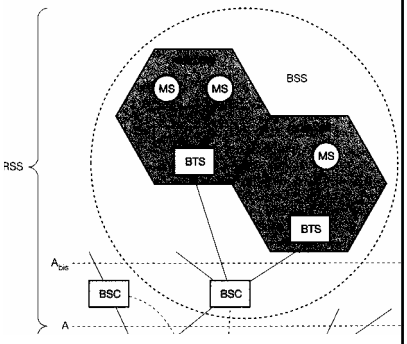
Radio SubSystem (RSS)

- The RSS comprises all radio specific entities, i.e., the mobile station (MS) and the ***base station subsystem*** (BSS).
- The connection between the RSS and NSS via the ***A-interface*** and the connection to the OSS via the ***O – interface***.
- The A-interface is typically based on ***PCM-30*** (E1) system carrying up to 30 64kbps connections (E0).
- The O-interface uses ***Signalling System No 7*** (SS7) based on ***X.25*** carrying management data to/from the BSS.



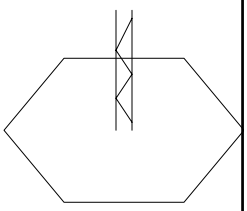
RSS – base station subsystem (BSS)

- A GSM network compromises many BSSs, each controlled by a base station controller (BSC).
- The BSS performs all functions necessary to maintain radio connections to an MS, coding/decoding of voice, rate adaptation to/from the wireless network part.
- Besides a BSC a BSS contains several ***base transceiver stations*** (BTS).

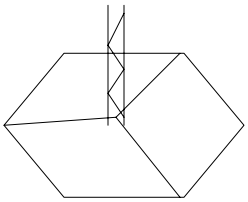


RSS – base transceiver station (BTS)

- A BTS compromises all radio equipment, i.e., antennas signal processing, amplifiers etc.
- A BTS can form one radio cell or, using sectorized antennas, several cells.
- The connection to MS is done via the $\mathbf{U_m}$ interface and to the BSC via the $\mathbf{A_{bis}}$ interface consisting of 26 or 64 kbps connections.

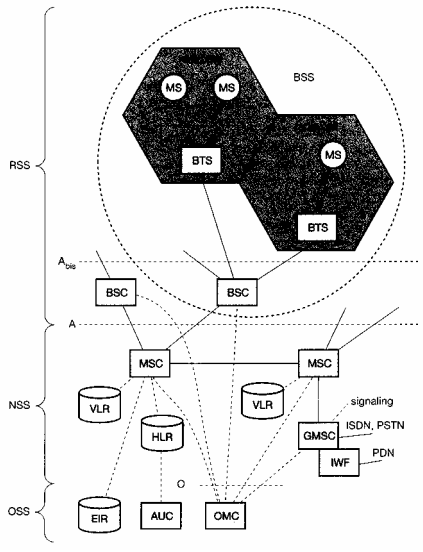


sectorized antennas



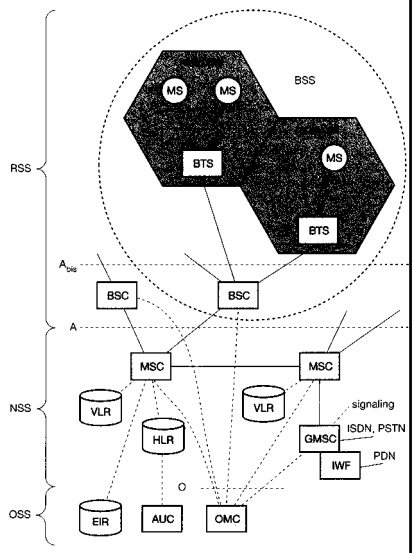
RSS – base station controller (BSC)

- The BSC manages the BTSs.
- It reserves radio frequencies, handles handover from one BTS to another within the BSS, and performs paging of the MS.
- The BSC also multiplexes the radio channels onto the fixed network connections at the A interface (E1).



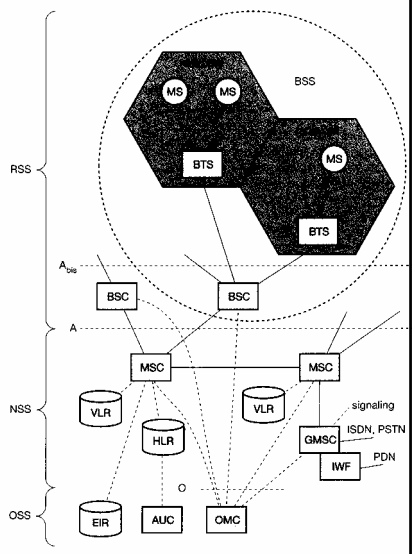
NSS

- The ***network and switching subsystem*** is the heart of the GSM system.
- The NSS connects the wireless network to the standard public networks.
- Perform handovers between different BSSs.
- Provide functions for world-wide localization of users.
- Support charging, accounting and roaming of users between different providers in different countries.



NSS – Mobile Service switching center (MSC)

- MSC is high-performancee digital ISDN switches.
- They set up connections to other MSCs and to the BSCs via the A interface.
- They form the the fixed backbone network of the GSM system.
- Typically an MSC manages several BSCs in a geographical area.
- A gateway MSC (GMSC) has connections to other fixed networks, i.e, PSTN and ISDN.

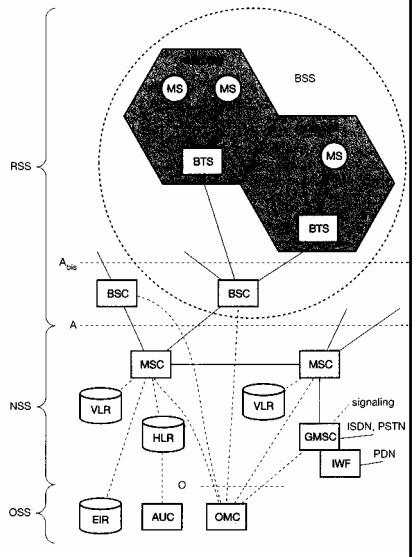


NSS – Mobile Service switching center (MSC)

- An MSC handles all signalling needed for connection setup, connection release and handover of connections to other MSCs.
- The standard ***Siganlling System No. 7*** is used for this purpose.
- It also performs all functions needed for supplementary services such as call forwarding, multi-part calls etc.

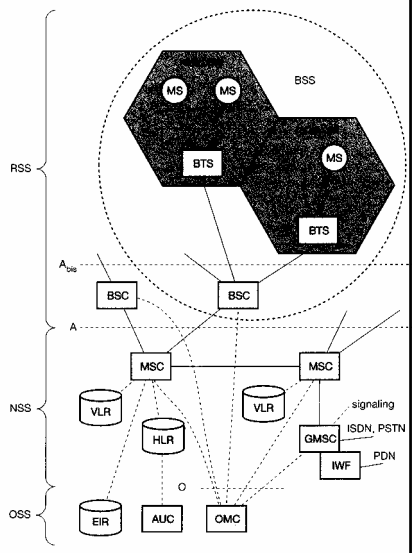
NSS – Home Location Register (HLR)

- The HLR is the most important database in GSM system, it stores all ***user relevant information.***
- The information can be divided into static information and dynamic information.
- All information in this database is uniquely stored in one HLR for each user.
- The HLR can store information for millions of subscribers.



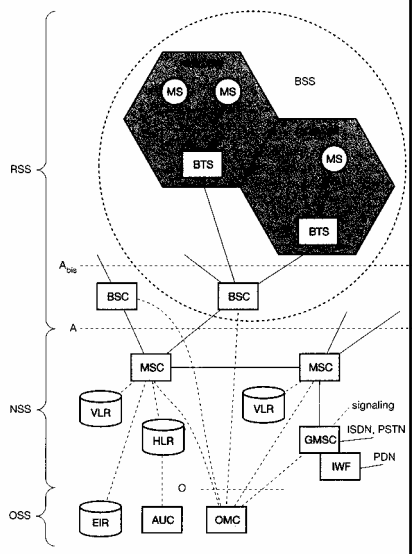
NSS – HLR – Static Information

- ***Mobile subscriber ISDN number*** (MSISDN)
- Subscribed Services:
  - Call forwarding
  - Roaming restrictions
  - GPRS
- ***International Mobile subscriber identity*** (IMSI)



NSS – HLR – Static Information

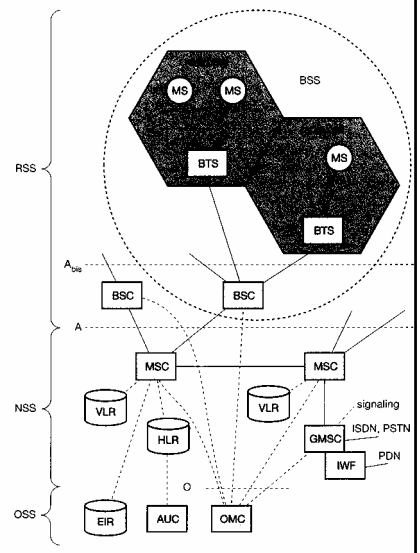
- ***Location Area*** (LA) of current MSC
- ***Mobile subscriber roaming number*** (MSRN)
  - Identifying the current VLR
  - Identifying the current MSC.
- This information is necessary to localize a user in the worldwide GSM network



NSS – Visitor location register (VLR)

The VLR is associated to MSC is a dynamic database which stores all important information needed for the mobile stations currently present in the LA that is associated to the MCS.

- IMSI
- MSISDN
- HLR address

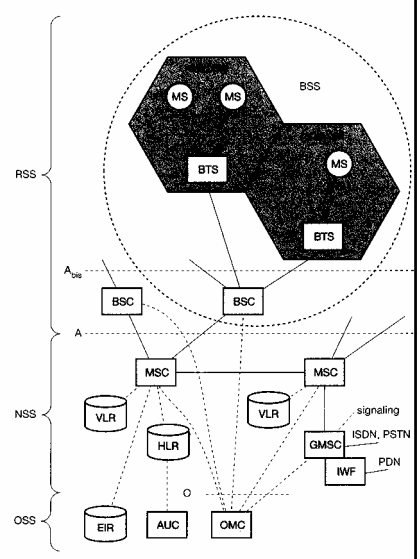


NSS – Visitor location register (VLR)

- If a new mobile station comes into the LA the WLR is responsible for copying all relevant information for this user from the HLR.
- This hierachy of VLR and HLR avoids frequent HLR updates and long distance signalling for user information.

Operation subsystem (OSS)

- The third part of GSM system, the OSS, contains the necessary functions for network operation and maintance.
- The OSS possesses network entities of its own and access other entities via SS7 signalling.

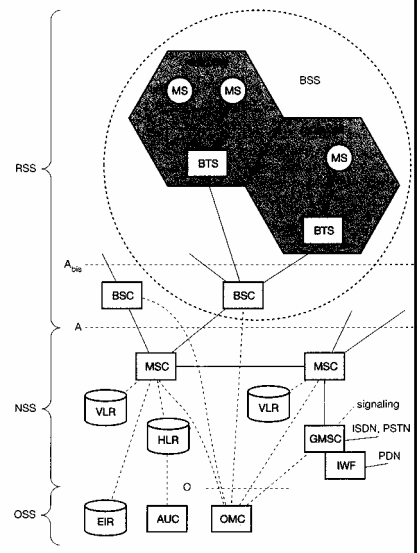


OSS – Operation and Maintenance Centre (OMC)

- The OMC monitors and controls all of the network entities via the o-interface (SS7 over X.25).
- OMC management functions are:
  - Traffic monitoring
  - Status report
  - Subscriber management
  - Security management
  - Accounting and billing

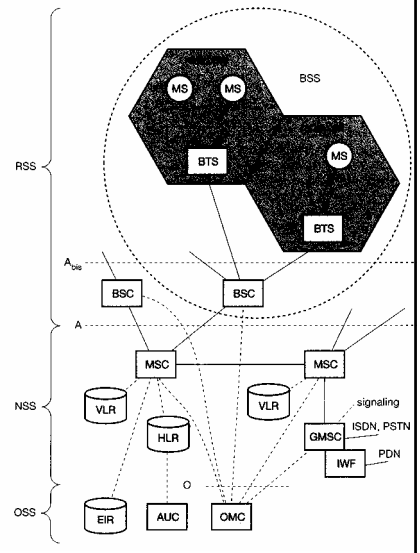
OSS – Authentication centre (AuC)

- As the radio interface and mobile stations are particular vulnerable, a separate **AuC** has been defined to protect users' identity.
- The **AuC** contains the algorithm for authentication as well as keys for encryption.
- It generates the values needed for a user authentication in the HLR.
- The **AuC** may in fact be situated in a special protected part of the HLR.



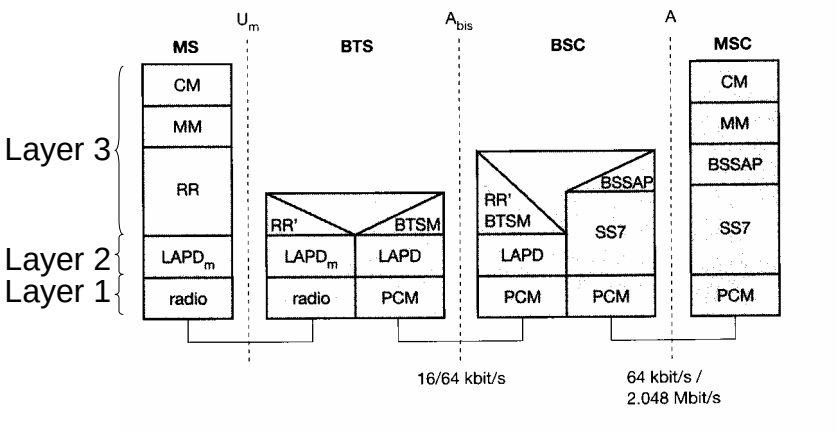
OSS – Equipment identity register (EIR)

- The EIR stores all device identifications registered for this network.
- The EIR has a backlist of stolen or locked devices.
- The EIR also contains a list of all IMEI (white list).
- And a list of all malfunctioning devices (grey list).



GSM protocols

GSM protocols



Layer 1 physical layer

All schemes and mechanisms used to make communication possible on the mobile radio channel.

- Modulation
- Power control
- Coding
- Timing
- Multiplexing of burst into frames
- Synchronization

Layer 2

- The protocol used in GSM for signalling transfer between a mobile station and the BTS is called the link access procedure for the D_m ($LAPD_m$).
- It is a mobile adaptation of the link access protocol data (LAPD) which is defined in ISDN for fixed networks.
- In essence, LAPD is designed to convert a potentially unreliable physical link into a reliable data link (CRC combined with ARQ).

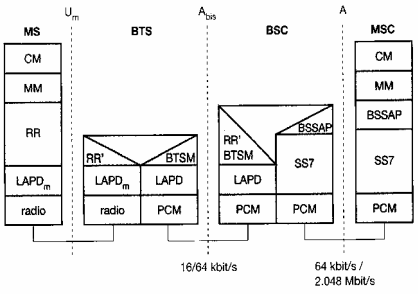
Layer 2

- Organization of layer 3 information into frames.
- Peer-to-peer transmission of signalling data in defined frame formats.
- Recognition of frame formats.
- Establishment, maintenance and termination of data links on signalling channels.
- Acknowlegement of transmission and reception of numbered information frames.
- Unacknowledge transmission and reception of unnumbered information frames.

Layer 3 (Network layer)

There are a number of sublayers defined for layer 3:

– Radio resource management (RR)
– Mobility management (MM)
– Connection management (CM)
– BTS management (BTSM)
– BSS application (BSSAP)



Layer 3 - Radio resource management (RR)

- The tasks covered in this segment of the network layer are closely connected to the physical layer.
- The RR is responsible for the management of the frequency spectrum.
- The GSM system's reaction to the changing radio environment.
- Everything related to maintain a clear channel between the BST and the mobile station.

Layer 3 - Radio resource management (RR)

- Channel assignment procedures
- Channel release
- Channel change and handover procedures
- Change of channel frequency (hopping sequence)
- Measurement reports from the mobile station
- Power control
- Timing advance
- Modification of channel modes
- Chipher mode settings

Layer 3 - Mobility management (MM)

- The MM sublayer copes with all the effects of handling a mobile user that are not directly related to radio functions.
- These tasks include the kinds of things a fixed network would do to authorize and connect a user to a fixed network (modified to account for the fact that the user may not remain at the same place).

Layer 3 - Mobility management (MM)

- Support of user's mobility
  - Registration
  - Management of mobility data
- Checking the user's and the equipment's identity.
- Checking if the user is allowed to use the services and what kind of extra services that are allowed.
- Support of user confidentiality
- Provision of user security
- Provision of an MM connection, based on a existing RR connection, to the CM layer.

Layer 3 - Connection management (CM)

- The CM sublayer manages all the functions necessary for circuit-switched call control.
- These functions are provided by the call control entity within the CM sublayer.
- There are other entities within the CM sublayer to cope with supplementary services as SMS.
- The call control in the CM sublayer are almost identical to those provided in a fixed network.
- The call control access scheme used in GSM is inherited from the ISDN.

Layer 3 - Connection management (CM)

- Call-establishment procedures for mobile orginated calls.
- Call-establishment procedures for mobile terminated calls.
- Changes of tranmission mode during an ongoing call.
- Call re-establishment after interuption of an MM connection.
- Dual-tone multifrequency (DTFM) control procedures for DTFM transmissons.

Layer 3- BTS management (BTSM)

- Performes various management and administrative functions at the base transceiver station (BTS).
- Under the control of the Base Staion Controler (BSC).

Layer 3 – BSS Application Part

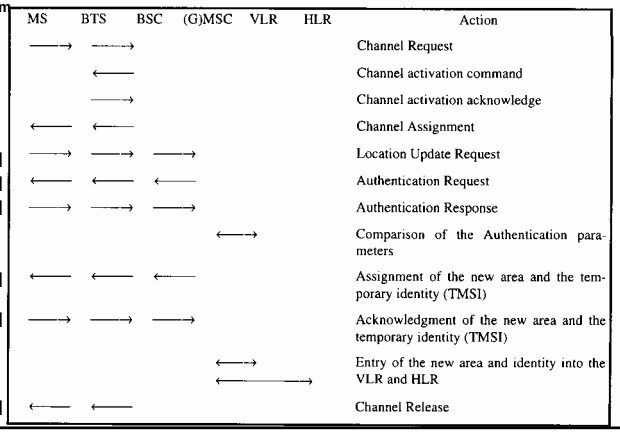
- Handles most of the signalling between different entities in the fixed part of the network.
- Such as, signalling between the VLR and HLR.

Registration

After a mobile station is switched on, it scans the presence of a network. It determines its current position within the network.

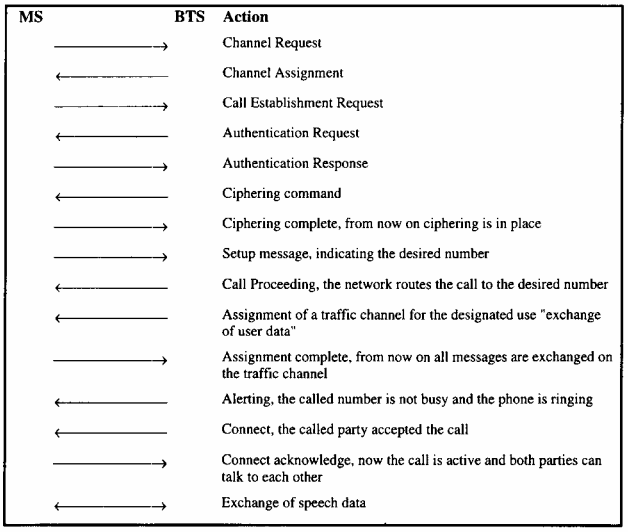
If the current position is not the same as it was when the mobile last was switched off, a registration procedure takes place.

Logical channel U_m

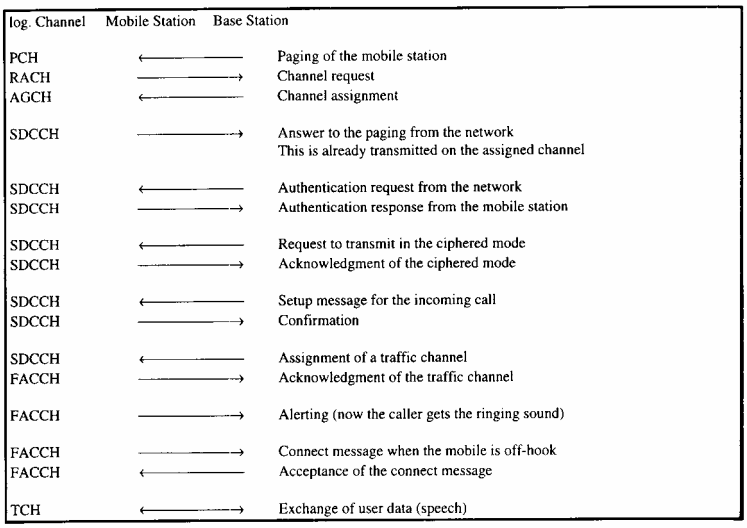


Mobile orginated call (MOC)

Logical Channel



Mobile terminated call (MTC)



log. Channel	Mobile Station	Base Station	
PCH	←		Paging of the mobile station
RACH	→		Channel request
AGCH	←		Channel assignment
SDCCH	→		Answer to the paging from the network This is already transmitted on the assigned channel
SDCCH	←		Authentication request from the network
SDCCH	→		Authentication response from the mobile station
SDCCH	←		Request to transmit in the ciphered mode
SDCCH	→		Acknowledgment of the ciphered mode
SDCCH	←		Setup message for the incoming call
SDCCH	→		Confirmation
SDCCH	←		Assignment of a traffic channel
FACCH	→		Acknowledgment of the traffic channel
FACCH	→		Alerting (now the caller gets the ringing sound)
FACCH	→		Connect message when the mobile is off-hook
FACCH	←		Acceptance of the connect message
TCH	↔		Exchange of user data (speech)

Data services

HSCSD

- A straightforward improvement of the GSM's data transmission capabilities is ***high speed circuit switched data*** (HSCSD).
- A mobile station requests more TCHs from the network, i.e., it allocates several TDM slots within a TDM frame.
- This allocation can be asymmetrical, e.g., it allocates more slots on the downlink than on the uplink.
- Basically, HSCSD only requires software updates in the mobile station and in the MSC.

HSCSD

- In theory, a mobile station could use all eight slots within a TDM frame and achieve an ***air interface user rate*** (AIUR) of, e.g., TCH/F14.4 channels or 115 kbps.
- The drawback with HSCSD is that it still uses a connection-oriented mechanism of GSM.
- These are not efficient for bursty data traffic, bad utilization and high cost.
- It also increases the average utilization time of the transmitter (amplifier) in the mobile station which demand for better coolers.

GPRS

- The next step toward more flexible and powerful data transmissions is being fully packet-oriented.
- The ***general packet radio service*** (GPRS) provides packet mode transfer for applications that exhibit bursty data traffic.
- GPRS is driven by packet-oriented applications.
- GPRS however needs additional software and hardware to the GSM system.
- It is actually a big step towards the UMTS (3G).

GPRS

Coding scheme	1 slot	2 slots	3 slots	4 slots	5 slots	6 slots	7 slots	8 slots
CS-1	9.05	18.2	27.15	36.2	45.25	54.3	63.35	72.4
CS-2	13.4	26.8	40.2	53.6	67	80.4	93.8	107.2
CS-3	15.6	31.2	46.8	62.4	78	93.6	109.2	124.8
CS-4	21.4	42.8	64.2	85.6	107	128.4	149.8	171.2

It should be noted that in the beginning only the coding schemes CS-1 and CS-2 are available.

It should further be noted that the real available data rate is dependent on the current load of the cell as GPRS typically only uses idle time slots.

Typically today is a receiving rate of 53.6 kbps and sending rate 26.8 kpbs.

GPRS

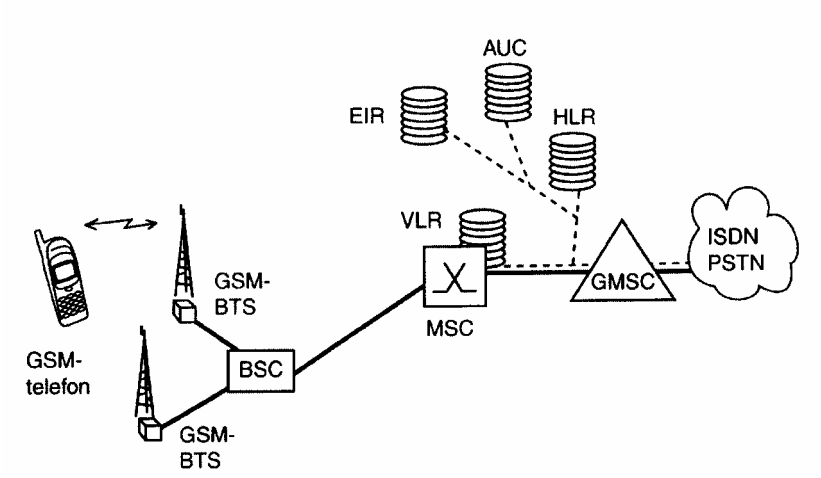
- The GPRS architechture introduces two new network elements:

- ***GPRS Support Node*** (GSN)
- ***Serving GPRS Support Node*** (SGSN).

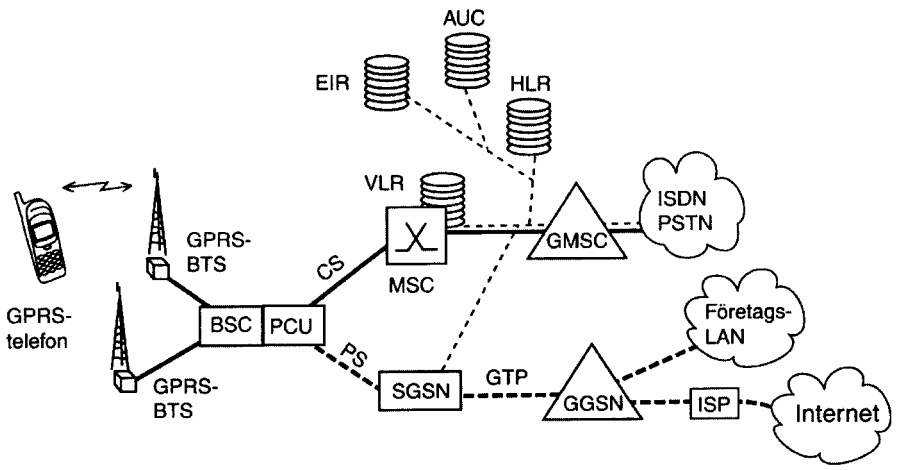
and some modifications

- ***Packet Control Unit*** (PCU)

GSM system



GSM system with GPRS



GPRS – GSN

- The GSN is simply a router.
- The ***gateway GPRS support node*** (GGSN) is the interworking unit between the GPRS network and external packet data networks (PDN).
- The GGSN is connected to external networks (e.g. IP or X.25) via the G_i interface and transfer packets to the SGSN via an IP-based GPRS backbone network(G_n interface)

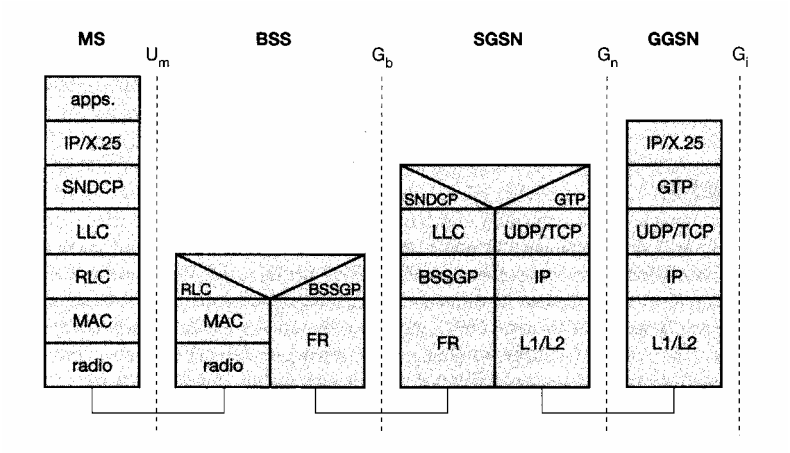
GPRS - SGSN

- The ***Serving GPRS Support Node*** (SGSN) supports the mobile station via the Gb interface.
- The SGSN, for example request user addresses from the ***GPRS register*** (GR).
  - Keep track of the individual MSs location
  - Collecting billing information
  - Several security functions

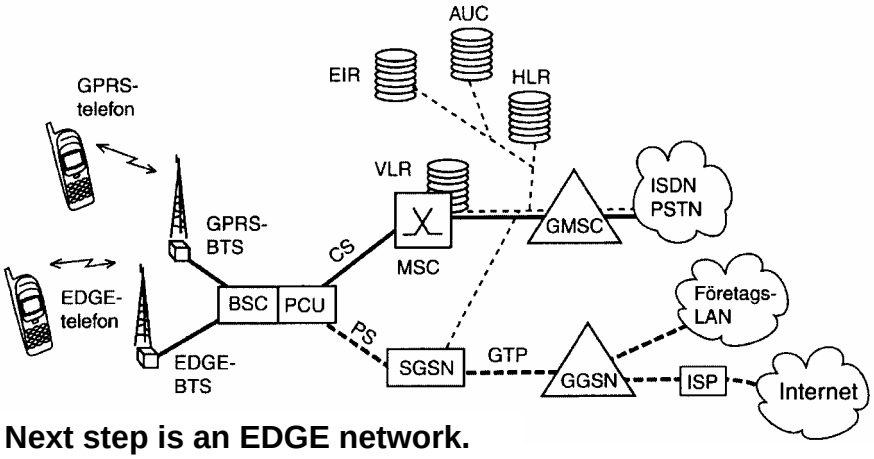
GPRS

- All data within the GPRS backbone is transferred using the ***GPRS tunneling protocol*** (GTP).
- GTP can use two different transport protocols:
  - TCP
  - UDP
- The network protocol for the GPRS backbone is IP.
- To adapt to the different characteristics of the underlaying networks, the ***subnetwork dependent convergence protocol*** (SNDCP) is used between the SGSN and the mobile station.

GPRS – protocol stack



Enhanced Data rates for GSM Evolution (EDGE)



Next step is an EDGE network.

Universal Mobile Telecommunication System (UMTS 3G)