UNIT-2
Telecommunication Systems

- GSM
  - New Data services
    - HSCSD
    - GPRS

- **New data services**
- As mentioned above, the standard bandwidth of 9.6 kbit/s (14.4 kbit/s with some providers) available for data transmission is not sufficient for the requirements of today's computers. with the requirements of, e.g., web browsing, file download, or even intensive e-mail exchange with attachments, this is not enough.
- To enhance the data transmission capabilities of GSM, two basic approaches are possible. As the basic GSM is based on connection-oriented traffic channels, e.g., with 9.6 kbit/s each, several channels could be combined to increase band-width. This system is called **HSCSD.**
- A more progressive step is the introduction of packet-oriented traffic in GSM, i.e., shifting from connections/telephone thinking to packets/internet thinking. The system, called **GPRS.**

- **HSCSD**
- *HSCSD is available with some providers. In this system, higher data rates are achieved by bundling several TCHs*. An MS requests one or more TCHs from the GSM network, i.e., it allocates several TDMA slots within a TDMA frame. This allocation can be asymmetrical, i.e., more slots can be allocated on the downlink than on the uplink, which fits the typical user behavior of downloading more data compared to uploading. Basically, HSCSD only requires software upgrades in an MS and MSC (both have to be able to split a traffic stream into several streams, using a separate TCH each, and to combine these streams again).
- In theory, an MS could use all eight slots within a TDMA frame to achieve **an air interface user rate (AIUR).** One problem of this configuration is that the MS is required to send and receive at the same time.

- bundling of several time-slots to get higher AIUR (Air Interface User Rate, e.g., 57.6 kbit/s using 4 slots @ 14.4)
- **advantage**: ready to use, constant quality, simple
- **disadvantage:** channels blocked for voice transmission

- All in all, HSCSD may be an attractive interim solution for higher bandwidth and rather constant traffic (e.g., file download). However, it does not make much sense for bursty internet traffic as long as a user is charged for each channel allocated for communication.

AIUR [kbit/s]	TCH/F4.8	TCH/F9.6	TCH/F14.4
4.8	1		
9.6	2	1	
14.4	3		1
19.2	4	2	
28.8		3	2
38.4		4	
43.2			3
57.6			4

- **GPRS**
- The general packet radio service (GPRS) provides packet mode transfer for applications that exhibit traffic patterns such as frequent transmission of small volumes (e.g., typical web requests) or infrequent transmissions of small or medium volumes (e.g., typical web responses) according to the requirement
- Compared to existing data transfer services, GPRS should use the existing network resources more efficiently for packet mode applications, GPRS should also allow **for broadcast, multicast, and unicast service.**
- The overall is the provision of a more efficient and, thus, cheaper **packet transfer service** for typical internet applications that usually rely solely on packet transfer.
- The main benefit for users of GPRS is the '**always on**' characteristic – no connection has to be set up prior to data transfer. Clearly, GPRS was driven by the tremendous success of the packet-oriented internet, and by the new traffic models and applications.

- However, GPRS, needs **additional network elements**, i.e., **software and hardware.**
- The main concepts of GPRS are as follows :
- For the new GPRS radio channels, the GSM system can allocate between one and eight time slots within a TDMA frame.
- Time slots are not allocated in a fixed, pre-determined manner but on demand.
- All time slots can be shared by the active users; up and downlink are allocated separately. Allocation of the slots is based on current load and operator preferences.
- Depending on the coding, a transfer rate of up to 170 kbit/s is possible.
- For GPRS, operators often reserve at least a time slot per cell to guarantee a minimum data rate.
- The GPRS concept is independent of channel characteristics and of the type of channel, and does not limit the maximum data rate. All GPRS services can be used in parallel to conventional services. Table shows the typical data rates available with GPRS if it is used together with GSM (GPRS can also be used for other TDMA systems).

GPRS user data rates in kbit/s

Coding scheme	1 slot	2 slots	3 slots	4 slots	5 slots	6 slots	7 slots	8 slots
CS-1	9.05	18.1	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

- Real available data rate heavily depends on the current load of the cell as GPRS typically only uses idle time slots.

- The transfer rate depends on the capabilities of the MS as not all devices are able to send and receive at the same time.
- Table gives examples for device classes together with their ability to use time slots for sending and receiving data. For example, a class 12 device may receive data using 4 slots within a GSM time frame or it may send data using 4 slots. However, a maximum number of 5 slots may be used altogether. Using all 8 slots for data encoded using CS-4 yields the maxi-mum rate of 171.2 kbit/s.

- In phase 1, GPRS offers a point-to-point (PTP) packet transfer service. One of the PTP versions offered is the PTP connection oriented network service (PTP-CONS), called circuit-switched packet-oriented transfer protocol available worldwide.

- The other PTP version offered is the PTP connectionless network service (PTP-CLNS), which supports applications that are based on the Internet Protocol IP. Multicasting, called point-to-multipoint (PTM) service, is left for GPRS phase 2.

Examples for GPRS device classes

Class	Receiving slots	Sending slots	Maximum number of slots
1	1	1	2
2	2	1	3
3	2	2	3
5	2	2	4
8	4	1	5
10	4	2	5
12	4	4	5

- **Users of GPRS can specify a QoS-profile.**
- This determines the service precedence (high, normal, low), **reliability class and delay class** of the transmission, and user data throughput.
- Table shows the three reliability classes together with the maximum probabilities for a lost service data unit (SDU),
- a duplicated SDU,
- an SDU out of the original sequence,
- and the probability of delivering a corrupt SDU to the higher layer.
- Reliability class 1 could be used for very error-sensitive applications that cannot perform error corrections them-selves. If applications exhibit greater error tolerance, class 2 could be appropriate. Finally, class 3 is the choice for error-insensitive applications or applications that can handle error corrections themselves.

GPRS quality of service

Reliability class	Lost SDU probability	Duplicate SDU probability	Out of sequence SDU probability	Corrupt SDU probability
1	10^{-9}	10^{-9}	10^{-9}	10^{-9}
2	10^{-4}	10^{-5}	10^{-5}	10^{-6}
3	10^{-2}	10^{-5}	10^{-5}	10^{-2}

Delay class	SDU size 128 byte		SDU size 1024 byte	
	mean	95 percentile	mean	95 percentile*
1	< 0.5 s	< 1.5 s	< 2 s	< 7 s
2	< 5 s	< 25 s	< 15 s	< 75 s
3	< 50 s	< 250 s	< 75 s	< 375 s
4	unspecified			

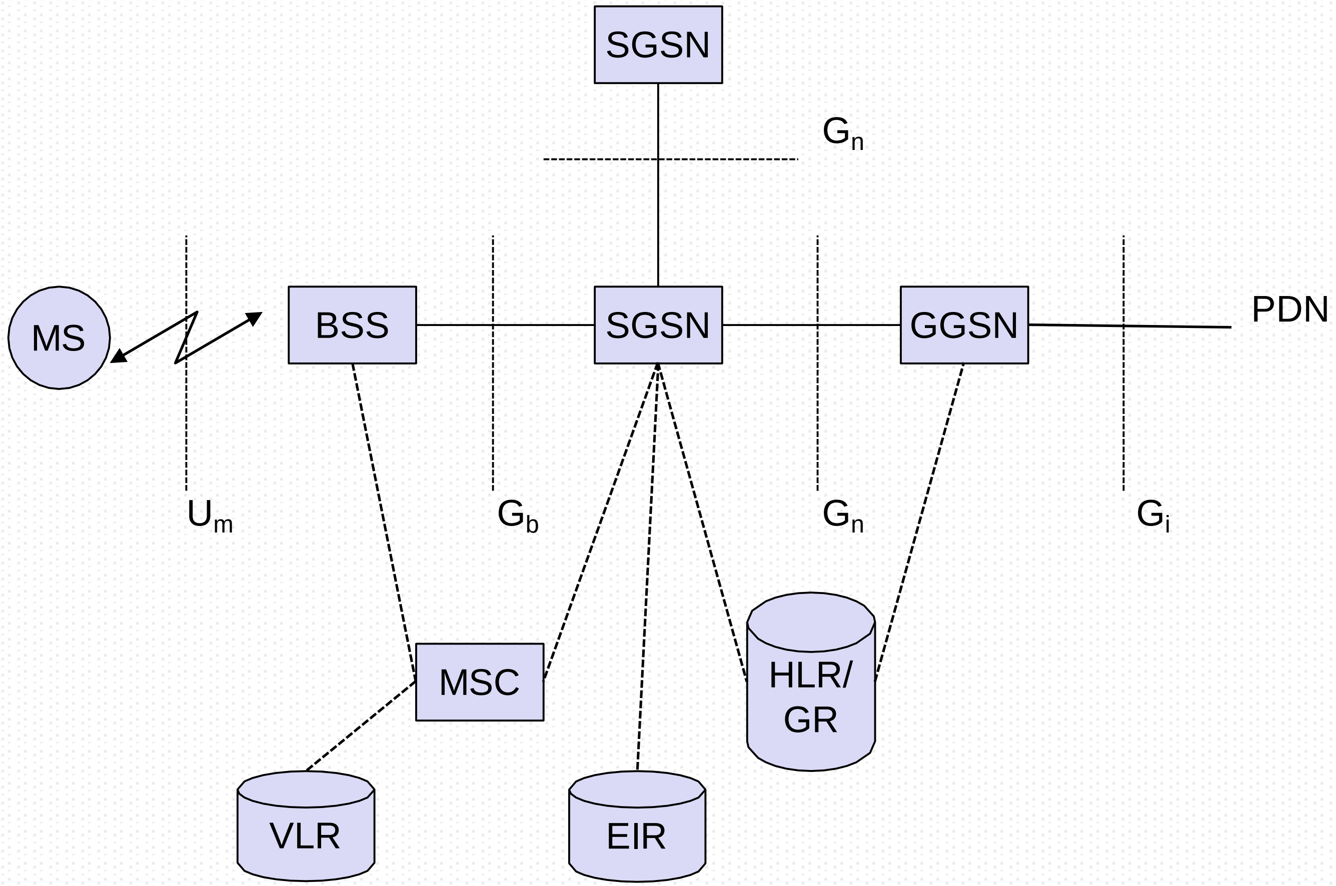
*In general terms, the 95th percentile tells you that 95 per cent of the time your network usage will be below a particular amount.

The 95th percentile basically says that 95 per cent of the time your usage is below this number, and the other 5 per cent of the time it exceeds that number.

- Delay within a GPRS network is incurred by:
- channel access delay,
- coding for error correction,
- and transfer delays in the fixed and wireless part of the GPRS network.
- GPRS does not produce additional delay by buffering packets as store-and-forward networks do. If possible, GPRS tries to forward packets as fast as possible.
- Table shows the specified maximum mean and 95 percentile delay values for packet sizes of 128 and 1,024 byte, all delays are orders of magnitude higher than fixed network delays. This is a very important.
- Typical round trip times (RTT) in fixed networks are in the order of 10 to 100 ms. Using real unloaded GPRS networks round trip times of well above 1 s for even small packets (128–512 byte) are common.
- Additionally, GPRS exhibits a large jitter compared to fixed networks.
- Finally, GPRS includes several security services such as authentication, access control, user identity confidentiality, and user information confidentiality.

- The GPRS architecture introduces two new network elements,
- which are called GPRS support nodes (GSN) and are in fact routers. All GSNs are integrated into the standard GSM architecture.
- The gateway GPRS support node (GGSN) is the inter-working unit between the GPRS network and external packet data networks (PDN).
- This node contains routing information for GPRS users, performs address conversion, and tunnels data to a user via encapsulation.
- The other new element is the serving GPRS support node (SGSN) which supports the MS via the Gb interface.
- The GGSN is connected to external networks (e.g., IP or X.25) via the Gi interface and transfers packets to the SGSN via an IP-based GPRS backbone network (Gn interface).

GPRS architecture and interfaces



- The SGSN, for example, requests user addresses from the GPRS register (GR), keeps track of the individual MSs' location, is responsible for collecting billing information (e.g., counting bytes), and performs several security functions such as access control.
- The SGSN is connected to a BSC.
- The GR, which is typically a part of the HLR, stores all GPRS-relevant data.
- GGSNs and SGSNs can be compared with home and foreign agents, respectively, in a mobile IP network.
- As shown in Figure, packet data is transmitted from a PDN, via the GGSN and SGSN directly to the BSS and finally to the MS.
- The MSC, which is responsible for data transport in the traditional circuit-switched GSM, is only used for signaling in the GPRS scenario.
- Additional interfaces to further network elements and other (PLMNs) Public land mobile network can be found.

- Before sending any data over the GPRS network, an MS must attach to it, following the procedures of the mobility management.
- The attachment procedure includes assigning a temporal identifier, called a temporary logical link identity (TLLI), and a ciphering key sequence number (CKSN) for data encryption.
- For each MS, a GPRS context is set up and stored in the MS and in the corresponding SGSN.
- This context comprises:
- the status of the MS which can be ready, idle, or standby;
- the CKSN, a flag indicating if compression is used
- routing data (TLLI, the routing area RA, a cell identifier, and a packet data channel, PDCH, identifier).
- authentication, location management, and ciphering

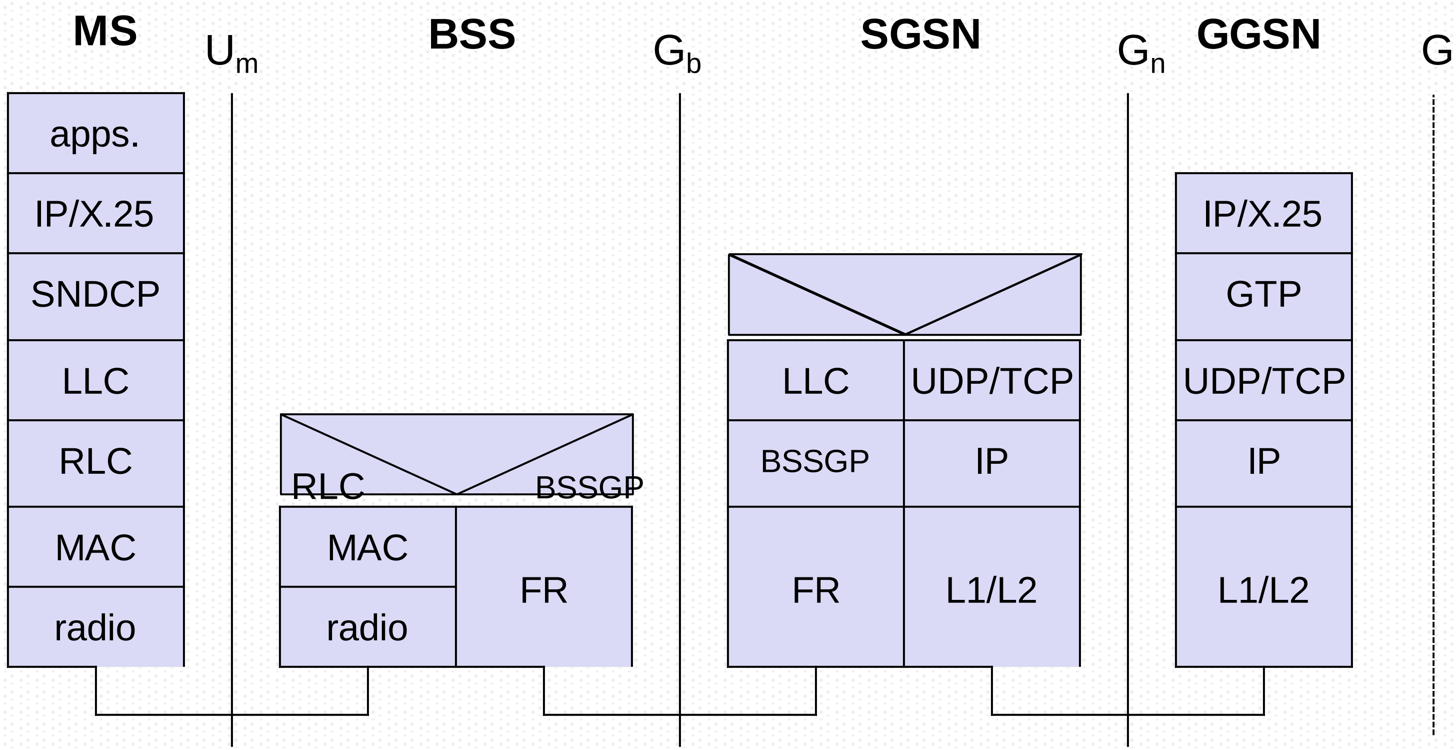
- In idle mode an MS is not reachable and all context is deleted.
- In the standby state only movement across routing areas is updated to the SGSN but not changes of the cell. Permanent updating would waste battery power

- Only in the ready state every movement of the MS is indicated to the SGSN.

- **Protocol architecture**

- Figure shows the protocol architecture of the transmission plane for GPRS.
- All data within the GPRS backbone, i.e., between the GSNs, is transferred using the GPRS tunnelling protocol (GTP).
- GTP can use two different transport protocols,
- TCP or UDP (used for IP packets).
- The network protocol for the GPRS back-bone is IP (using any lower layers).
- To adapt to the different characteristics of the underlying networks, the subnetwork dependent convergence protocol (SNDCP) is used between an SGSN and the MS.
- On top of SNDCP and GTP, user packet data is tunneled from the MS to the GGSN and vice versa.

GPRS protocol architecture



- To achieve a high reliability of packet transfer between SGSN and MS, a special LLC is used, which comprises ARQ* and FEC mechanisms for PTP/ PTM services.
- A base station subsystem GPRS protocol (BSSGP) is used to convey routing and QoS-related information between the BSS and SGSN.
- Finally, radio link dependent protocols are needed to transfer data over the Um interface. The radio link protocol (RLC) provides a reliable link, while the MAC controls access with signaling procedures for the radio channel.
- The radio interface at Um needed for GPRS does not require fundamental changes compared to standard GSM. However, several new logical channels and their mapping onto physical resources have been defined.

- *Automatic Repeat ReQuest (**ARQ**) is a group of error – control protocols for transmission of data over noisy or unreliable communication network

- All PDNs (packet data network) forward their packets for a GPRS user to the GGSN, the GGSN asks the current SGSN for tunnel parameters, and forwards the packets via SGSN to the MS.
- Although MSs using GPRS may be considered as part of the internet. All MSs are assigned private IP addresses which are then translated into global addresses at the GGSN.
- The advantage of this approach is the inherent protection of MSs from attacks. Private addresses are not routed through the internet so it is not possible to reach an MS from the internet.
- This is also a disadvantage if an MS wants to offer a service using a fixed, globally visible IP address