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Program : **B.Tech**

Subject Name: **Wireless and Mobile Computing**

Subject Code: **IT-602**

Semester: **6th**

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Unit 2:

GSM- Services: GSM offers three basic types of services:

- Telephony services or teleservices
- Data services or bearer services
- Supplementary services

Teleservices

The abilities of a Bearer Service is used by a teleservice to transport data. These services are further transited in the following ways:

Voice Calls

The most basic teleservice supported by GSM is telephony. This includes full-rate speech at 13 kbps and emergency calls, where the nearest emergency-service provider is notified by dialing three digits.

Videotext and Facsmile

Another group of teleservices includes Videotext access, Teletex transmission, Facsmile alternate speech and Facsmile Group 3, Automatic Facsmile Group, 3 etc.

Short Text Messages

Short Messaging Service (SMS) service is a text messaging service that allows sending and receiving text messages on your GSM mobile phone. In addition to simple text messages, other text data including news, sports, financial, language, and location-based data can also be transmitted.

Bearer Services

Data services or Bearer Services are used through a GSM phone. to receive and send data is the essential building block leading to widespread mobile Internet access and mobile data transfer. GSM currently has a data transfer rate of 9.6k. New developments that will push up data transfer rates for GSM users are HSCSD (high speed circuit switched data) and GPRS (general packet radio service) are now available.

Supplementary Services

Supplementary services are additional services that are provided in addition to teleservices and bearer services. These services include caller identification, call forwarding, call waiting, multi-party conversations, and barring of outgoing (international) calls, among others. A brief description of supplementary services is given here:

Conferencing: It allows a mobile subscriber to establish a multiparty conversation, i.e., a simultaneous conversation between three or more subscribers to setup a conference call. This service is only applicable to normal telephony.

Call Waiting: This service notifies a mobile subscriber of an incoming call during a conversation. The subscriber can answer, reject, or ignore the incoming call.

Call Hold: This service allows a subscriber to put an incoming call on hold and resume after a while. The call hold service is applicable to normal telephony.

Call Forwarding: Call Forwarding is used to divert calls from the original recipient to another number. It is normally set up by the subscriber himself. It can be used by the subscriber to divert calls from the Mobile Station when the subscriber is not available, and so to ensure that calls are not lost.

Call Barring : Call Barring is useful to restrict certain types of outgoing calls such as ISD or stop incoming calls from undesired numbers. Call barring is a flexible service that enables the subscriber to conditionally bar calls.

Number Identification: There are following supplementary services related to number identification:

Calling Line Identification Presentation: This service displays the telephone number of the calling party on the screen.

Calling Line Identification Restriction: A person not wishing their number to be presented to others subscribes to this service.

Connected Line Identification Presentation: This service is provided to give the calling party the telephone number of the person to whom they are connected. This service is useful in situations such as forwarding's where the number connected is not the number dialed.

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Connected Line Identification Restriction: There are times when the person called does not wish to have their number presented and so they would subscribe to this person, normally, this overrides the presentation service.
Malicious Call Identification: The malicious call identification service was provided to combat the spread of obscene or annoying calls. The victim should subscribe to this service, and then they could cause known malicious calls to be identified in the GSM network, using a simple command.
Advice of Charge (AoC): This service was designed to give the subscriber an indication of the cost of the services as they are used. Furthermore, those service providers who wish to offer rental services to subscribers without their own SIM can also utilize this service in a slightly different form. AoC for data calls is provided on basis of time measurements.
Closed User Groups (CUGs): This service is meant for groups of subscribers who wish to call only each other and no one else.
Unstructured supplementary services data (USSD) : This allows operator-defined individual services.

Radio interface: The common boundary between a mobile station and the radio equipment in the network, which is the boundary defined by functional characteristics, physical interconnection characteristics, signal characteristics, and other characteristics as appropriate
Radio Interface Layer (RIL) is a layer in an operating system which provides an interface to the hardware's radio and modem on e.g. a mobile phone.
Android RIL
The Android Open Source Project provides a Radio Interface Layer (RIL) between Android telephony services (android.telephony) and the radio hardware.
It consists of a stack of two components: a RIL Daemon and a Vendor RIL. The RIL Daemon talks to the telephony services and dispatches "solicited commands" to the Vendor RIL. The Vendor RIL is specific to a particular radio implementation, and dispatches "unsolicited commands" up to the RIL Daemon.
Windows Mobile RIL
A RIL is a key component of Microsoft's Windows Mobile OS. The RIL enables wireless voice or data applications to communicate with a GSM/GPRS or CDMA2000 1X modem on a Windows Mobile device. The RIL provides the system interface between the CellCore layer within the Windows Mobile OS and the radio protocol stack used by the wireless modem hardware. The RIL, therefore, also allows OEMs to integrate a variety of modems into their equipment by providing this interface.
The RIL comprises two separate components: a RIL driver, which processes AT commands and events; and a RIL proxy, which manages requests from the multiple clients to the single RIL driver. Except for PPP connections, all interaction between the Windows Mobile OS and the device radio stack is via the RIL. (PPP connections initially use the RIL to establish the connection, but then bypass the RIL to connect directly to the virtual serial port assigned to the modem.) In essence, the RIL accepts and converts all direct service requests from the upper layers (i.e., TAPI) into commands supported and understood by the modem.

GSM Logical Channels and Their Functions
There are two main types of channels in the GSM. Traffic channels and control channels. Different bursts are mapped to these channels uniquely as per *GSM TECHNICAL SPECIFICATION 05.02*.
Traffic channels carry speech or data. There are two main categories here, **Full rate (13 kpbs) and Half rate**.
Control channels used to for control/command/signaling. Control channels are divided into three categories.
Category 1: Broadcast channels
As the name suggests they are point-to-multipoint and downlink only channels.
FCCH: Frequency correction control channel, this is transmitted by BTS to MS. This helps MS tune its local oscillator to exact RF carrier frequency of the BTS cell. All zero sequences are transmitted here which will produce fixed tone at the output of GMSK modulator. The frequency value will be about 67.7075 KHz.
SCH: synchronization channel, this carry BSIC(Base transceiver station identity code) and Frame number which helps MS tune to specific (Frequency, Ts) physical slot on TDMA frame in GSM network.

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BCCH: Broadcast control channel, carry CGI, MNC, MCC, which is received by MS. It compared with SIM information, once verified OK connection established with the network.

Category 2: Common Control channels

They are point-to-multipoint and downlink only channels except RACH which is used in uplink.

PCH: Paging channel, when someone is calling mobile phone, this channel sent information on downlink to alert called mobile phone. This known as mobile phone terminated call.

RACH: Random Access channel, used in mobile originated call, when mobile wants to call some other mobile phone, control information sent on this channel.

AGCH: Access Grant Channel, transmitted by BTS to MS once network approves request of mobile by RACH

CBCH: Cell Broadcast channel, Used to carry the short message service cell broadcast.

Category 3: Dedicated Control channels

They are bidirectional and point-to-point Channels.

SDCCH: Stand-alone dedicated control channel, used for call setup.

SACCH: Slow associated control channel, is used for control and supervisory signals associated with the traffic channels.

FACCH: Fast associated control channel, is used for control requirements such as handoff/handovers.

GSM Protocols

GSM architecture is a layered model that is designed to allow communications between two different systems. The lower layers assure the services of the upper-layer protocols. Each layer passes suitable notifications to ensure the transmitted data is formatted, transmitted, and received accurately.

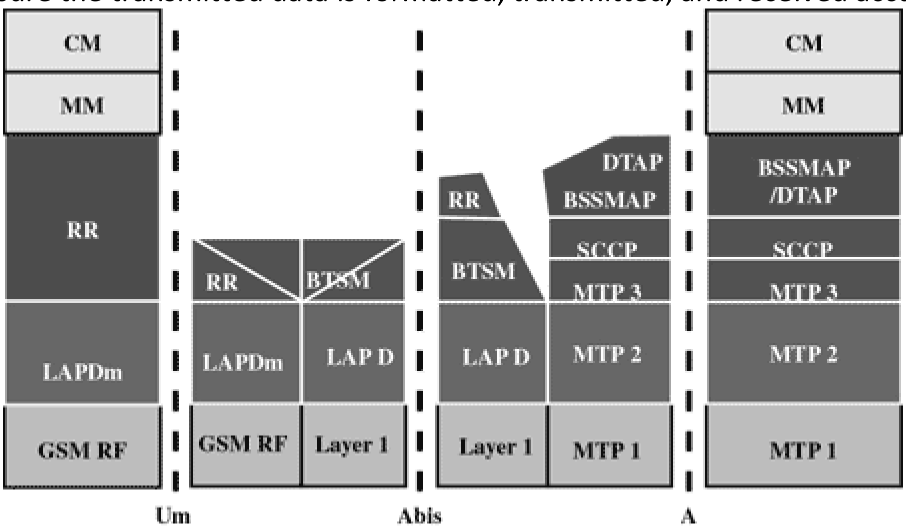

Figure 12: The GSM protocol stacks

MS Protocols

Based on the interface, the GSM signaling protocol is assembled into three general layers:

- **Layer 1**: The physical layer, it uses the channel structures over the air interface.
- **Layer 2**: The data-link layer, across the Um interface, the data-link layer is a modified version of the Link access protocol for the D channel (LAP-D) protocol used in ISDN, called Link access protocol on the Dm channel (LAP-Dm). Across the A interface, the Message Transfer Part (MTP), Layer 2 of SS7 is used.
- **Layer 3** : GSM signaling protocol's third layer is divided into three sub-layers:
    - Radio Resource Management (RR),
    - Mobility Management (MM), and
    - Connection Management (CM)

MS to BTS Protocols

The RR layer is the lower layer that manages a link, both radio and fixed, between the MS and the MSC. For this formation, the main components involved are the MS, BSS, and MSC. The responsibility of the RR layer is to manage the RR-session, the time when a mobile is in a dedicated mode, and the radio channels including the allocation of dedicated channels.

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The MM layer is stacked above the RR layer. It handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered-on MS so that incoming call routing can be completed.

The CM layer is the topmost layer of the GSM protocol stack. This layer is responsible for Call Control, Supplementary Service Management, and Short Message Service Management. Each of these services are treated as individual layer within the CM layer. Other functions of the CC sublayer include call establishment, selection of the type of service (including alternating between services during a call), and call release.

BSC Protocols

The BSC uses a different set of protocols after receiving the data from the BTS. The Abis interface is used between the BTS and BSC. At this level, the radio resources at the lower portion of Layer 3 are changed from the RR to the Base Transceiver Station Management (BTSM). The BTS management layer is a relay function at the BTS to the BSC.

The RR protocols are responsible for the allocation and reallocation of traffic channels between the MS and the BTS. These services include controlling the initial access to the system, paging for MT calls, the handover of calls between cell sites, power control, and call termination. The BSC still has some radio resource management in place for the frequency coordination, frequency allocation, and the management of the overall network layer for the Layer 2 interfaces.

To transit from the BSC to the MSC, the BSS mobile application part or the direct application part is used, and SS7 protocols is applied by the relay, so that the MTP 1-3 can be used as the prime architecture.

MSC Protocols

At the MSC, starting from the BSC, the information is mapped across the A interface to the MTP Layers 1 through 3. Here, Base Station System Management Application Part (BSS MAP) is said to be the equivalent set of radio resources. The relay process is finished by the layers that are stacked on top of Layer 3 protocols, they are BSS MAP/DTAP, MM, and CM. This completes the relay process. To find and connect to the users across the network, MSCs interact using the control-signalling network. Location registers are included in the MSC databases to assist in the role of determining how and whether connections are to be made to roaming users.

Each GSM MS user is given a HLR that in turn comprises of the user's location and subscribed services. VLR is a separate register that is used to track the location of a user. When the users move out of the HLR covered area, the VLR is notified by the MS to find the location of the user. The VLR in turn, with the help of the control network, signals the HLR of the MS's new location. With the help of location information contained in the user's HLR, the MT calls can be routed to the user.

Localization and Calling

GSM (Global System for mobile communication) provides many useful services in which, one of the most important is the automatic, worldwide localization of users. The service provider system always knows where a user currently is, and the same phone number is valid worldwide.

For localization of users, GSM performs periodic location updates even if a user does not use the mobile phones or some other devices but user should not be out of GSM network and is not completely switched off their devices.

GSM uses two types of databases:

- Home Location Register (HLR)
- Visitor Location Register (VLR)

The Home Location Register is a database from a mobile network in which information from all mobile subscribers is stored.

The VLR contains the exact location of all mobile subscribers currently present in the service area.

VLR is responsible for the MS (Mobile Station) to inform the HLR about location changes.

As soon as user moves from one location to another location, the HLR sends all user data needed to the new VLR (New Location). Changing of one VLR to another VLR and their uninterrupted services is called as Roaming.

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Roaming can be taken place as follows:

- Within the network of one provider
- Between two providers in one country (National Roaming)
- Different providers in different countries (International Roaming)

To locate an MS and to address the MS, several numbers are needed:

- Mobile station international ISDN number (MSISDN)
- International mobile subscriber identity (IMSI)
- Temporary mobile subscriber identity (TMSI)
- Mobile station roaming number (MSRN)

Handover

One of the key elements of a mobile phone or cellular telecommunications system is that the system is split into many small cells to provide good frequency re-use and coverage. However, as the mobile moves out of one cell to another it must be possible to retain the connection. The process by which this occurs is known as handover or handoff.

GSM systems require a procedure known as a Handover to maintain the continuity of the call. This is because a single cell does not cover the whole service area e.g. a whole city or country. However, a single cell has a maximum service area of approximately 23 miles (35 km) for each antenna. The smaller the size of the cell and the faster the movement of the MS through the cells (Up to 155 mph (250 kph) for GSM), the more handovers of ongoing calls are required, but a handover should not cause the a call drop. There are two main reasons for handovers.

The MS moves out of coverage of the serving BTS thus the signal level becomes lower continuously until it falls beneath the minimal requirements for communications. Or the error rate may grow due to interference, the distance to the BTS may be do high. All these effects may diminish the quality of the radio link and make transmission impossible in the near future.

The wired infrastructure i.e. the MSC, BSC may decide that the traffic in one cell is too high thus introducing congestion and hence decides to shift some MSs to other cells with a lower level of traffic, if that is possible. Thus, handovers can be used as a method of controlling traffic through load balancing to relieve localized congestion.

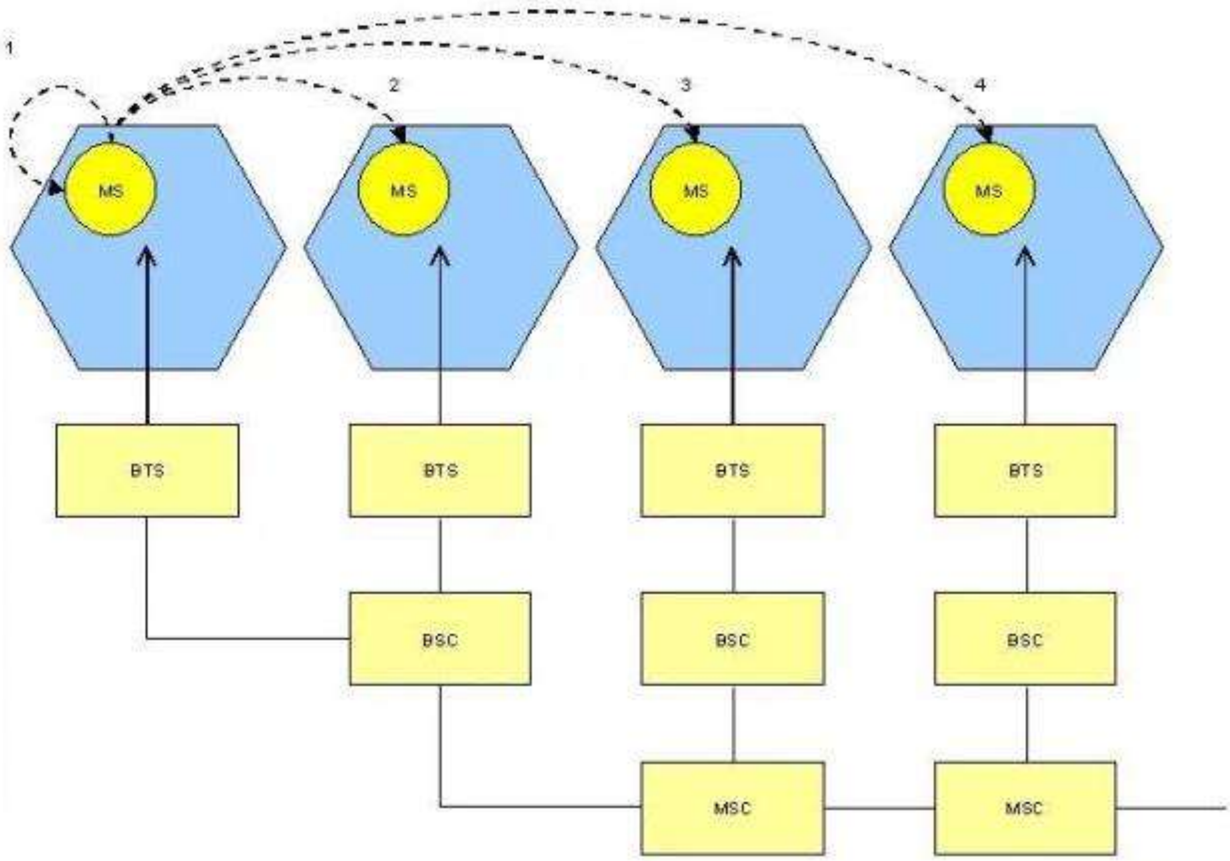

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Figure 13: Possible handover scenarios with in the GSM system

1. Intra Cell Handover: This happens when within a cell, when narrowband interference could make transmission at a certain frequency impossible. The BSC could then decide to change the carrier frequency.
2. Inter Cell, intra BSC handover: This type of handover is a typical handover within the GSM system and occurs when the MS moves from one BTS to another but stays within the control of same BSC. The BSC performs the handover and assigns a new radio channel in the new BTS, and then releases the old BTS.
3. Inter BSC, Intra MSC handover: Since a BSC controls a limited number of BTSs, the GSM system has to perform handovers between BSCs. This form of handover is controlled by the MSC.
4. Inter MSC handover: A handover could also be required between two BTSs that belong to two different MSCs, now both MSCs perform the handover together.

GSM security is provided for gsm network subscribers to communicate securely without any intrusion. The security here is covered for the air interface part and and not for the fixed network part. The air interface is considered to be weakest for the hackers. Security for SS7 part was not provided as SS7 was used for few of the institutions.

Security

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GSM security

The gsm security mechanism is covered with following:

- Authentication (used for billing purposes)
- Confidentiality
- Anonymity (used to identify users)
- PIN Lock, EIR, personalization etc.

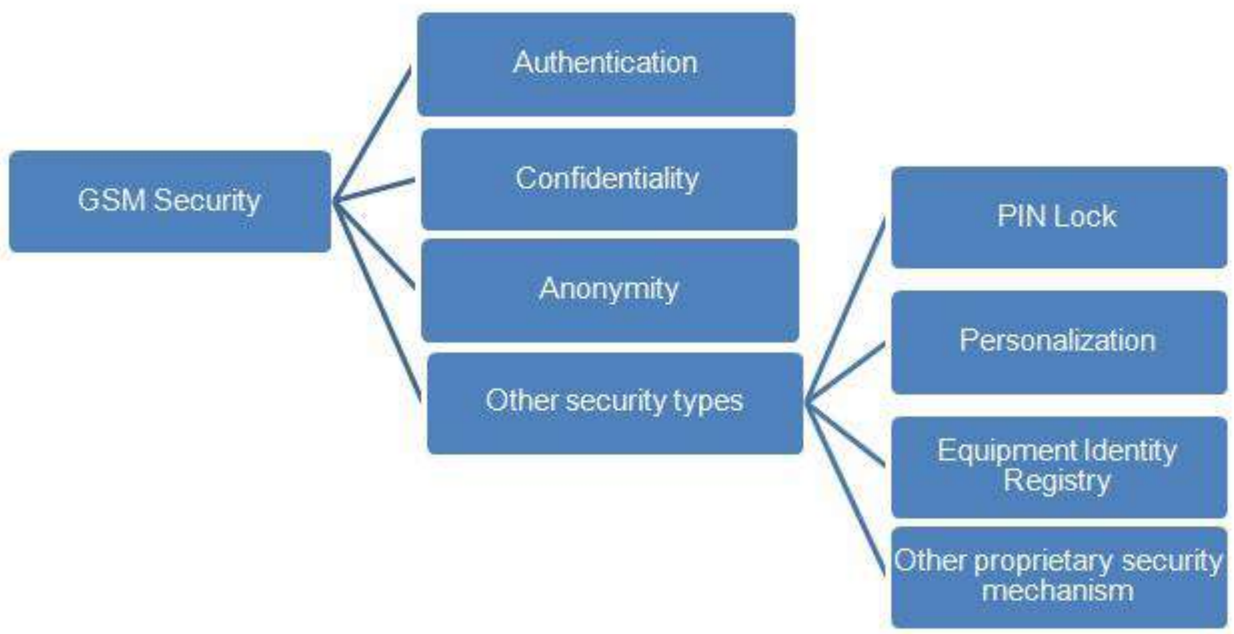

Figure 14: GSM Security

Authentication process helps gsm network authenticate the right user. This process is based on exchanged secret key Ki which is known to AuC (Authentication Center) and SIM card. there is no provision to read the key Ki from the SIM. This authentication procedure in gsm security mechanism is triggered due to following:

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1. on the first access to the network;
2. accessing the network for the purpose of making or receiving a call;
3. location update process and the change of subscriber-related information stored in either HLR or VLR.

Anonymity: Here IMSI is associated with a unique user (SIM), after the initial registration, a TMSI is assigned to the subscriber. The TMSI is stored along with the IMSI in the network HLR.

HSCSD

High-Speed Circuit-Switched Data is essentially a new high speed implementation of GSM (Global System for Mobile Communication) data transfer. Four times faster than GSM, with a transfer rate of up to 57.6Kbps, it achieves this speed by allocating up to eight time slots to an individual user. This speed makes it comparable to many fixed-line telecommunications networks and will allow users to access the Internet and other datacom services via a GSM network.

HSCSD Technology

HSCSD operates across a GSM network, and therefore no extra hardware is required by a mobile communications operator to offer the service, just a network software upgrade. In a GSM network single slots are allocated to each user, which has a standard data transfer rate of 9.6Kbps, although some networks are now being upgraded to 14.4Kbps, an increase of 50%. In HSCSD, users are allocated multiple slots so that the transmission speed can be drastically increased, with some service providers offering rates of up to 57.6Kbps. This enables internet access at the same speed of many dial-up modem services across fixed line networks.

GPRS architecture

GPRS architecture works on the same procedure like GSM network, but, has additional entities that allow packet data transmission. This data network overlaps a second-generation GSM network providing packet data transport at the rates from 9.6 to 171 kbps. Along with the packet data transport the GSM network accommodates multiple users to share the same air interface resources concurrently.

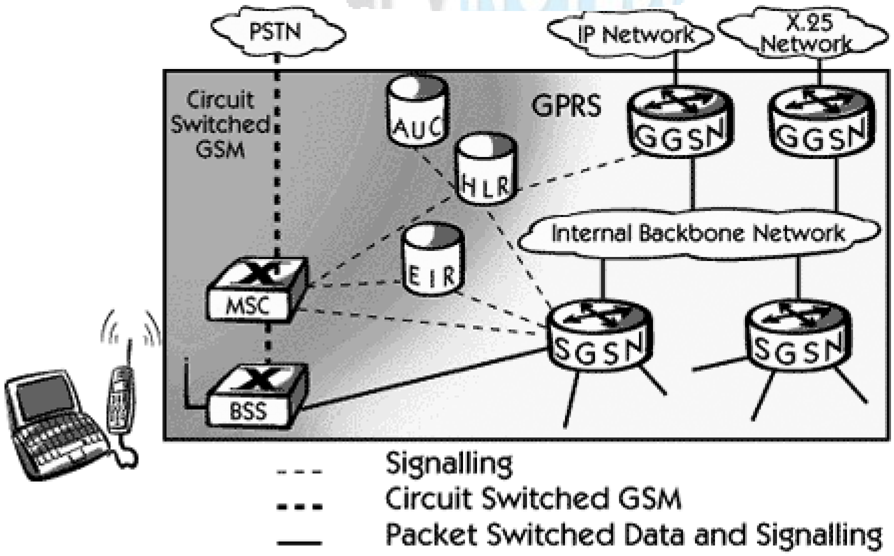

Figure 15: GPRS Architecture diagram

GPRS attempts to reuse the existing GSM network elements as much as possible, but to effectively build a packet-based mobile cellular network, some new network elements, interfaces, and protocols for handling packet traffic are required.

Therefore, GPRS requires modifications to numerous GS

SM Network Element	Modification or Upgrade Required for GPRS.

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Mobile Station (MS)	New Mobile Station is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.
BTS	A software upgrade is required in the existing Base Transceiver Station(BTS).
BSC	The Base Station Controller (BSC) requires a software upgrade and the installation of new hardware called the packet control unit (PCU). The PCU directs the data traffic to the GPRS network and can be a separate hardware element associated with the BSC.
GPRS Support Nodes (GSNs)	The deployment of GPRS requires the installation of new core network elements called the serving GPRS support node (SGSN) and gateway GPRS support node (GGSN).
Databases (HLR, VLR, etc.)	All the databases involved in the network will require software upgrades to handle the new call models and functions introduced by GPRS.

***Table 3:** Modification or Upgrade Required for GPRS*

Interfaces: GPRS network interfaces used in **transmission plane** and **control plane**. It includes Um,Gb,Gn,Gp,Gi,Gr,Gc,Gf,Gd and Gs interfaces.
Transmission plane provides means for exchange of the user data. The control plane is used to ensure availability of the transmission plane. The control plane also facilitates signalling between the Mobile Station(MS) and the GPRS network elements.

Transmission Plane

GPRS interface type	Between	Basic description	Protocol	Reference
Um	MS-BSS	Used between MS and BSS for exchange of user and signaling information	Physical RLC/MAC	43.064/45.002 44.060
Um	MS-SGSN	Used between MS and SGSN for exchange of user and signaling information	LLC GMM SM SMS	44.064 24.008 24.008 24.011
Gb	SGSN-BSS	Used between SGSN and BSS for data transfer and mobility management	Physical network service BSSGP	48.014 48.016 48.018
Gn	SGSN-GGSN	Used to support mobility ;applicagle when GGSN and SGSN are located in	GTP-C	29.060

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		same PLMN		
Gp	SGSN-GGSN	Used to support mobility ;applicagle when GGSN and SGSN are located in different PLMNs	GTP-C	29.060
Gr	SGSN-HLR	Used by the SGSN to obtain subscriber information from HLR	MAP	29.002
Gc	GGSN-HLR	Used by the GGSN to retrieve information about the location and supported services for the MS,to be able to activate a packet data network address ;this is optional interface	MAP	29.002
Gf	SGSN-EIR	Used by SGSN to enagbel EIR to verify the IMEI retrieved from MS; this is optional interface	MAP	29.002
Gd	SGSN-SMS-IWMSC SGSN-SMS-GMSC	Used to deliver to and receive short message form MS to SM service center	MAP	29.002
Gs	SGSN-VLR	Used for coordinating the functions of SGSN and VLR when and Mobile has both GSM and GPRS services; this is optional interface	BSSAP+	29.016,29.018

Table 4: Interfaces

Control Plane

GPRS interface type	Between	Basic description	Protocol	Reference
Um	MS-BSS	Used between MS and BSS for exchange of user and signaling information	Physical RLC/MAC	43.064/45.002 44.060
Um	MS-SGSN	Used between MS and SGSN for exchange of user and signaling information	LLC SNDCP	44.064 44.065
Gb	SGSN-BSS	Used between SGSN and BSS for data transfer and mobility management	Physical network service BSSGP	48.014,48.016.48 .018

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Gn	SGSN-GGSN	Used to support mobility;applicable when GGSN and SGSN are located in the same PLMN	GTP-U	29.060
Gp	SGSN-GGSN	Used to support mobility;applicable when GGSN and SGSN are located in different PLMNs	GTP-U	29.060
Gi	GGSN-PDN	Used to exchange data with external packet data network	IP	29.061

Table 5: Control Plane Interfaces

Logical channels

There is a variety of channels used within GPRS, and they can be set into groups dependent upon whether they are for common or dedicated use. Naturally the system does use the GSM control and broadcast channels for initial set up, but all the GPRS actions are carried out within the GPRS logical channels carried within the PDCH.

Broadcast channels:

Packet Broadcast Central Channel (PBCCH): This is a downlink only channel that is used to broadcast information to mobiles and informs them of incoming calls etc. It is very similar in operation to the BCCH used for GSM. In fact the BCCH is still required in the initial to provide a time slot number for the PBCCH. In operation the PBCCH broadcasts general information such as power control parameters, access methods and operational modes, network parameters, etc, required to set up calls.

Common control channels:

- ***Packet Paging Channel (PPCH):*** This is a downlink only channel and is used to alert the mobile to an incoming call and to alert it to be ready to receive data. It is used for control signalling prior to the call set up. Once the call is in progress a dedicated channel referred to as the PACCH takes over.
- ***Packet Access Grant Channel (PAGCH):*** This is also a downlink channel and it sends information telling the mobile which traffic channel has been assigned to it. It occurs after the PPCH has informed the mobile that there is an incoming call.
- ***Packet Notification Channel (PNCH):*** This is another downlink only channel that is used to alert mobiles that there is broadcast traffic intended for a large number of mobiles. It is typically used in what is termed point-to-point multicasting.
- ***Packet Random Access Channel (PRACH):*** This is an uplink channel that enables the mobile to initiate a burst of data in the uplink. There are two types of PRACH burst, one is an 8 bit standard burst, and a second one using an 11 bit burst has added data to allow for priority setting. Both types of burst allow for timing advance setting.

Dedicated control channels:

- ***Packet Associated Control Channel (PACCH):*** : This channel is present in both uplink and downlink directions and it is used for control signalling while a call is in progress. It takes over from the PPCH once the call is set up and it carries information such as channel assignments, power control messages and acknowledgements of received data.
- ***Packet Timing Advance Common Control Channel (PTCCH):*** This channel, which is present in both the uplink and downlink directions is used to adjust the timing advance. This is required to ensure that messages arrive at the correct time at the base station regardless of the distance of the mobile from the base station. As timing is critical in a TDMA system and signals take a small but finite time to travel this aspect is very important if long guard bands are not to be left.

Dedicated traffic channel:

- ***Packet Data Traffic Channel (PDTCH):*** This channel is used to send the traffic and it is present in both the uplink and downlink directions. Up to eight PDTCHs can be allocated to a mobile to provide high speed data.

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Mobility management:
Mobility management is a functionality that facilitates mobile device operations in Universal Mobile Telecommunications System (UMTS) or Global System for Mobile Communications (GSM) networks. Mobility management is used to trace physical user and subscriber locations to provide mobile phone services, like calls and Short Message Service (SMS).
UMTS and GSM are each made up of separate cells (base stations) that cover a specific geographical area. All base stations are integrated into one area, allowing a cellular network to cover a wider area (location area).
The location update procedure allows a mobile device to notify a cellular network when shifting between areas. When a mobile device recognizes that an area code differs from a previous update, the mobile device executes a location update, by sending a location request to its network, prior location and specific Temporary Mobile Subscriber Identity (TMSI). A mobile device provides updated network location information for several reasons, including reselecting cell location coverage due to a faded signal.
Location area includes a group of base stations assembled collectively to optimize signaling. Base stations are integrated to form a single network area known as a base station controller (BSC). The BSC manages allocation of radio channels, acquires measurements from cell phones, and handles handovers from one base station to another.
Roaming is among the basic procedures of mobility management. It enables subscribers to use mobile services when moving outside of the geographical area of a specific network

DECT:
DECT (Digital Enhanced Cordless Telecommunications) is a digital wireless telephone technology that is expected to make cordless phones much more common in both businesses and homes in the future. Formerly called the Digital European Cordless Telecommunications standard because it was developed by European companies, DECT's present name reflects its global acceptance. Like another important wireless standard, Global System for Mobile communication (GSM), DECT uses time division multiple access (TDMA) to transmit radio signals to phones. Whereas GSM is optimized for mobile travel over large areas, DECT is designed especially for a smaller area with a large number of users, such as in cities and corporate complexes. A user can have a telephone equipped for both GSM and DECT (this is known as a dual-mode phone) and they can operate seamlessly.

DECT has five major applications:
1**) The "cordless private branch exchange**": A company can connect to a wired telephone company and redistribute signals by radio antenna to a large number of telephone users within the company, each with their own number. A cordless PBX would be especially useful and save costs in a company with a number of mobile employees such as those in a large warehouse.
2) Wireless Local Loop (WLL): Users in a neighborhood typically served by a telephone company wired local loop can be connected instead by a cordless phone that exchanges signals with a neighborhood antenna. A standard telephone (or any device containing a telephone such as a computer modem or fax machine) is simply plugged into a fixed access unit (FAU), which contains a transceiver. The Wireless Local Loop can be installed in an urban area where many users share the same antenna.
3) Cordless Terminal Mobility: The arrangement used by businesses for a cordless PBX can also be used by a service that provided cordless phone numbers for individual subscribers. In general, the mobility would be less than that available for GSM users.
4) Home cordless phones: A homeowner could install a single-cell antenna within the home and use it for a number of cordless phones throughout the home and garden.
5) GSM/DECT internetworking: Part of the DECT standard describes how it can interact with the GSM standard so that users can be free to move with a telephone from the outdoors (and GSM signals) into an indoor environment (and a DECT system). It's expected that many GSM service providers may want to extend their service to support DECT signals inside buildings. A dual-mode phone would automatically search first for a DECT connection, then for a GSM connection if DECT is not available.

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TETRA:

TErrestrial Trunked RAdio (TETRA) is a digital trunked mobile radio standard developed to meet the needs of traditional Professional Mobile Radio (PMR) user organizations such as:

- Public Safety
- Transportation
- Utilities
- Government
- Military
- PAMR
- Commercial & Industry
- Oil & Gas

The TETRA standard has been specifically developed to meet the needs of a variety of traditional PMR user organizations. This means it has a scalable architecture allowing economic network deployments ranging from single site local area coverage to multiple site wide area national coverage.

Some unique PMR services of TETRA are:

- Wide area fast call set-up "all informed net" group calls
- Direct Mode Operation (DMO) allowing "back to back" communications between radio terminals independent of the network
- High level voice encryption to meet the security needs of public safety organizations
- An Emergency Call facility that gets through even if the system is busy
- Full duplex voice for PABX and PSTN telephony communications

Besides meeting the needs of traditional PMR user organizations, the TETRA standard has also been developed to meet the needs of Public Access Mobile Radio (PAMR) operators.

UMTS:

The Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard.

UMTS supports maximum theoretical data transfer rates of 42 Mbit/s when Evolved HSPA (HSPA+) is implemented in the network. Users in deployed networks can expect a transfer rate of up to 384 kbit/s for Release '99 (R99) handsets (the original UMTS release), and 7.2 Mbit/s for High-Speed Downlink Packet Access (HSDPA) handsets in the downlink connection. These speeds are significantly faster than the 9.6 kbit/s of a single GSM error-corrected circuit switched data channel, multiple 9.6 kbit/s channels in High-Speed Circuit-Switched Data (HSCSD) and 14.4 kbit/s for CDMAOne channels.

Since 2006, UMTS networks in many countries have been or are in the process of being upgraded with High-Speed Downlink Packet Access (HSDPA), sometimes known as 3.5G. Currently, HSDPA enables downlink transfer speeds of up to 21 Mbit/s. Work is also progressing on improving the uplink transfer speed with the High-Speed Uplink Packet Access (HSUPA). Longer term, the 3GPP Long Term Evolution (LTE) project plans to move UMTS to 4G speeds of 100 Mbit/s down and 50 Mbit/s up, using a next generation air interface technology based upon orthogonal frequency-division multiplexing.

The first national consumer UMTS networks launched in 2002 with a heavy emphasis on telco-provided mobile applications such as mobile TV and video calling. The high data speeds of UMTS are now most often utilized for Internet access. The user demand for video calls is not high and telco-provided audio/video content has declined in popularity in favour of high-speed access to the World Wide Web—either directly on a handset or connected to a computer via Wi-Fi, Bluetooth or USB

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