UNIT II MOBILE TELECOMMUNICATION SYSTEM: Introduction to Cellular Systems - GSM – Services & Architecture – Protocols – Connection Establishment – Frequency Allocation – Routing–MobilityManagement–Security–GPRSUMTS– Architecture –Handover-Security.

INTRODUCTIONTOCELLULARNETWORKS

Digital cellular networks are the segment of the market for mobile and wireless deviceswhich aregrowing most rapidly. They are the wireless extensions of traditional PSTN or ISDN networks andallow for seamless roaming with the same mobile phone nation or even worldwide.Today, thesesystemsaremainlyusedforvoicetraffic.However,datatrafficiscontinuouslygrowingandtherefore,thesearehandled byseveral technologies forwireless datatransmissions

- AMPS(AdvancedMobilesPhoneSystem)à1G
- GSM,TDMA,CDMA,andPDC(PersonalDigitalCellular)andPCS(PersonalCommunicationSystem)areall second generationsystems.
- Examplesforsecondgeneration(2G)mobilephonenetworks-GSM,GPRSà2.5GNetworks
- DECT(DigitalEuropeanCordlessTelephone)andTERTA(TerrestrialTrunkedRadio)àexamplesforcordlesstelephonyandtrunkedradiosystems.
- UMTSexampleforà3Gmobiletelecommunicationnetworks.
- 2Gà1990'sto2000,2.5Gà2001to2004,3Gà2004to2015,4Gà2010–2020, 5G→now

GlobalSystemforMobileCommunications(GSM)

GSM (Global System for Mobile Communications) is at present being used in India. Itis possiblythemostsuccessfuldigitalmobilesystemtohaveeverbeenusedtillnow.AnimportantcharacteristicoftheGSMsystemisthatitprovidesdataservicesinadditiontovoiceservices,andyetiscompatibleto1Gsystem.GSMnetworksoperateinfourdifferentradiofrequencies.MostGSMnetworksoperateeitherinthe900 MHzorinthe1800MHzfrequencybands.SomecountriesintheAmericancontinent(especially the USA and Canada) use the 850 MHz and 1900MHz bands because the 900 MHz and1800 MHz frequency bands are already allocated for otherpurposes. The relatively rarely used 400MHz and 450 MHz frequency bands are assigned in some countries, notably Scandinavia wherethese frequencies were previously used for the first generation systems. In the 900 MHz band, theuplinkfrequencybandis890–915MHz,andthedownlinkfrequencybandis 935–960MHz

PerformancecharacteristicsofGSM:

- **Communication**
  - Mobile,wirelesscommunication; supportforvoiceanddataservices
- **Totalmobility**
  - Internationalaccess, chip-cardenablesuseofaccesspoints ofdifferentproviders
- **Worldwideconnectivity**
  - Onenumber,thenetworkhandleslocalization
- **Highcapacity**
  - Betterfrequencyefficiency,smallercells,morecustomerspercell
- **Hightransmissionquality**
  - Highaudioqualityandreliabilityforwireless,uninterruptedphonecalls athigherspeeds (e.g., fromcars, trains)
- **Securityfunctions**
  - Accesscontrol,authenticationviachip-cardandPIN

DisadvantagesofGSM:

- Thereisnoperfectsystem!!
  - Noend-to-end encryptionofuserdata
  - NofullISDNbandwidthof64Kbit/stotheuser,notransparentB-channel
- Reducedconcentrationwhiledriving
- Electromagneticradiation
- Abuseofprivatedata possible
- Roamingprofilesaccessible
- Highcomplexityof thesystem
- SeveralincompatibilitieswithintheGSMstandards

GSMServices

GSMprovidesthreemaincategoriesofservices.Theseare:(i)***Bearerservices(ii)Teleservices***

(iii) Supplementaryservices.Inthefollowing,weelaboratethesedifferentcategoriesofservices.

Bearerservices:

Bearerservicesgivethesubscribersthecapabilitytosendandreceivedatato/fromremotecomputers or mobile phones. For this reason, bearer services are also known as data services.These services also enable the transparent transmission of data between GSM and other networkslike PSTN, ISDN, etc. at rates from 300 bps to 9600 bps. These services are implemented on thelower-threelayersoftheOSIreferencemodel.BesidessupportingSMS,e-mail,voicemailbox,and

Internetaccess,thisserviceprovidestheuserswiththecapabilitytoexecuteremoteapplications.GSMsupports data transfer rates of up to 9.6 kbps.

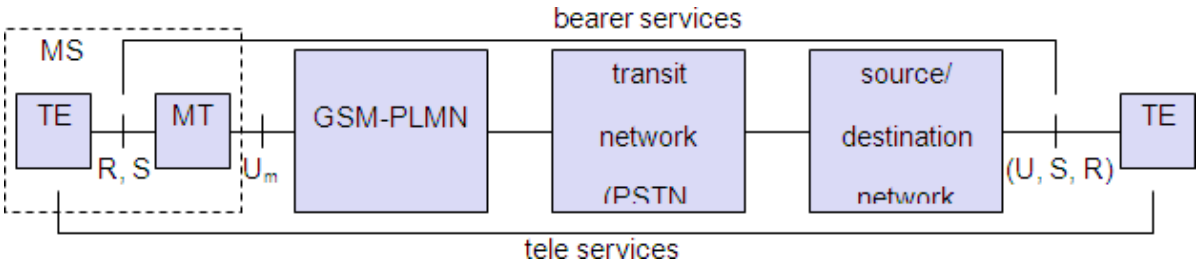


Figure2.1.1Reference ModelforGSMServices

Figure2.1.1showsthereferencemodelforGSMservices.

The Mobile station MS is connected to GSM public Land Mobile Network via a Um interface.ThisnetworkisconnectedtoTransitISDNorPSTN.TheBearerservicespermiteithertransparentor non-transparent, and either synchronous or asynchronous modes of data transmission. Weelaboratethesein thefollowing.

- The transparent bearer services use the functions of the physical layer of transmission ofdata leading to constant delay and throughput if no transmission errors occur. There is amechanismcalledFEC(ForwardErrorCorrection)toincreasethequalityofdatatransmission.
- Thenon-transparentbearerservicesuseprotocolsofthesecondandthirdlayerstoimplement error correction and flow control. They use transparent bearer services inaddition to a Radio Link Protocol (RLP). This protocol comprises mechanisms of highleveldatalink control.

Teleservices:

GSM provides both the voice-oriented teleservices and the non-voice teleservices, as discussedbelow. Telephony: The main goal of GSM was to provide high quality digital voice transmission,offering the bandwidth of 3.1 kHz of analog phone systems. Special codecs are used for voicetransmission, while other codecs are used for the transmission of analog data for communicationwithtraditional computer modems used in fax machines.

- Telecommunicationservicesthatenablevoicecommunicationviamobilephones
- Allthesebasicserviceshavetoobeycellularfunctions, securitymeasurementsetc.
- Offeredservices
    - **Mobiletelephony**
      primary goal of GSM was to enable mobile telephony offering the traditionalbandwidthof 3.1kHz

- **Emergencynumber**
  common number throughout Europe (112); mandatory for all service providers; freeof charge; connection with the highest priority (preemption of other connectionspossible)
- **Multinumbering**
  several ISDNphonenumbersperuserpossible

➢ Additionalservices

❖ Non-Voice-Teleservices

- ✓ Group3fax-twodataistransmittedasdigitaldataovertheanalogtelephonenetwork.
- ✓ Voice mailbox (implemented in the fixed network supporting the mobileterminals)
- ✓ Electronic mail (MHS-Message Handling System, implemented in the fixednetwork)

❖ ShortMessageService(SMS)

- ✓ Alphanumeric data transmission to/from the mobile terminal (160 characters)using the signalling channel, thus allowing simultaneous use of basic servicesandSMS(almostignored inthebeginningnowthemostsuccessfuladd-on!)

Emergencynumber: Thesamenumberisusedthroughoutanarea.Thisserviceis freeofcostandmandatorilyprovidedbyallserviceproviders.Thisconnectionwillautomaticallybesetup withtheclosestemergencycentre.

Short message services: This service offers transmission of text messages of sizes up to 160characters. SMS services use the signalling channels, making possible the duplex system of thesendingand receiving the SMSs messages.

Fax: In this service, using modems fax data is transmitted as digital data over the analog telephonenetwork according to theITU-T Standards T.4 andT.30.

Supplementaryservices:GSMprovidescertainsupplementaryservicessuchasuseridentification,callr edirection,andforwardingofongoingcalls.Inaddition,standardISDNfeaturessuchas‘closeusergroups’ and ‘multiparty’communication areavailable.

- ➢ Servicesinadditiontothebasicservices,cannotbeofferedstand-alone
- ➢ SimilartoISDNservicesbesides lowerbandwidthduetotheradiolink
- ➢ Maydifferbetweendifferentserviceproviders,countriesandprotocolversions
- ➢ **Importantservices**

- Identification:forwardingofcallernumber
- Suppressionofnumberforwarding
- Automaticcall-back
- Conferencingwithupto7participants

- Lockingofthemobileterminal (incoming oroutgoingcalls)

SystemArchitectureofGSM

AGSM systemconsistsofthreemain subsystems:

(i) RadioSubsystem (RSS)
(ii) (ii)NetworkingandSwitchingSubsystem (NSS)
(iii) OperationSubsystem(OSS)
(iv) AschematicofthefunctionalarchitectureofaGSMsystemisshowninFig.2.1.2.Thedifferentcomponentsofthis architecturearebrieflyexplained inthefollowing.

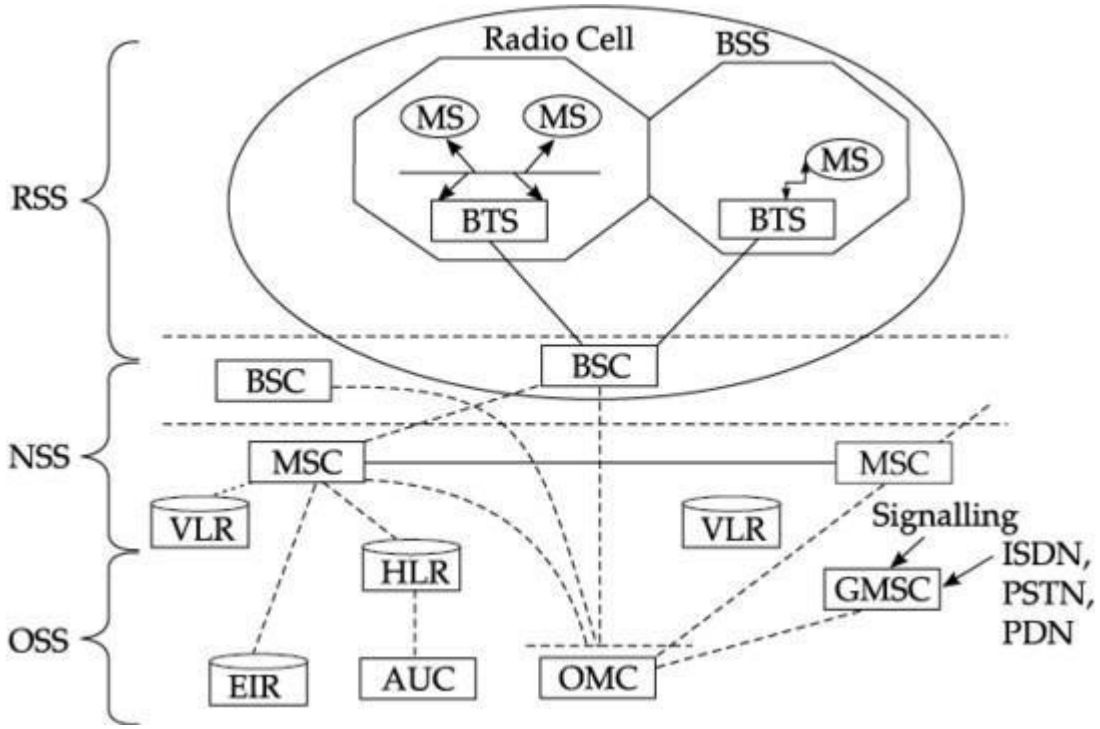


Figure2.1.2FunctionalArchitectureofaGSMSystemRadiosubsystem(RSS)

Thissubsystemcomprisesalltheradiospecificentities.Thatis,themobilestations,thebasestationsubsystems, the base transceiver station and the base station controller. Webrieflyexplain theimportantcomponents of the radio subsystem in the following:

MobileStation(MS):

Amobilestation(MS)orcellphonecontainstwomajorcomponents:thesubscriberidentitymodule(SIM)and themobile device.TheSIMisaremovablesmartcard.Eachmobile device has aunique identifier that is known as its IMEI (International Mobile EquipmentIdentity). Apart fromthe telephone interface, an MS also offers other types of interfaces to the users suchas USB,Bluetooth,etc.DespiteitssmallsizeaSIMcardisaveryimportantcomponentofaGSMnetwork.It contains all the subscription information of a subscriber and holds the key information thatactivatesthephoneafteritispoweredon.Itcontainsamicrocontrollertoprimarilystoreandretrievedata from the flash storage on the SIM. Identification information is stored in the SIM card'sprotectedmemory(ROM)that isnot accessible or modifiable bythe customer.

Additionalflashmemoryisincludedinthemobiledevicetoallowstorageofotherinformationsuchasaddresses,pictures,audioandvideoclips,andshortmessages.TheSIMcardcontainsmanyotheridentifiers and tables such as card type, serial number, a list of subscribed services, and a PersonalIdentityNumber(PIN).

BaseStation Subsystem(BSS):

AGSMnetworkcomprisesmanyBSSs.EachBSSconsistsofaBaseStationController(BSC)andseveral Base Transceiver Stations (BTSs). We will explain these components subsequently. A BSSperformsallfunctionsnecessarytomaintainradioconnectionstoanMS,aswellasdoescoding/decoding of voice.

BaseTransceiverStation(BTS):

A BTS comprises all radio equipment such as antenna, signal processors and amplifiers that arenecessaryforradiotransmission.Itencodesthereceivedsignal,modulatesitonacarrierwave,andfeeds theRFsignals tothe antenna.Itcommunicateswith boththemobile stationand the BSC.

BaseStationController(BSC):

ABSCmanagestheradioresourceoftheBTSsinthesensethatitassignsfrequencyandtimeslotsfor all MSs in the area. It also manages the handoff from one BTS to another within the BSS. TheBSCalsomultiplexestheradiochannelsontothefixednetworkconnectiontotheMobileSwitchingCentre(MSC).

Networkandswitchingsubsystem(NSS)

ThissubsystemformstheheartoftheGSMsystem.Itconnectsthewirelessnetworkstothestandardpublic networksandcarriesoutusage-basedcharging,accounting,andalsohandles

roaming.NSS consistsofaswitchingcentreandseveraldatabases asdescribedbelow.

MobileSwitchingCenter(MSC):

An MSC can be considered to form the heart of a GSM network. An MSC sets up connectionstoother MSCs and to other networkssuch asPublic Data Network (PDN).An MSCis responsiblefor the connection setup, connection release, and call handoff to other MSCs. A Gateway MSC(GMSC) is responsible for gateway functions, while a customer roams to other networks. It alsoperformscertainother supplementaryservicessuchascallforwarding,multipartycalls, etc.

HomeLocation Registers(HLRs):

AHLRstoresinadatabaseimportantinformationthatisspecifictoeachsubscriber.Theinformationcontainssubscriber'sIMSI,pre/postpaid,user'scurrentlocation,etc.

VisitorLocation Register(VLR):

Itisessentiallyatemporarydatabasethatisupdatedwheneveranew MSentersitsareabyroaming.The information is obtained from the corresponding HLR database. The function of the VLR is toreducethenumberofqueriestotheHLR andmaketheuserfeelas ifhewereinhishomenetwork.

Operationsubsystem(OSS)

Theoperationsubsystemcontainsallthefunctionsnecessaryfornetworkoperationandmaintenance.Itconsists of thefollowing:

OperationandMaintenanceCentre(OMC):

Itsupervisesallothernetworkentities.Itsfunctionsaretrafficmonitoring,subscribers,securitymanagement andaccounting billing.

AuthenticationCentre (AuC):

Itprotectsagainstintruders targetingtheair interface.The AuCstoresinformationconcernedwithsecurityfeaturessuch asuserauthenticationand encryption.

TheAuC isrelated totheHLR.

EquipmentIdentityRegister(EIR):

ItisessentiallyadatabasethatisusedtotrackhandsetsusingtheIMEI.
Ithelpstoblockcallsfromstolen,unauthorized, ordefective mobiles.

GSMPROTOCOLS

The signalling protocol in GSM is structured into three general layers depending on the interface,as shown below. Layer 1 is the physical layer that handles all **radio**-specific functions. Thisincludes the creation of bursts according to the five different formats, **multiplexing** of bursts intoa TDMA frame, **synchronization** with the BTS, detection of idle channels, and measurement ofthe**channelqualit**yonthedownlink.ThephysicallayeratUmusesGMSKfordigital**modulation** and performs **encryption/decryption** of data, i.e., encryption is not performed end-to-end,but onlybetweenMS andBSS over theairinterface.

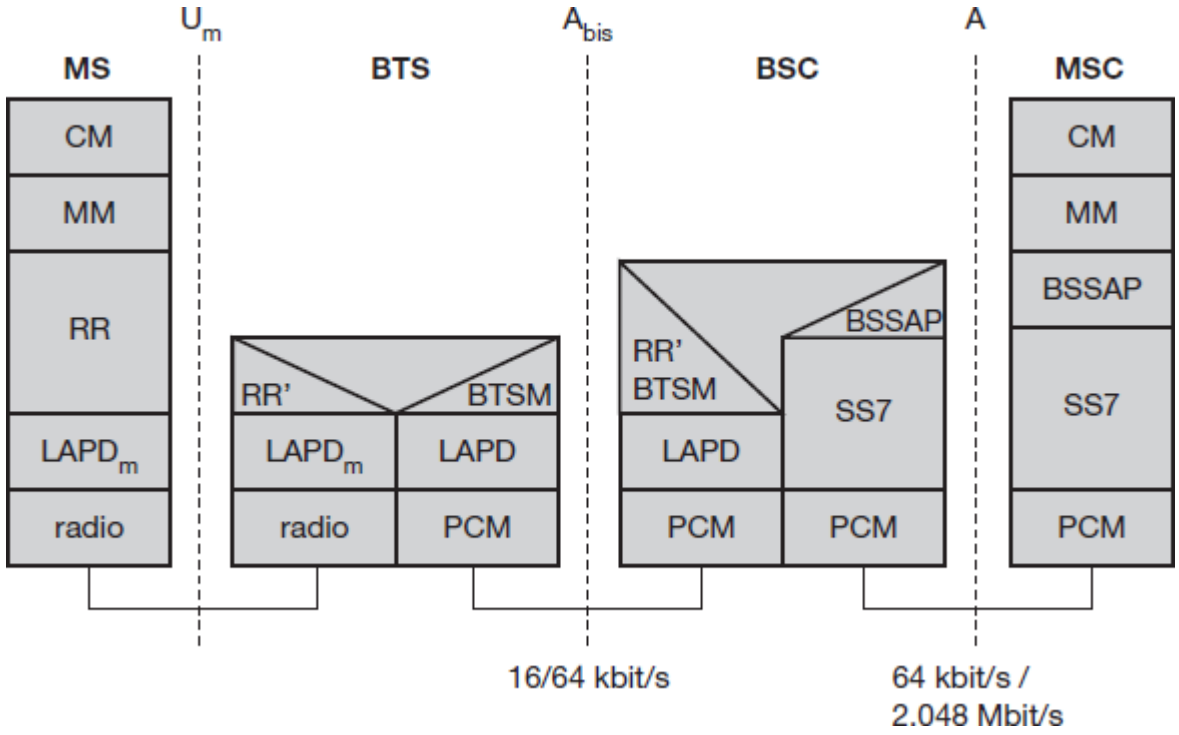


Figure2.1.3ProtocolarchitectureforSignalling

Themaintasksofthephysicallayercomprise**channelcoding**and**errordetection/correction**,which isdirectlycombinedwiththecodingmechanisms.Channelcodingmakesextensive useof

different**forwarderrorcorrection (FEC)** schemes.Signallingbetween entities in a GSMnetworkrequireshigherlayers.Forthispurpose,the**LAPDm**protocolhasbeendefinedattheUmint erface for **layer two**. LAPDm has been derived from link access procedure for the D-channel(**LAPD**) in ISDN systems, which is a version of HDLC. LAPDm is a lightweight LAPD becauseitdoesnotneedsynchronizationflagsorchecksummingforerrordetection.LAPDmoffersreliab ledatatransfer over connections,re-sequencing ofdata frames,andflowcontrol.

The network layer in GSM, layer three, comprises several sublayers. The lowest sublayer is theradio resource management (RR). Only a part of this layer, RR', is implemented in the BTS, theremainder is situated in the BSC. The functions of RR' are supported by the BSC via the BTSmanagement(BTSM).ThemaintasksofRRaresetup,maintenance,andreleaseofradiochannels.M obility management (MM) contains functions for registration, authentication, identification,locationupdating, and the provisionofatemporary mobilesubscriberidentity (TMSI).

Finally, the call management (CM) layer contains three entities: call control (CC), short messageservice(SMS),andsupplementaryservice(SS).SMSallowsformessagetransferusingthecontr olchannelsSDCCHandSACCH,whileSSoffersttheserviceslikeuseridentification,callredirection,orf orwardingofongoingcalls.CCprovidesapoint-to-pointconnectionbetweentwoterminals and is used by higher layers for call establishment, call clearing and change of callparameters. This layer also provides functions to send in-band tones, called dual tone multiplefrequency (DTMF), over the GSM network. These tones are used, e.g., for the remote control ofanswering machines or the entry of PINs in electronic banking and are, also used for dialing intraditionalanalog telephone systems.

Additional protocols are used at the Abis and A interfaces. Data transmission at the physicallayertypically uses **pulse code modulation (PCM)** systems. LAPD is used for layer twoat Abis,BTSM for BTS management. **Signalling system No. 7 (SS7)** is used forsignalling between anMSC and a BSC. This protocol also transfers all management information between MSCs, HLR,VLRs, AuC, EIR, and OMC. An MSC can also control a BSS via a **BSS application part(BSSAP)**.

GSMSECURITY

Security in GSM is broadly supported at three levels: operator's level, customer's level and systemlevel.Thesethreelevelshelpoverseeaspectssuchascorrectbillingtothecustomer,avoidingfraud, protectingservices,andensuringanonymity.Thefollowingareafewimportantfeaturesassociatedwithpr oviding securityin GSM networks.

GSM offers several security services using confidential information stored in the AuC and in theindividualSIM.TheSIMstorespersonal,secretdataandisprotectedwithaPINagainstunauthorized use. Three algorithms have been specified to provide security services in GSM.Algorithm A3 is used for authentication, A5 for encryption, and A8 for the generation of a cipherkey.Thevarious securityservices offered byGSMare:

ACCESSCONTROL ANDAUTHENTICATION:

The first step includes the authentication of a valid user for the SIM. The user needs a secret PINtoaccess the SIM. The next step is the subscriber authentication. This step is based on a challenge-responsescheme as shown below:

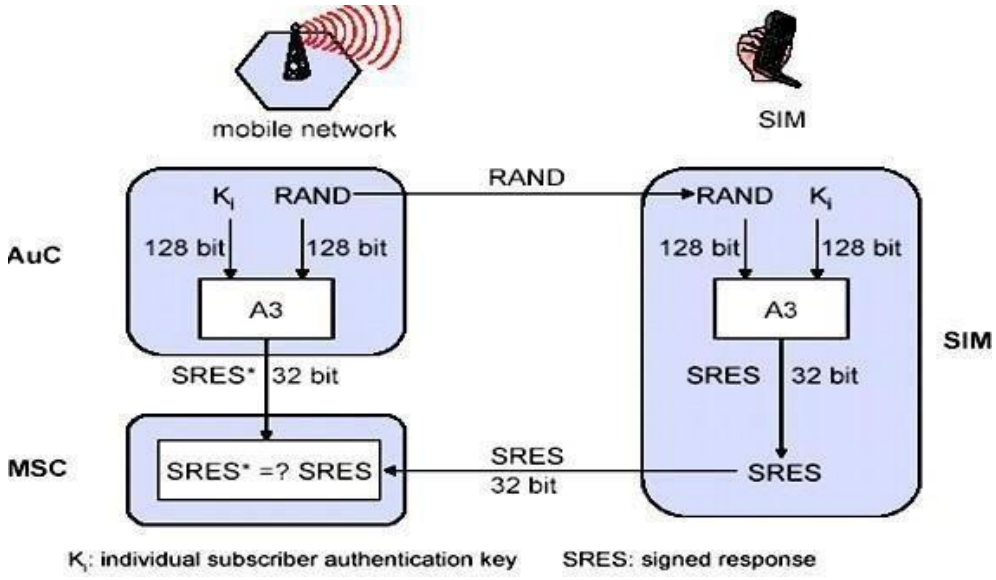


Figure2.1.4SubscriberAuthentication

AUTHENTICATION:

Authentication is based on the SIM, which stores the individual authentication key Ki, the useridentification IMSI, and the algorithm used for authentication A3. The AuC performs the basicgeneration of random values RAND, signed responses SRES, and cipher keys Kc for each IMSI,andthenforwardsthisinformationtotheHLR.ThecurrentVLRrequeststheappropriatevaluesforRAND,SRES, and Kcfrom the HLR.

For authentication, the VLR sends the random value RAND to the SIM. Both sides, network andsubscriber module, perform the same operation with RAND and the key Ki, called A3. The MSsends back the SRES generated by the SIM; the VLR can now compare both values. If they are thesame,theVLR accepts thesubscriber, otherwisethesubscriberisrejected.

The purpose of authentication is to protect the network against unauthorized use. In the GSMcontext,ithelpsprotecttheGSMsubscribersbydenyingthepossibilityforintruderstoimpersonateauthorizedusers.AGSMnetworkoperatorcanverifytheidentityofthesubscriber,makingithighlyimprobable to clone someone else's mobile phone identity. Authentication can be achieved in asimple way by using a password such as Personal Identification Number (PIN). This method is notverysecureinGSMnetworksasanattacker can"listen"thePINand easilybreakthe code.

CONFIDENTIALITY:

AGSMnetworkprotectsvoice,dataandsensitivesignallinginformation(e.g.dialeddigits)againsteavesdropping on the radio path. Confidentiality of subscriber-dialled information in the GSMnetworkisachievedbyusingencryptiontechniquesprescribedbytheGSMdesigners.

Data on the radio path is encrypted between the Mobile Equipment (ME) and the BTS whichprotectsuser trafficand sensitivesignalling dataagainsteavesdropping.

Alluser-relateddataisencrypted.Afterauthentication,BTSandMSapplyencryptiontovoice,data,andsignalling as shown below.

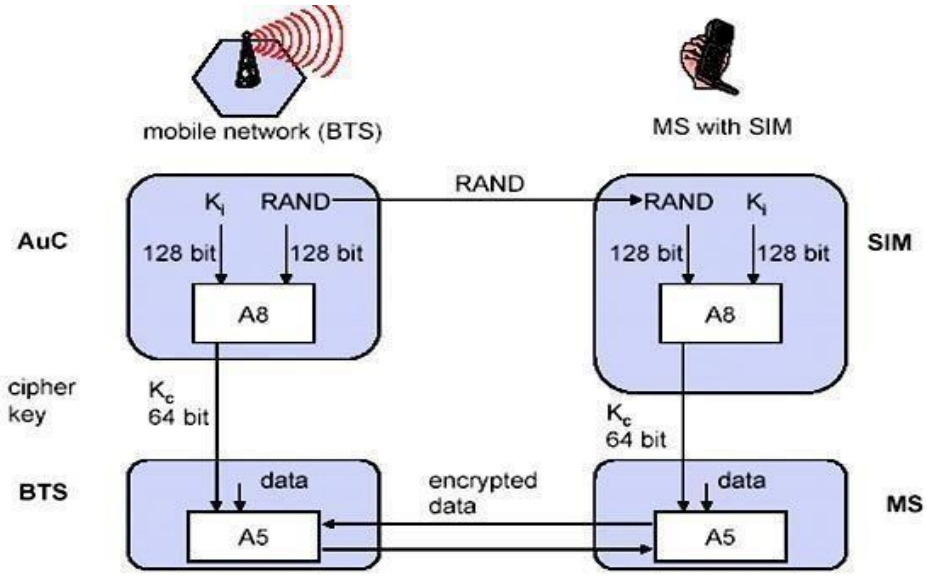


Figure3.1.5Confidentiality

Toensureprivacy,allmessagescontaininguser-relatedinformationareencryptedinGSMovertheair interface. After authentication, MS and BSS can start using encryption by applying the cipherkey Kc, which is generated using the individual key Ki and a random value by applying thealgorithmA8.NotethattheSIMintheMSandthenetworkbothcalculatethesameKcbasedontherando m value RAND. The key Kc itself is not transmitted over the air interface. MS and BTS cannowencrypt and decryptdata usingthe algorithm A5 and thecipherkeyKc.

ANONYMITY:

A GSM network protects against someone tracking the location of a user or identifying calls madeto (or from) the user by eavesdropping on the radio path. The anonymity of the subscriber on theradio access link in the GSM network is achieved by allocating Temporary Mobile SubscriberIdentity (TMSIs) instead of permanent identities. This helps to protectagainst tracking a user'slocationand obtaining information about auser'scallingpattern.

To provide user anonymity, all data is encrypted before transmission, and user identifiers are notused over the air. Instead, GSM transmits a temporary identifier (TMSI), which isnewly assignedbythe VLRafter eachlocation update.Additionally, theVLR can changetheTMSIatanytime.

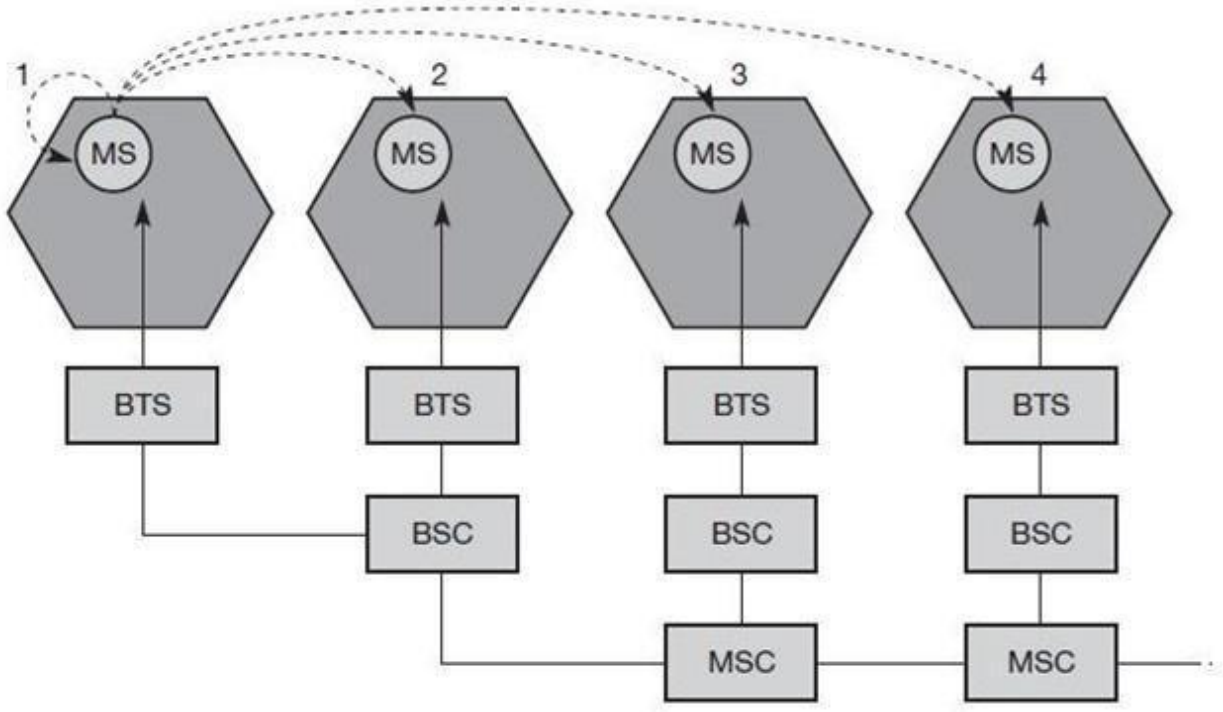
GSM HANDOVER(Mobilitymanagement)

Cellular systems require **handover** procedures, as single cells do not cover the whole service area.However, a handover should not cause a cut-off, also called **call drop**. GSM aims at maximumhandoverduration of60 ms. Therearetwo basic reasons fora handover:

1. Themobilestation**movesoutoftherange**ofaBTS,decreasingthereceived**signallevel** increasingthe **errorrate** therebydiminishing the**qualityoftheradiolink.**

2. Handovermaybedueto**loadbalancing,**whenanMSC/BSCdecidesthetrafficistoohighinonecell and shifts someMS toothercellswith a lower load.

ThefourpossiblehandoverscenariosofGSM are shown below:



- **Intra-cell handover:** Within a cell, narrow-band interference could make transmission atacertainfrequencyimpossible.TheBSCcouldthendecidetochangethecarrierfrequency(scenario1).
- **Inter-cell, intra-BSC handover:** This is a typical handover scenario. The mobile stationmoves from one cell to another, but stays within the control of the same BSC. The BSCthenperformsahandover,assignsanewradiochannelinthenewcellandreleasestheoldone(scenario 2).
- **Inter-BSC, intra-MSC handover:** As a BSC only controls a limited number of cells;GSMalsohastoperformhandoversbetweencellscontrolledbydifferentBSCs.This

handoverthenhastobecontrolled bytheMSC (scenario3).

- **Inter MSC handover:** A handover could be required between two cells belonging todifferentMSCs. Nowboth MSCsperform thehandover together(scenario4).
  To provide all the necessary information for a handover due to a weak link, MS and BTSboth perform periodic measurements of the downlink and uplink quality respectively.Measurement reports are sent by the MS about every half-second and contain the qualityof the current link used for transmission as well as the quality of certain channels inneighboringcells (the BCCHs).

GSMCONNECTIONESTABLISHMENT/CALLSETUP (Localization&Calling)

The fundamental feature of the GSM system is the automatic, worldwide localization of users forwhich,thesystemperformsperiodiclocationupdates.TheHLRalwayscontainsinformationaboutthe current location and the VLR currently responsible for the MS informs the HLR about thelocation changes. Changing VLRs with uninterrupted availability is called roaming. Roamingcantake place within a network of one provider, between two providers in a country and also betweendifferentproviders in different countries.

Tolocateandaddressan MS,severalnumbersareneeded:

- **MobilestationinternationalISDNnumber(MSISDN)**:-Theonlyimportantnumberfora user of GSM is the phone number. This number consists of the country code (CC), the nationaldestinationcode(NDC)and the subscriber number(SN).
- **Internationalmobilesubscriberidentity(IMSI)**:GSMusestheIMSIforinternaluniqueidenti fication of a subscriber. IMSI consists of a mobile country code (MCC), the mobile networkcode(MNC),and finallythe mobilesubscriberidentification number(MSIN).
- **Temporary mobile subscriber identity (TMSI)**: To hide the IMSI, which would giveaway the exact identity of the user signalling over the air interface, GSM uses the 4 byte TMSI forlocalsubscriber identification.
- **Mobile station roaming number (MSRN)**: Another temporary address that hides theidentityandlocationofasubscriberisMSRN.TheVLRgeneratesthisaddressonrequestfromtheMSC, andtheaddressisalsostoredintheHLR.MSRNcontainsthecurrentvisitorcountrycode

(VCC),thevisitornationaldestinationcode(VNDC),theidentificationofthecurrentMSCtogetherwiththes ubscribernumber. TheMSRN helpsthe HLR tofind asubscriber foranincomingcall.

For***amobileterminatedcall(MTC),***thefollowingfigureshowsthedifferentstepsthat take place:

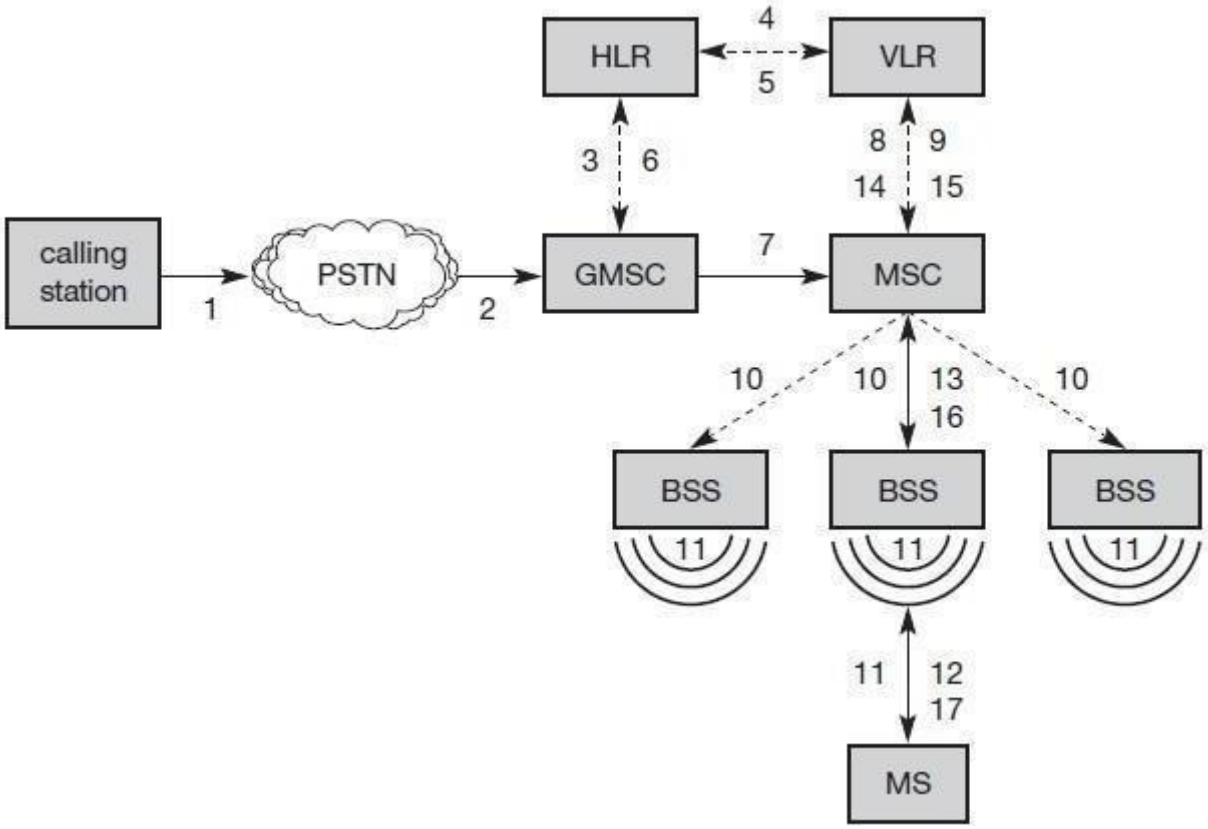


Figure2.1.9MobileTerminatedCall(MTC)St

ep 1: Userdials thephonenumberofaGSMsubscriber.

Step2: Thefixednetwork(PSTN)identifiesthenumberbelongstoauserinGSM networkandforwardsthecallsetup tothe GatewayMSC (GMSC).

Step 3: TheGMSC identifiestheHLRforthesubscriberandsignalsthecall setuptoHLR**Step 4:** The HLR checks for number existence and its subscribed services and requests anMSRNfrom thecurrentVLR.

Step5:VLRsendsthe MSRNtoHLR

Step6: UponreceivingMSRN,theHLRdeterminestheMSCresponsibleforMSandforwardstheinformationto theGMSC

Step7: TheGMSC cannowforwardthecall setuprequest totheMSCindicated

Step 8: TheMSCrequests theVLR forthecurrentstatusofthe MS

Step9:VLR sendstherequestedinformation

Step10: IfMSisavailable,theMSCinitiatespaginginall cellsitisresponsiblefor.

Step 11: Thebtss ofall bssstransmit thepagingsignal totheMS

Step12:Step 13:IfMSanswers,VLRperformssecuritychecks

Step 15:Tillstep 17:Thenthe VLRsignalstotheMSCto setup aconnectiontotheMS

Fora**mobileoriginatedcall(MOC),**thefollowingstepstakeplace:

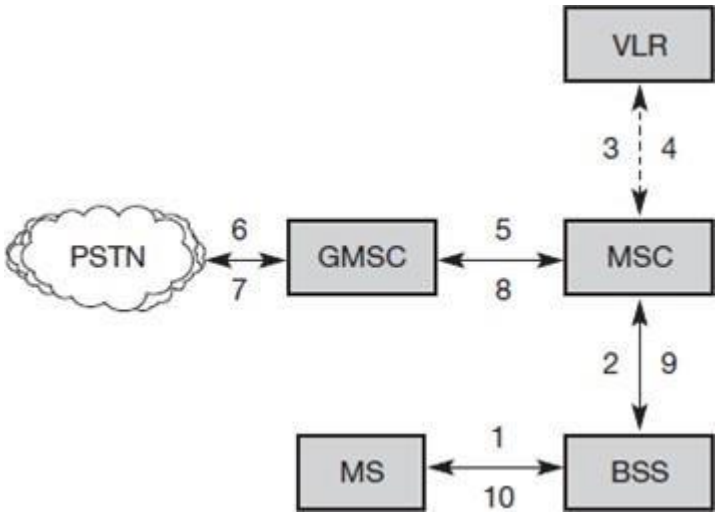


Figure2.1.10MobileOriginatedCall(MOC)

Step1: TheMStransmitsarequestfor anew connection

Step 2: TheBSS forwardsthisrequest totheMSC

Step 3: TheMSCthenchecksifthisuserisallowedtoset upacall withtherequestedandchecksthe availabilityof resourcesthrough theGSMnetworkand intothePSTN.

Step4:

Ifallresourcesareavailable,theMSCsetsupaconnectionbetweentheMSandthefixednetwork.

GeneralPacketRadioService(GPRS)

GPRSwhenintegratedwithGSM,significantlyimprovesandsimplifiesInternetaccess.Ittransfersdata packets from GSM mobile stations to external packet data networks (PDNs). Packets can bedirectly routed from the GPRS mobile stations to packet switched networks making it easy toconnect to the Internet. GSM uses a billing system based on the time (duration)of connection,whereasGPRSusesabillingsystembasedontheamountoftransmitteddataratherthanthedura tionof the connection. So, users can remain continuously connected to the system, and yet get chargedonlyfortheamount oftransmitted data.

- ✓ GPRS extends data capability of GSM and provides connection to external packet datanetwork through GSM infrastructure with short access time to network for independentshortpackets (500-1000bytes)
- ✓ ItisanenhancementofGSM.ItusessamephysicalchannelsasGSMandonlynewlogicalGPRSra dio channels aredefined.
- ✓ Onetoeightradio interfacetimeslotscanbeallocatedperTDMAframe.
- ✓ Theactiveusers sharetimeslots anduplink anddownlinkareallocatedseparately
- ✓ AllocationofGPRS isdonedynamicallyaccordingto“capacityondemand”
- ✓ GPRSofferspermanentconnectionstointernetwithvolumebasedchargingthatenablesauser to obtain alessexpensive connection to theinternet.
- ✓ Thisshouldalsoallowforbroadcast,multicastandunicastservice.
- ✓ GPRSMSsareofthreetypes:
    - ClassAterminals operateGPRSandotherGSMservicessimultaneously

- ClassBterminalscanmonitorallservicesbutoperateeitherGPRSorGSM

- ClassCterminalsoperateonlyGPRSservice.

✓ Dependingoncoding, transferrateupto170kbits ispossible

✓ Inphase1,GPRSoffersapoint-to-point(PTP)packettransferservice

✓ One of the PTP version offer is PTP connection oriented Network service (PTP-CONS),which includes the ability of GPRS to maintain a virtual circuit upon change of the cellwithin theGSM network.

✓ TheotherPTPversionofferedisPTPConnectionlessNetworkservice(PTP-CLNS)whichsupportsIPapplications

✓ MulticastingcalledPoint–to-multipoint(PTM)serviceisleftforGPRS phase2

✓ Users of GPRS can specify a QoS-profile. This determines the service precedence (high,normal,low),reliabilityclass anddelayclass ofthetransmission.

GPRSSERVICES

GPRSoffersend-to-end packet-switcheddatatransferservices which canbecategorizedintothefollowingtwotypes:

(i) Point-to-Point(PTP)service
(ii) Point-to-Multipoint(PTM)service.

PTP(Point-To-Point)Services

Some of the GPRS services are not likely to be provided by network operators during earlydeployment of GPRS due in part to the phased development of the standard. Market demand isanotherfactoraffectingthedecisionoftheoperatorsregardingwhichservices toofferfirst.
ThePTPserviceisbetweentwousersandcaneitherbeconnectionlessorconnection-oriented.

GPRS will support applications based on IP. Applications based on the Connection OrientedNetworkProtocolsarealsodefinedtobesupported.TheX.25protocolwasinitiallymentionedbuthas been dropped in recent standard developments. Table 1 illustrates the general description ofthePTP services and some possible applications.

Service	Description	Applications
PTP-CONS Point-To-Point Connection Oriented Network Service	• Bursty transactive or interactive applications. • A logical relation is established between users • Multiple packets are sent between a single source and a single destination	Credit card validations Electronic monitoring Telnet applications Data base access and information retrieval
PTP-CLNS Point-To-Point Connectionless Network Service	• Datagram type service for bursty applications • No logical link required between users • Packets are sent between a single source and a single destination • Each packet is independent of its predecessor and successor	Electronic mail Internet's World Wide Web

TABLE 1. PTP (Point-To-Point) GPRS Services

PTM(Point-To-Multipoint)Services

The PTM is a data transfer service from one user to multiple users. Again, there are two types ofPTM services. One is multicast PTM where the data packets are broadcast in a certain area and theotherisgroupcallPTMwherethedatapacketsareaddressedtoagroupofusers.ThePTMservicesprovide the subscribers with the capability to send data to multiple destinations within one singleservicerequest.Table2showsageneraldescriptionoftheseservicesandsomepossibleapplications. WiththeexceptionofPTM-M(Point-To-Multi-pointMulticast)services,groupsmustbe defined and members are required to join an ongoing call to become participants.A PTM-G(Point-to-MultipointGroup)callisusuallyrestrictedtomemberslocatedwithinaspecificgeographicalarea.AnIP-M(IP-Multicast)callisontheotherhandindependentofthegeographical area of the participants and can be internal to the network or distributed across theinternet.

Service	Description	Applications
PTM-M Point-To-Multipoint Multicast	• Messages are transmitted to a specific geographical area and optionally to a specified group within that area • The recipients are anonymous • Delivery time is scheduled • Uni-directional transmission	News Weather and traffic reports
PTM-G Point-To-Multipoint Group Call	• Messages are transmitted to a specific group within a specific geographical area • Group members must join the PTM-G call to become participants • Delivery in real time • Uni-directional, bi-directional and multi-directional transmission	Conferencing services
IP-M IP Multicast	• Messages are transmitted to a specified group • Group members must join the IP-M call to become participants • Delivery in real time • Multi-directional transmission	Live multimedia trans-missions Corporate messages to employees

TABLE 2. PTM (Point-To-Multipoint) GPRS Services

GPRSARCHITECTURE

GPRS architecture introduces two new network elements, calledGPRS Support Node (GSN)andtheGatewayGPRSSupportNode(GGSN).AGSNisessentiallyarouter.AllGSNsareintegrate dinto a standard GSM architecture. The GGSN is the interworking unit between the GPRS networkand the external packet data network (PDN). The GGSN contains routing information for GPRSusers, performs address connection and tunnells data to a user through encapsulation. In Fig. 2.10,the GGSN is connected to an external network and it transfers packets to the SGSN through an IP-basedGPRS backbonenetwork.

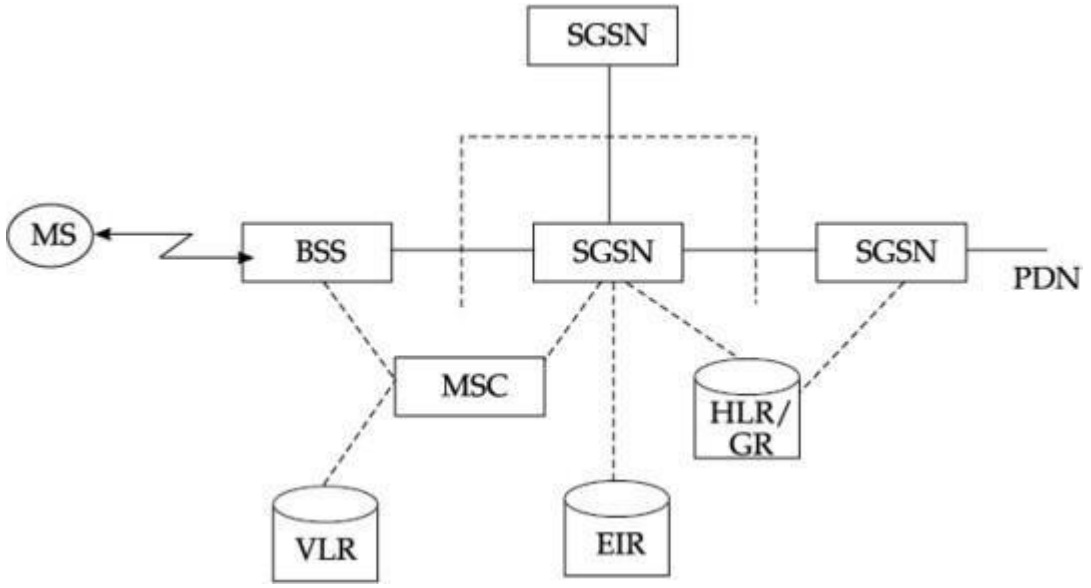


Figure2.2.1GPRSArchitectureReferenceModel

AsshowninFig.SGSN(ServingGPRSSupportNode)helpssupportMS.TheSGSNisconnectedto BSC through frame relay and it is at the same hierarchy level as the MSC. The GPRS Register(GR) is a part of HLR which stores all the relevant GPRS data. In a part of HLR which stores alltherelevantdataofGPRSinamobileIPnetwork,GGSNandSGSNscanbecomparedwithhomeagenta ndforeignagentrespectively.ThedatapacketsaretransmittedtotheBSSandfinallytothe MS through the GGSN and SGSN. The MSC as we have already discussed is responsible fordatatransport in thetraditional circuit-switchedGSM.

- **GPRSnetworkelements**

  Two new network element which are called GSN (**G**PRS **S**upport **N**odes): GGSNandSGSN

  - **GGSN(Gateway GSN)**
    - InterworkingunitbetweenGPRSandPDN(Packet DataNetwork)
    - PDNcontainsroutinginformationforGPRSusersandperformsaddr essconversion
  - **SGSN (ServingGSN)**
    - SupportstheMSviatheGbinterface(location,billing, security)

- Request user addresses from GPRS register (GR) keeps track ofindividualMSslocationanditisresponsibleforcollectingbillinginformation.

- **GR(GPRSRegister)**
- storesall GPRSrelevantdataanduseraddresses

All GSN are integrated into standard GSM architecture. Packet data is transmitted from PDN, viaGGSNandSGSNdirectlytotheBSSandfinallytoMS.BeforesendingdataoverGPRSnetwork,An MS must attach a Temporary Logical link Identity (TLLI) and a Ciphering key sequenceNumber (CKSN) for data encryption. Besides attachment and detachment Mobility managementalso comprises functions for authentication, location management etc. For each MS, a GPRScontext is set up and stored in the MS and in the corresponding SGSN.This context comprises thestatusofMS(ready,idle,standby)InidlemodeanMSisnotreachableandallcontextsaredeleted.Instandbyonlymovementacrossroutingareasisupdatedto SGSNbutnotchangesofthecell.Inreadystateeverymovement of MS is indicatedto theSGSN.

UniversalMobileTelecommunicationsSystem(UMTS)

- UTRA(was:UMTS,now:UniversalTerrestrialRadioAccess)
- EnhancementsofGSM
  - EDGE(EnhancedDataratesforGSMEvolution):usesenhancedmodulation(8PSK)and GSM up to 384 kbit/s
  - CAMEL(CustomizedApplicationforMobileEnhancedLogic)
  - VHE(virtualHomeEnvironment)
- FitsintoGMM(GlobalMultimediaMobility)initiativefromETSI
- Requirements
  - min.144kbit/srural(goal:384kbit/s)
  - min.384kbit/ssuburban(goal: 512 kbit/s)
  - upto 2Mbit/surban
- UTRA-FDD:
  (FDD-FrequencyDivision Duplex)

  - Uplink1920-1980 MHz
  - Downlink2110-2170MHz
  - Duplexspacing 190MHz

- 12channels, each5MHz

- UTRA-TDD:
  (TDD-TimeDivision Duplex)

  - 1900-1920MHz,
  - 2010-2025MHz;
  - 5MHzchannels

UMTSNetworkArchitecture

TheUMTSnetworkarchitecturecanbedividedinto threemainelements:

UserEquipment(UE):

The User Equipment (UE) is the name by which a cell phone is referred to. The new name waschosen because of the considerably greater functionality that the UE incorporates compared to acellphone.Itcanbethoughtofasbothamobilephoneusedfortalkingandadataterminalattachedtoacomputerwithnovoicecapability.TheUTRANisconnectedtoUEviatheradiointerface$U_u$andvia$I_u$interfaceUTRANcommunicates withCoreNetwork(CN)

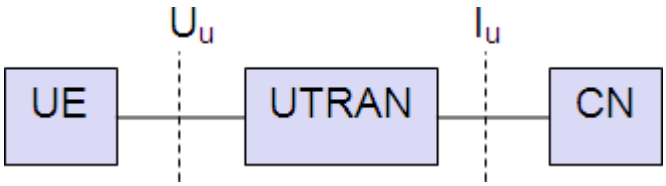


Figure2.3.1UMTSNetworkArchitectureUT

RAN(UniversalTerrestrialRadioAccess Network):

- ✓ Celllevelmobility
- ✓ RadioNetworkSubsystem(RNS)
  - Function of this system include ciphering, deciphering, hand overcontrol,Radio resourcemanagement etc.
- ✓ Encapsulationofall radiospecifictasks

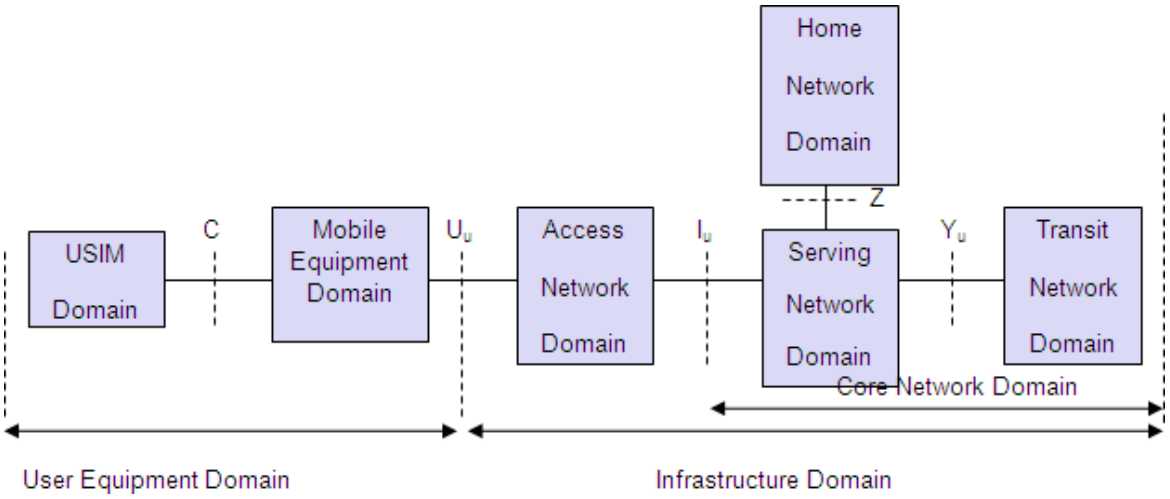
CoreNetwork:

Thecorenetworkisthe equivalentoftheGSMNetworkSwitchingSubsystem(NSS).

- ✓ Intersystemhandover
- ✓ Containsthefunctionforinter-systemhandover,gatewaystoothernetworksetc
- ✓ Locationmanagementifthereisnodedicatedconnectionbetween UEand UTRAN

- UMTSfurthersubdividestheabovearchitectureinto**DomainsUM**

TSDOMAINSANDINTERFACES



- **UserEquipmentDomain**
  - ✓ Assignedtoasingleuserinordertoaccess UMTSservices
- **InfrastructureDomain**
  - ✓ Sharedamong allusers
  - ✓ OffersUMTSservicesto allacceptedusers
- **UniversalSubscriberIdentityModule(USIM)**
  - ✓ Functionsforencryptionandauthenticationofusers
  - ✓ LocatedonaSIM inserted intoamobiledevice
- **MobileEquipmentDomain**
  - ✓ Functionsforradio transmission
  - ✓ Userinterfaceforestablishing/maintainingend-to-endconnections
- **AccessNetworkDomain**
  - ✓ Accessnetworkdependentfunctions
  - ✓ ContainsRadio AccessNetworks(RAN)andCorenetworkDomain

- **CoreNetworkDomain**
  - ✓ Accessnetworkindependentfunctions
  - ✓ This domain separated into three domains with specific tasks: Service Networkdomainand Homenetworkdomain
  - ✓ **ServingNetworkDomain**
    - Networkcurrentlyresponsibleforcommunication
  - ✓ **HomeNetworkDomain**
- Locationandaccessnetworkindependentfunctions

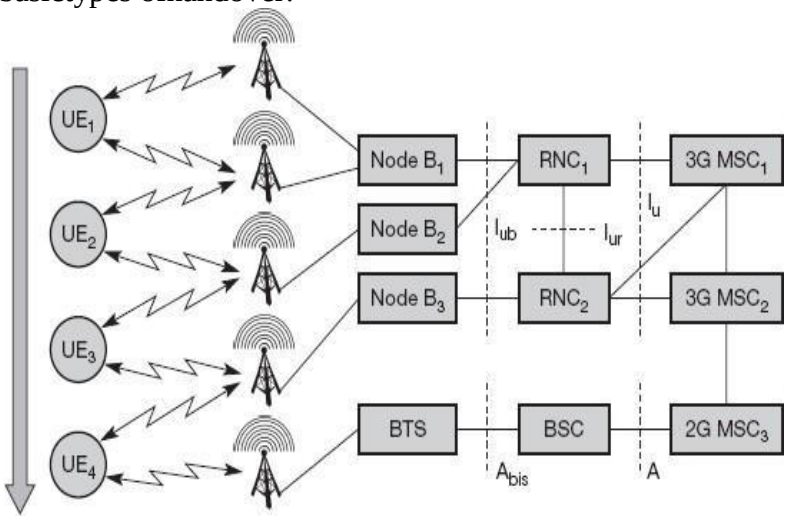
UMTSHANDOVER

- HandoverorhandoffisasimportantforUMTSasanyotherformofcellulartelecommunicationss ystem.
- AswithanyothercellulartelecommunicationssystemitisessentialthatUMTShandoverisperformed seamlessly so that theuser is not awareof anychange.
- AnyfailureswithintheUMTShandoverprocedurewillleadtodroppedcallswhichwillinturnres ult inuserdissatisfactionandultimatelyit mayleadto userschangingnetworks.

Handoversareanimportantpartofeverycellularcommunicationsystem.Theyareuse dforproviding mobility incellulararchitectures.

TypesofHandover

Therearefourbasictypes ofhandover:



(1) Softerhandover:**Intra-nodeB,Intra-RNC**

NotafullformofUMTShandover,buttheUEcommunicateswithmorethanonesectormanagedby the sameNodeB.

(2) Softhandover:**Inter-nodeB,Intra-RNC**

ThisformofhandoverisamoregradualandtheUEcommunicates simultaneouslywithmorethanoneNodeB or basestation duringthe handover process.

3.*Hardhandover:* (i)Inter-RNC,Intra-MSC&(ii)Inter-MSC

This form of handover is essentially the same as that used for 2G networks where one link isbrokenand anotherestablished.

4.* Inter-System*handover:* (*UMTS-GSM)

ThisformofhandoveroccurswhenmobileshavetochangebetweenRadioAccessTechnologies(i.e.between 3G and2G).