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OVERVIEWOFDIGITALMOBILE ARCHITECTURES

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ABSTRACT*— In this paper, we have given the complete overview of the network architectures of 2G, 3G, 4G & 5G Mobile Communication Systems. At the outset, we have described in brief the overview of present communication system. The standardization agency of wireless technologies namely ITU is also briefly described. 3G, 4G& 5G mobile system design, development& implementing agency i.e. 3GPP is also discussed in paper. 3GPP2 is not covered because 3GPP2 is merged with 3GPP for development of 4G & 5G Mobile systems.GSM architecture for 2G is explained in details. LTE architectures for 3G& 4G are also described. The 5G Mobile system architecture which is developed recently is also discussed. Finally salient features of all 2G, 3G, 4G & 5G mobile architectures are compared successfully.*

I. INTRODUCTIONTOCOMMUNICATIONSYSTEM

Ever since human civilization came in existence, we had a principal need to communicate in our society. At present,wehavethemobileasalatestcommunicationsystem.Thecommunication&wirelesstechnologieshave rapid& significant growth over last 4decadesdue tonumerous advantagesinnot onlyin Economic Sectors but also in many other sectors. This need created interests in E&TC engineers to develop an efficient mobile communicationsystem keepinginmind 4parameters: speed,bandwidth, latency& Reliability.

II. INTRODUCTIONTOITU

The International Telecommunication Union [ITU], Geneve, carries out the International Standardization of Wireless Technology for the world to communicate any time at any place. ITU is consisted of three bodies namely:ITU-T,ITU-R&ITU-D.ITU-TdealswithTelecommunicationstandardization&NetworkandService Aspects.ITU-RmainlycarriesoutRadioCommunicationStandardization&GlobalSpectrumManagement.The thirduniti.e.ITU-DassistsImplementation&Operationof TelecommunicationsinDevelopingCounties.
TheITU has189MemberStates,630SectorMembersand106Associates.UnitedNations(UN)bodiessuchas WHO&WMOare associatedwithITU.IndustryforumsuchasWiMAXisalsoassociatedwithITU.Regional FrequencyManagement such as CEPT [Conference Europeenne des Postes et des Telecommunications] is also associatedwith ITU. Regional/National SDO'ssuchasETSI & IEC are also associatedwith ITU.

III. 3GPPRELEASESFORMOBILESYSTEM

TheThirdGenerationPartnershipProject[3GPP]isacollaborationgroupoftelecommunicationstandards, founded in December, 1998.It consists of 7organizations:
1 EuropeanTelecommunicationsStandardsInstitute–[**ETSI**–Europe]
2 AllianceforTelecommunicationsIndustrySolutions–[**ATIS**–USA]
3 TelecommunicationsTechnologyCommittee–[**TTC**–Japan]
4 AssociationofRadioIndustries&Businesses–[**ARIB**–Japan]
5 TelecommunicationsTechnologyAssociation–[**TTA**–SouthKorea]
6 TelecommunicationsStandardsDevelopmentSocietyofIndia–[**TSDSI**–India]
7 ChinaCommunicationsStandardsAssociation–[**CCSA**–China]
The initial scope of 3GPP was to make a globally applicable the third Generation [3G] mobile phone specification based on evolved GSM specifications within the scope of the I*nternational Mobile Telecommunications-2000*[IMT-2000]projectoftheInternationalTelecommunicationsUnion[ITU].The scopewaslaterincreasedtoincludethedevelopment&maintenance of:

* GSM,GPRS,EDGE,UMTS&HSPA
* LTE,LTE-Advanced,LTE-AdvancedPro&5Gstandards

Various3GPPreleasesforspecifications,development&maintenanceofGSM,GPRS&EDGE,UMTS& HSPA, LTE, LTE-Advanced & 5G are given in Table I.

TABLEI

3GPP Release	YearofRelease	MainFeatures
Release99	March,2000	Basisfor3GMobileDeployment
Release 4	March,2001	AllIPcoreNetwork+LowChiprateTD-SCDMA
Release 5	June,2002	IPbasedMultimedia
Release 6	March,2005	econdPhaseofHighSpeedIMS
Release 7	December,2007	EnhancedUPLINK&Multiple Input&MultipleoutputAntennas[MIMO]
Release 8	December,2008	LongTermEvolution(LTE)+SystemArchitectureEvolution(SAE)
Release 9	December,2009	Bandwidth20MHz OFDM&studiesof LTE-Advanced[4G]
Release10	March,20011	4GLTE-Advanced(IMTAdvanced)+LTERadio+CarrierAggregation (CA)
Release11	September,2012	eICICevolution+ MIMOwithSpace Multiplexing
Release12	March,2013	Inter SiteCA
Release13	2015	5Grequirements study+ 5G Architecturestudy
Release14	2016	5GRAN
Release15	2017	Basisfor IMT2020&5GPhase1deploymentin2020
Release16	2018	Basisfor5GPhase2Deploymentin2021

IV GSMARCHITECTURE:

GSMisshortformof'**G**lobal **S**ystemfor**M**obile'.Itwasthefirstdigitalcellularsystem(2G)forspeech&data communication services& was implemented in 1991. TDMA (**T**ime**D**ivision**M**ultiple**A**ccess)& digital modulation are used in the GSM architecture.

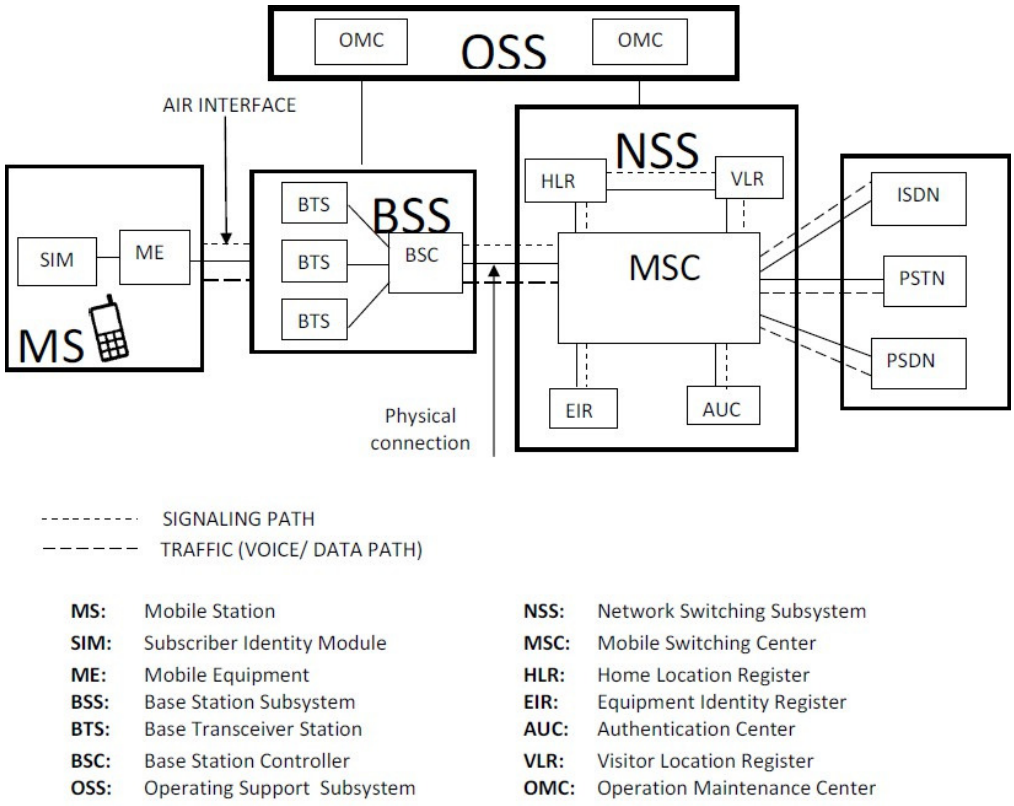

FIG. 1: GSM ARCHITECTURE

TheGSMarchitectureiscomprisedoffourentities:

1. MS 2.BSS 3.NSS4.OSS

The MS is equipped with detachable SIM card along with ME. The BTS of BSS controls multiple MS. The multipleBTSiscontrolledbyMSC. The MSCisresponsibleforhandlingmobile location,paging, othermobile and profile information for all mobile subscribers registered with this MSC as their "home location". The VLR registers the profile information of foreign visitors into HLR of MSC in that area.

The registration & authentication of a MS turning itself on, preparatory to either sending or receiving calls, is performed by sending control signals across the air interface between MS and BSS. These control signals are forwarded to the MSC for authentication. If MS is in home location, then local MSC/VLR combination will forward the requested registration of MS to its HLR. The HLR communicates with AUC and confirms the registration to MSC for further actions.

OSSperformsthreethings:

1. FaultManagement2.ConfigurationManagement3.SoftwareManagement.

When a fault occurs in the system, then OSS invokes alarm about the faulty elements of BSS and the fault is resolved by either Software or technician.

When a new BTS is set up, then OSS carries out configuration of newlyset upBTS. It alsokeepsthe hardware inventory list & changes radio frequencies of newly set up BTS.

OSSupdates&managesthesoftwareinventorylist.Italsoinstallsnewsoftware.

Light dashed lines in Fig. 1 indicate the paths taken by the various control signals. Bold dashed line represent paths taken by speech& data traffic, once a call is set up& is in progress. Traffic is also shown flowing to ISDN, PSTN & PSDN.

BSCofGSMArchitecture

The BSS& MS of GSM architecture is shown in Fig. 2. BSC is an important entity of BSS which controls multiple BTS. It is a high quality switch which handles handoffs between two BTSs which are under control of same BSC. Thus BSC reduces the burden of MSC.

BSC assigns free radio channel to MS & controls RF power levels in BTS. It is also responsible for maintaining the radio path between MS during the call & discontinuation of path after the call is over.

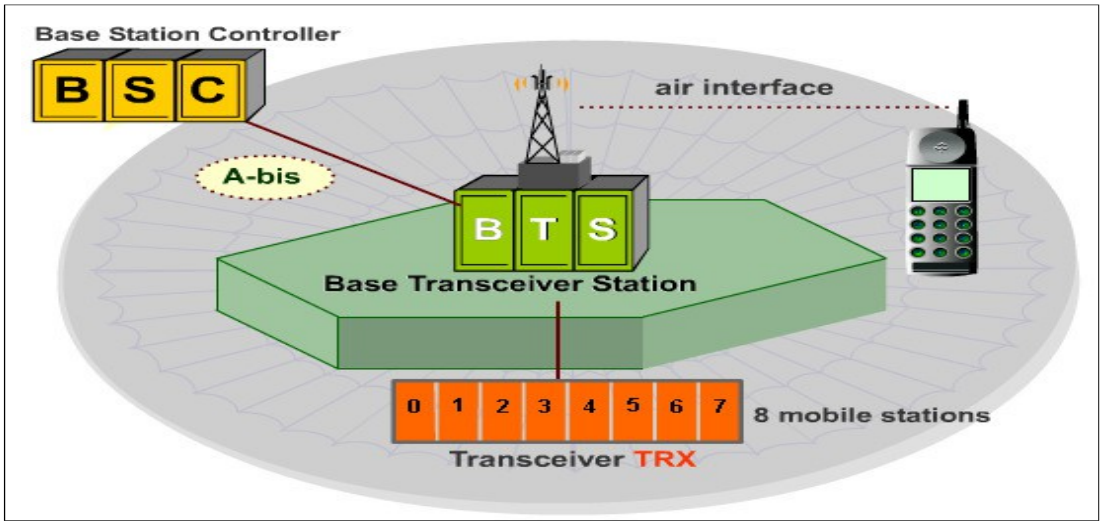

Fig.2:BSS&MSofGSMArchitecture MSC of

GSM Architecture

AsshowninFig.4.1,MSCiscomprisedof4functionalentities:

1–HLR 2–VLR 3-EIR&4–AUC

HLR–Itisthedatabaseofinformationrelatedtopermanentmobilesubscribers.User&mobileinformationare stored in VLR. It identifies the MS using IMSI & MSISDN. It also provides information about GSM services such as teleservices & its supplementary services. In case of a moving mobile user, HLR provides VLR data to MSC.

VLR–Itisthedatabaseofamovingmobileuserwhenhe/sheentersintheVLRarea.VLRworksin association with HLR & AUC.

When the roaming MS enters the new MSC area, then he/she needs to register in new MSC. The registrationprocess is completed in 5 steps:

Step1: ThehomeVLRidentifiestheMSbelongingtootherMSCarea.

Step2: ThehomeVLRidentifiestheHLRofMS&communicateswiththesame.

Step3: VLR constructs the GT (Global Title) from IMSI to facilitate data transfer between VLR & Home VLR. **Step 4:** VLR generates MSRN [Mobile Subscriber Roaming Number] to allow MS to use the network while in roaming. **Step5:** VLR sends the MSRN [Mobile Subscriber Roaming Number] to home HLR. VLR stores MSRN, TMSI, the home Location of MS, Supplementary services data of MS, MSISDN, IMSI, GT, & Local MS identity.

EIR- It is the data base of all legitimate, fraudulent, working & faulty MS. It maintains list of all valid & invalid mobile equipment in the area. EIR data base also stores IMEI given by Manufacturer.

AUC-It is the database of secret authentication keys for all mobile subscribers & generates encryption keys for security purpose. It carries out authentication in association with HLR.

V ARCHITECTURE OF LTE:

The block diagram of the architecture of LTE is described in Fig.3.

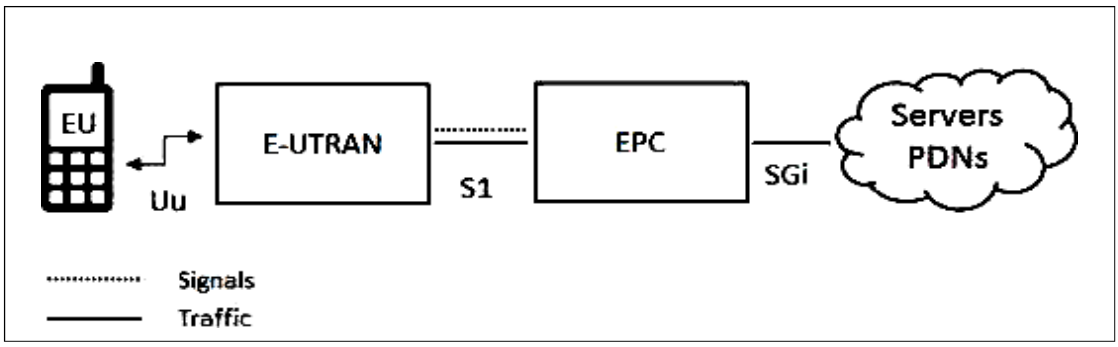

Fig.3 Block diagram of LTE Network Architecture:

MME=Mobility Management Entity; S-GW=Serving Gateway; HSS=Home Subscriber Server; PCRF = Policy & Charging Rules Function; P-GW = Public Data Network Gateway; Evolved Universal Terrestrial Radio Access Network = E-UTRAN; EPC = Evolved Packet Core

The architecture of LTE is consisted of three entities:

1 E-UTRAN
2 EPC
3 IP Network

E-UTRAN

E-UTRAN is nothing but radio access network and is used for wireless radio connection between the mobile phones & antennas from the mobile operator. E-UTRAN block is consisted of three entities:

1. LTE mobile terminals
2. Radio Interface
3. eNode BoreNB

1. LTE mobile terminals are mobile phones & other devices that support the LTE standards.
2. Radio Interface is a wireless connection between the LTE mobile terminals & eNB. It is wireless signals that form the mobile cells.
3. eNBs are situated all over the network of the mobile operator. They connect the LTE mobile terminal via radio interface to EPC.

EPC is the core network of LTE system. It is the brain of the system. EPC devices connect mobile phones in the network. They also connect the mobile network with fixed telephone system & internet. EPC is formed from five nodes namely: MME, S-GW, P-GW, HSS & PCRF. MME is the central control node & is responsible for mobility & security signaling, tracking and paging of mobile terminals. S-GW transports the user traffic between the mobile terminals & external networks. It also interconnects the radio access network with MME & P-GW.

P-GW connects EPC to external IP network. HSS is the database of all mobile users & is also responsible for authentication & session setup of call. PCRF is node responsible for real-time policy rules & charging.

VI OPEN WIRELESS ARCHITECTURE OF 5G NETWORK:

The Open Wireless Architecture of 5G Network is shown in Fig.4. The architecture is using flat IP Network to connect different Radio Access Networks (RANs) on a single Nano-core for communication.

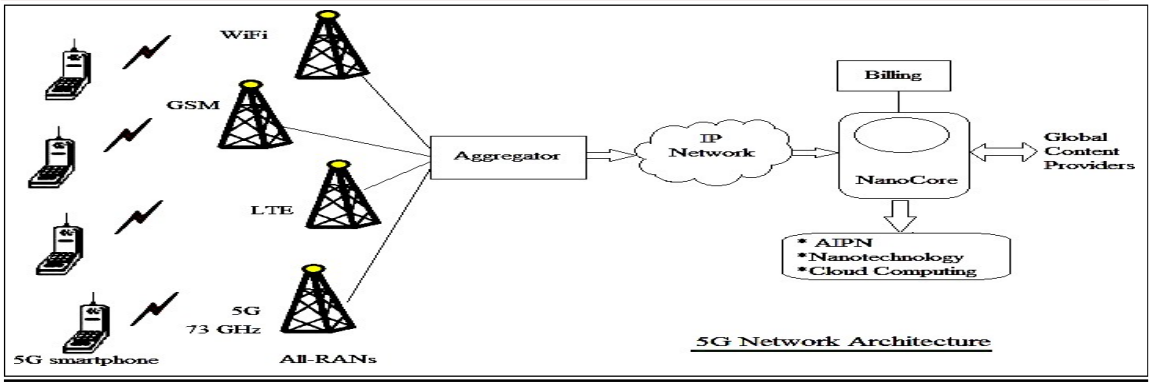

Fig.4:OpenwirelessArchitectureof5GNetwork

RANs supported architecture is GSM, GPRS/EDGE, UMTS, LTE, LTE A, Wimax, WiFi, CDMA2000, EV-DO,CDMA-One&IS-95. Thisarchitecturereducesnumberofnetworkelementsin data path&hencereduces cost & latency.

5G aggregator is located at BSC. The aggregator connects all the traffic of GSM, LTE 4G & 5G and routes it to Nano-Core. The Nano-Core is consists of nanotechnology & cloud computing. Cloud computing utilizes**Internet& central remote servers**to maintain data& applications of users. It allows users to use applications from any computer across the globe with the use of internet.

VII FEATURECOMPARISONOFVARIOUSMOBILEARCHITECTURE:

TheSalientFeaturesof2G,3G,4G&5GmobilearchitecturesaregiveninTABLEII. TABLE II FeaturesofGSM,UMTS,LTE&5GArchitectures

Parameters	GSM	IMT2000 (UMTS)	IMT-ADVANCED(LTE)	IMT-2020
Generation	2G	3G	4G	5G
Start/Deployment	1990-2004	2004-2012	2012-2019	2020
Technology	DigitalCellular	EVDO/EDGE	WiMAX,LTE,WiFi	WWWW
Access Methodology	TDM/FDM	WCDMA	OFDMA/SC-FDMA	CDMA&BDMA/ OFDMA
Maximum DownlinkSpeed	10-150Kbps	384 Kbps	1000 Mbps	10Gbps
Maximum UplinkSpeed	10-100 Kbps	128 Kbps	50 Mbps	1Gbps
Bandwidth	200 KHz	5MHz	1.4to20MHz	20MHz
TypesofModulation Supported	GMSK	QPSK	QPSK,16QAM& 64QAM	64QAM
TypeofCoreNetwork	Circuit Switched	Circuit&Packet Switched	FullyIPBased	FlatterIPNetwork

VIII CONCLUSIONS:

* The complete overview of the network architectures of 2G, 3G, 4G & 5G Mobile Communication Systems was given.
* The standardization agency of wireless technologies namely ITU& 3G, 4G& 5Gmobile system design ,development & implementing agency i.e. 3GPP is described in brief.
* 3GPP2isnotcoveredbecause3GPP2ismergedwith3GPPfordevelopmentof4G&5GMobilesystems.
* GSMarchitecturefor2G&LTEarchitecturesfor3G&4Garealsodescribed.
* The5GMobilesystemarchitecturewhichisdevelopedrecentlyisalsodiscussed.
* Finallysalientfeaturesofall2G,3G,4G&5Gmobilearchitecturesarecomparedsuccessfully.

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