

## OVERVIEW OF DIGITAL MOBILE 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. INTRODUCTION TO COMMUNICATION SYSTEM

Ever since human civilization came in existence, we had a principal need to communicate in our society. At present, we have the mobile as a latest communication system. The communication & wireless technologies have rapid & significant growth over last 4 decades due to numerous advantages in not only in Economic Sectors but also in many other sectors. This need created interests in E&TC engineers to develop an efficient mobile communication system keeping in mind 4 parameters: speed, bandwidth, latency & Reliability.

### II. INTRODUCTION TO ITU

The International Telecommunication Union [ITU], Geneva, 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-T deals with Telecommunication standardization & Network and Service Aspects. ITU-R mainly carries out Radio Communication Standardization & Global Spectrum Management. The third unit i.e. ITU-D assists Implementation & Operation of Telecommunications in Developing Countries.

The ITU has 189 Member States, 630 Sector Members and 106 Associates. United Nations (UN) bodies such as WHO & WMO are associated with ITU. Industry forum such as WiMAX is also associated with ITU. Regional Frequency Management such as CEPT [Conference Europeenne des Postes et des Telecommunications] is also associated with ITU. Regional/National SDO's such as ETSI & IEC are also associated with ITU.

### III. 3GPP RELEASES FOR MOBILE SYSTEM

The Third Generation Partnership Project [3GPP] is a collaboration group of telecommunication standards, founded in December, 1998. It consists of 7 organizations:

- 1 European Telecommunications Standards Institute – [ETSI – Europe]
- 2 Alliance for Telecommunications Industry Solutions – [ATIS – USA]
- 3 Telecommunications Technology Committee – [TTC – Japan]
- 4 Association of Radio Industries & Businesses – [ARIB – Japan]
- 5 Telecommunications Technology Association – [TTA – South Korea]
- 6 Telecommunications Standards Development Society of India – [TSDSI – India]
- 7 China Communications Standards Association – [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 *International Mobile Telecommunications-2000* [IMT-2000] project of the International Telecommunications Union [ITU]. The scope was later increased to include the development & maintenance of:

- \* GSM, GPRS, EDGE, UMTS & HSPA
- \* LTE, LTE-Advanced, LTE-Advanced Pro & 5G standards

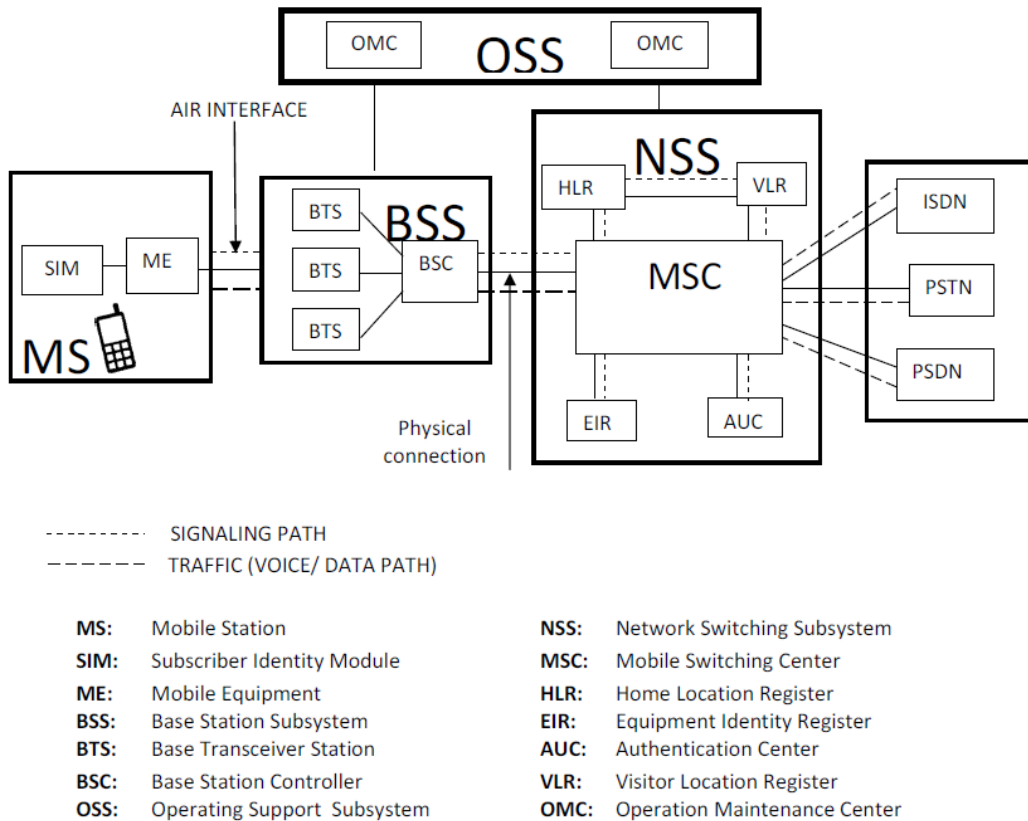
Various 3GPP releases for specifications, development & maintenance of GSM, GPRS & EDGE, UMTS & HSPA, LTE, LTE-Advanced & 5G are given in Table I.

TABLE I

3GPP Release	Year of Release	Main Features
Release 99	March, 2000	Basis for 3G Mobile Deployment
Release 4	March, 2001	All IP core Network + Low Chip rate TD-SCDMA
Release 5	June, 2002	IP based Multimedia
Release 6	March, 2005	second Phase of High Speed IMS
Release 7	December, 2007	Enhanced UPLINK & Multiple Input & Multiple output Antennas [MIMO]
Release 8	December, 2008	Long Term Evolution (LTE) + System Architecture Evolution (SAE)
Release 9	December, 2009	Bandwidth 20 MHz OFDM & studies of LTE-Advanced [4G]
Release 10	March, 2011	4G LTE-Advanced (IMT Advanced) + LTE Radio + Carrier Aggregation (CA)
Release 11	September, 2012	eICIC evolution + MIMO with Space Multiplexing
Release 12	March, 2013	Inter Site CA
Release 13	2015	5G requirements study + 5G Architecture study
Release 14	2016	5G RAN
Release 15	2017	Basis for IMT2020 & 5G Phase 1 deployment in 2020
Release 16	2018	Basis for 5G Phase 2 Deployment in 2021

**IV GSM ARCHITECTURE:**

GSM is short form of ‘Global System for Mobile’. It was the first digital cellular system (2G) for speech & data communication services & was implemented in 1991. TDMA (Time Division Multiple Access) & digital modulation are used in the GSM architecture.



**FIG. 1: GSM ARCHITECTURE**

The GSM architecture is comprised of four entities:

1. MS
2. BSS
3. NSS
4. OSS

The MS is equipped with detachable SIM card along with ME. The BTS of BSS controls multiple MS. The multiple BTS is controlled by MSC. The MSC is responsible for handling mobile location, paging, other mobile 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.

OSS performs three things:

1. Fault Management 2. Configuration Management 3. Software Management.

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 newly set up BTS. It also keeps the hardware inventory list & changes radio frequencies of newly set up BTS.

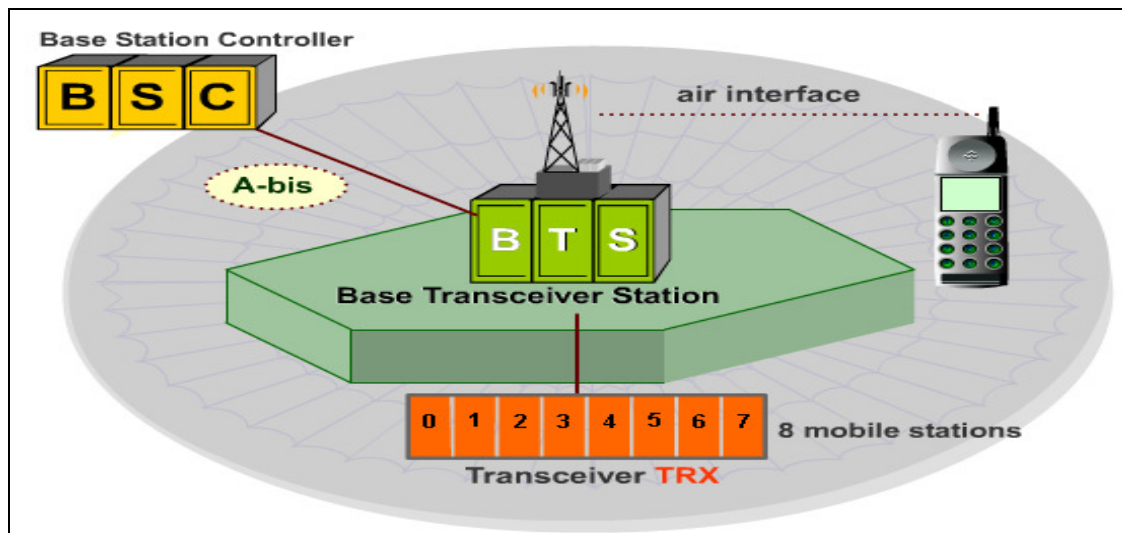
OSS updates & manages the software inventory list. It also installs new software.

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.

### **BSC of GSM Architecture**

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 & MS of GSM Architecture**

### **MSC of GSM Architecture**

As shown in Fig. 4.1, MSC is comprised of 4 functional entities:

1 – HLR      2 – VLR      3 - EIR      & 4 – AUC

HLR – It is the data base of information related to permanent mobile subscribers. User & mobile information are 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 – It is the data base of a moving mobile user when he/she enters in the VLR area. VLR works in association with HLR & AUC.

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

**Step 1:** The home VLR identifies the MS belonging to other MSC area.

**Step 2:** The home VLR identifies the HLR of MS & communicates with the same.

**Step 3:** 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.

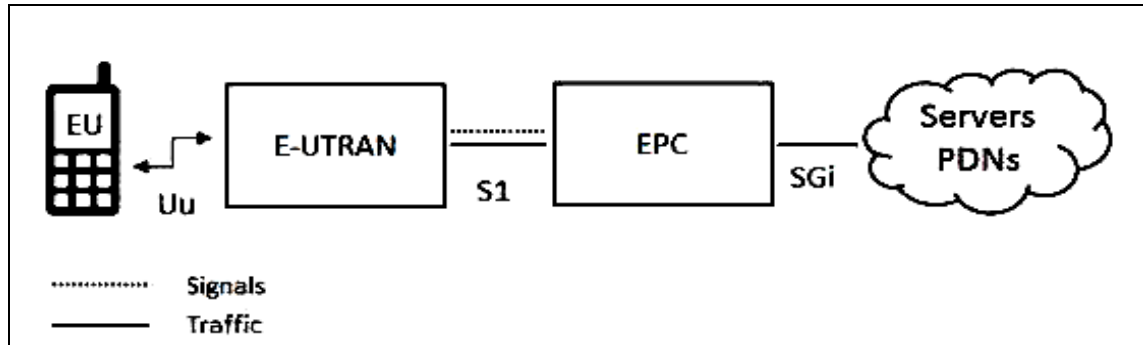
**Step 5:** VLR sends the MSRN [Mobile Subscriber Roaming Number] to home HLR. VLR stores MSRN, TMSI, the home Location of MS, Supplementary services data of MS, MSISDN, IMSI, GT, & Local MS identity.

**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 data base 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**

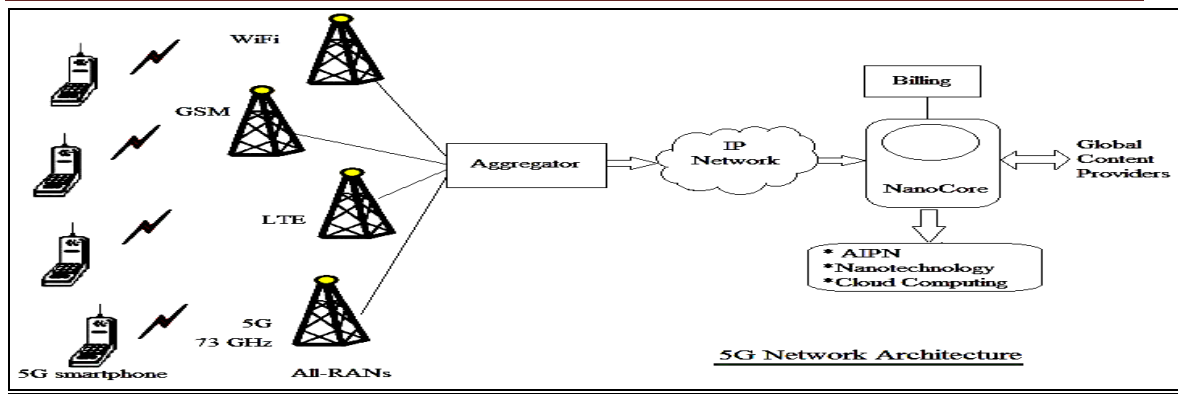
E-UTRAN is nothing but radio access network and is used for wireless radio connection between the mobile phones & antennas from the mobile operator. E-UTRAN block is consisted of three entities:

1. LTE mobile terminals
  2. Radio Interface
  3. eNodeB or eNB
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: Open wireless Architecture of 5G Network**

RANs supported architecture is GSM, GPRS/EDGE, UMTS, LTE, LTE A, Wimax, WiFi, CDMA2000, EV-DO, CDMA -One & IS-95. This architecture reduces number of network elements in data path & hence reduces 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 FEATURE COMPARISON OF VARIOUS MOBILE ARCHITECTURE:**

The Salient Features of 2G, 3G, 4G & 5G mobile architectures are given in TABLE II.

TABLE II

Features of GSM, UMTS, LTE & 5G Architectures

Parameters	GSM	IMT 2000 (UMTS)	IMT-ADVANCED (LTE)	IMT-2020
Generation	2G	3G	4G	5G
Start/Deployment	1990-2004	2004-2012	2012-2019	2020
Technology	Digital Cellular	EVDO/EDGE	WiMAX, LTE, WiFi	WWW
Access Methodology	TDM/FDM	WCDMA	OFDMA/SC-FDMA	CDMA& BDMA/ OFDMA
Maximum Downlink Speed	10 -150 Kbps	384 Kbps	1000 Mbps	10 Gbps
Maximum Uplink Speed	10-100 Kbps	128 Kbps	50 Mbps	1 Gbps
Bandwidth	200 KHz	5 MHz	1.4 to 20 MHz	20 MHz
Types of Modulation Supported	GMSK	QPSK	QPSK, 16 QAM & 64QAM	64 QAM
Type of Core Network	Circuit Switched	Circuit & Packet Switched	Fully IP Based	Flatter IP Network

**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 & 5G mobile system design , development & implementing agency i.e. 3GPP is described in brief.
- \* 3GPP2 is not covered because 3GPP2 is merged with 3GPP for development of 4G & 5G Mobile systems.
- \* GSM architecture for 2G & 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.

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