Development of Architecture of Wireless Communication

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***Abstract*—**Evolution of telephone network was similar to t.v. broadcasting in 1946 with push to talk system. First generation comes with advanced mobile phone system and regulations on bandwidth, frequency, modulation and multiplexing. Second generation, based on global system for mobile communication, became digital from existing analog first generation system, which made possible short messaging services and internet with voice communication.GSM was evolved to general packet radio service by changing circuit switched system to both circuit and packet switched system for voice and data respectively. For live data with voice and multimedia, universal mobile telephone service, wideband code division multiple access were developed as third generation telephone network, by evaluating base station to radio access network and GPRS support nodes. Fourth generation was packed switching based with voice over internet protocol and data in long term evolution. The circuit and packet switched system was evolved into evolved packet core and RAN into evolved node B, in LTE as a main system that was in direction of 4G recommendations of 3GPP was in release 8 to release 11.

***Keywords*—**Advance Mobile Phone System (AMPS); Evolved Packet Core (EPC); General Packet Radio Service (GPRS); Global System of Mobile Communication (GSM); Long Term Evolution (LTE); Public Switched Telephone Network (PSTN); Radio Access Network (RAN); Radio Network Control (RNC); Universal Mobile Telephone Service (UMTS).

***Abbreviations*—**Base Station Controller (BSC); Base Transceiver Station (BTS); Code Division Multiple Access (CDMA); Frequency Division Duplex (FDD); Frequency Division Multiple Access (FDMA); Frequency Modulation (FM); Multiple Input Multiple Output (MIMO); Mobile Subscriber Unit (MSU); Mobile Terminal Switching Office (MTSO); Orthogonal Frequency Division Multiple Access (OFDMA); Suppressed Carrier FDMA (SCFDMA); Third Generation Partnership Project (3GPP); Time Division Multiple Access (TDMA); Time Division Duplex (TDD); Wideband Code Division Multiple Access (WCDMA).

I. INTRODUCTION

WIRELESS network was evolved to connect more subscribers with increasing facilities along with voice conversation, included data for SMS, MMS and internet and enhanced to multimedia and live data connectivity. The study of development from first generation to fourth generation is presented in presented paper. Specifications are being developed by many institutions, in which 3GPP specifications are main consideration. The motivation of this research are (a) to understand development in each generation of wireless communication and (b) to make a concept by which contributions in further generations can be made. The objective of this research are (a) to write a paper that give detailed review of growth of architecture of each generation and (b) to study communication among it's units in each generation. The contributions of this manuscript are (a) represented a detailed review of block diagram and software architecture in each generation since it's early stage and (b) represented a detailed review of burst structure in uplink and downlink.

II. EARLY MOBILE TELEPHONE SYSTEM ARCHITECTURE

Mobile system was developed in 1946 with a single broadcasting station. Subscribers had to be near with base station for better signal with range was up to fifty kilometers. Each subscriber was allocated a particular frequency. Early network was according to figure 1. Base station transmitter was installed on large heights with power 200 watt and same frequency was used for sending and receiving signal by push to talk system in which user have to press 'push button' to 'on' the transmitter of phone to talk and 'off' the button to receive a call. With installation of Improved Mobile Phone System (IMPS) in 1960, the two frequencies were allocated to each subscriber to made a single channel to transmit and receive signal. Channels were 23, ranging 150MHz to 450MHz frequency [1].

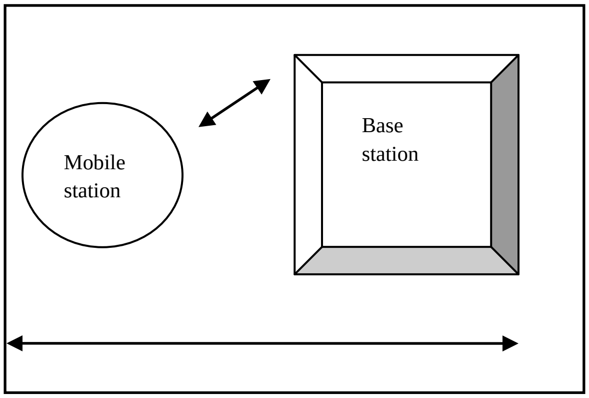

Figure 1: Early Mobile Telephone System, Range 50kms

III. Introduction of Cellular Concept

Instead of one transmitter, transmission area was divided by engineers into different cells with each cell having a transmitter. Each cell was given 1 2 frequencies (channels) [1], so for 100 cells there could be 1200 subscribers. There could be reuse of frequency in every cluster of cells, such as cluster of 7 cells in figure 2. The cell size was made small because for small cells and more distance between cells those use the same frequency, had minimum interference. Cellular structure was hexagonal shown in figure 2.

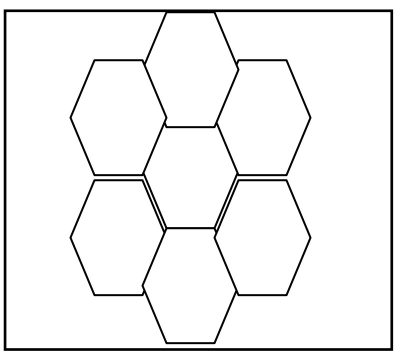

Figure 2: Cellular Concept

IV. First Generation Network

The first generation network was based on advanced mobile phone system developed in 1983(AMPS) by Bell labs. In this system there was a regulation of modulation, frequency, maximum power level, messaging sequences and call processing. The system consists of four main units,

1. Public Switched Telephone Network (PSTN), 2. Mobile Terminal Switching Office (MTSO) 3. Cell site and antenna (Mobile base station), 4. Mobile Subscriber Unit (MSU).

To separate the channels for frequency reuse AMPS used 824MHz to 849MHz of 30kHz wide transmitting channels and 869MHz to 894MHz for receiving 832 simplex channels with same width which made 832 duplex channels with bandwidth 30kHz and frequency division multiplex access or FDMA. Frequency reuse made number of voice channels per cell from 832 to 45. For control 21 channels were reserved and saved into PROM of mobile. This made 32 bit serial number. In next 34 bits 10 bits had 3 digit area code and 24 bits had 7 digit subscriber number. Thus 66 bits packet was transmitted several times with error correcting codes to base station after many collisions which could happen in the access. Base station send packet to it's MTSO, which send packet to it's home MTSO to inform the current location of subscriber. Home MTSO search for idle channel by broadcasting for availability and send back it's channel number to control channel when get it making subscriber phone switched to called subscriber. The average connection time was 15 minutes. The service used 40cm long radio waves with only voice communication [3].First generation network was shown in figure 3.

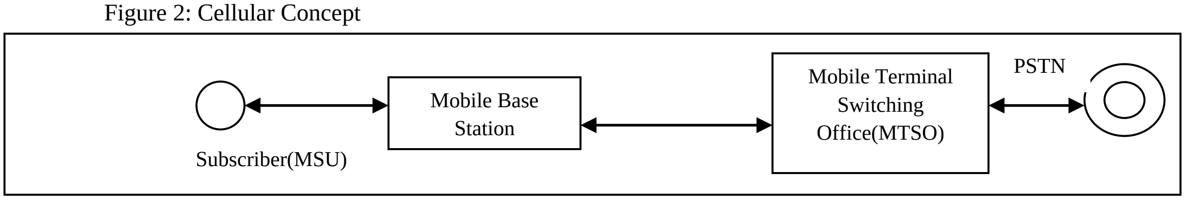

Figure 3: Advanced Mobile Phone System

V. Second Generation Network

There were many systems after AMPS but global system for mobile communications GSM, produced recommendations, instead of restrictions so that different manufacturers could produce different equipments to meet those recommendations, so that equipments could communicate with each other. This made possibility for many type of equipments. The standard for GSM speech coder was residually excited linear predictive coder or RELP containing long term predictor LTP provided 260 bits with 20ms for each speech block giving data rate of 13kbps.First 50 bits were type Ia bits into which 3 parity bits were added for cyclic redundancy check or CRC, next 132 bits were type Ib bits into which 4 zero trailing bits were added and type II 78 bits. Type Ia and Ib block of 189 bits was encoded by ½ convolutional encoder with constrained length K=5 giving a sequence of 378 bits in which type 78 bits added that gave 456 bits in 20ms frame giving 22.8kbps data rate. These 456 bits were coded by full data rate traffic channels (TCH/F9.6) in 60 bits data at 5ms intervals according to modified CCITT V.110 modem standard gave 240 bits were decoded by half rate punctured convolutional coder with constraint length K=5 resulting 488 coded bits minus 32 bits in puncturing then applied to consecutive frames in 114 bits parts by interleaving [2] as in table 1.

Table 1: Diagonal Interleaving for TCH/SACCH/FACCH Data

i+0		i+1		i+2		i+3		i+4		i+5		i+6		i+7	
0a	4b	1a	5b	2a	6b	3a	7b	4a	0b	5a	1b	6a	2b	7a	3b

← 114 bits → ← 114 bits →

184 bits were generated by a generator polynomial.40 parity bits and four trail bits were added to message bits gave 228 bits and when applied to 1/2 rate convolutional coder with K=5 gave 456 bits control channel which was interleaved on eight consecutive frames according to table 1 with 456 traffic channel speech data bits. According to recommendations of GSM, frequency band was 1850-1990MHz,duplex distance was 80 MHz, simplex channel separation was 200 kHz and supported each frequency pair of frequency division multiplex was split into eight time slots for eight subscribers that made a time division multiplex frame or TDM frame. One TDM frame was to transmit, one to receive and 6 to measure signal strength on adjacent base stations including own base station. Such 26 TDM frame made a multiframe. Such 51 multiframes made one superframe and 2048 superframes made one hyperframe on which encryption algorithms were applied for security. To made a call, control channel multiframe of 235.65 ms was used which had broadcast channel bursts or BCH bursts contained broadcast control channel or BCCH, frequency correction channel or FCCH and synchronization channel or SCH, common control channel bursts or CCCH contained paging channel or PCH, random access channel or RACH and access grant channel or AGCH and dedicated control channel bursts or DCCH contained stand alone dedicated control channels or SDDHs, slow associated control channel or SACCH and fast associated control channel or FACCH. From first frame and repeated every 10th frame FCCH burst of table 2 was received on mobile station by broadcasting base station for synchronizing frequency.

Table 2: FCCH Burst

3 start bits	142 fixed bits of all zeros	3 stop bits	8.25 bits guard period

After every FCCH frame, a SCH burst of table 3 was received that identify the serving base station by frame number FN from 0 to 2,715,647 sent with base station identity code or BSIC, timing advancement commands were also issued by base station to mobile station to synchronize received signal on base station with base station clock.

Table 3: SCH Burst

3 start bits	39 bits of encrypted data	64 synchronization bits	39 bits of encrypted data	3 stop bits	8.25 bits guard period

Then BCCH bursts were received from 2nd frame to 5th frame about sending cell and network identity and operating characteristics of cell such as current control channel structure, channel availability and congestion. When subscriber dial a number, mobile station sent a RACH burst, given in table 4 corresponding to received BCH.

Table 4: RACH Burst

8 start bits	41 synchronization bits	36 bits of encrypted data	3 stop bits	68.25 bit extended guard period

Base station then send AGCH burst according to table 5 at last that assign frame to mobile station for SDCCH for 120 ms for PSTN connected to the dialed subscriber to its MSC and which switched it to serving base station with continuing serving base station to send SACCH for information about transmit power level instructions and timing advance information. The mobile station send reverse SACCH to give received signal strength, quality of TCH and received signal strength from adjacent BCHs. And after that SDCCH send information of new frame for TCH assignment and TCH data of table 6 was transferred after encryption by A3, A5 algorithm and 0.3 GMSK modulation in which 1 and 0 were represented by shifting RF carrier by +67.708 and -67.708 kHz at transmitter. Then it demodulated, deinterleaved, channel decoded and speech decoded at receiver of dialed subscriber and SDCCH became vacant.

Table 5: Control Multiframe of 235 msec

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	.	.	49	50
F	S	B	B	B	B	C	C	C	C	F	S	C	C	C	C			C	I

Where, F FCCH,S SCH,B BCCH,C AGCH,I Idle

For voice or TCH data each slot of 576.92 micro second contained 148 bit data frame contains two 57 bit information field for voice and data communication, which was total 114 bits that were interleaved according to table 1, and 26 bits for sync field for synchronization between sender and receiver frame boundaries. Three zero bits were used at each end of frame for delineation. Two flags were at both sides of sync used to show that information field was voice or TCH data. An average 8.25bits guard period was added to each frame. Multiframe was of 120ms, in which 12th frame was for control and 25th frame reserved for future use.

Table 6: Normal Burst

000	Information 57 bits	Voice/ data bits flag	Sync 26 bits	Voice/ data bits	Information 57 bits flag	000	8.25 bit guard period

Hence downlink and uplink structure of GSM was according to table 7 and table 8.

Table 7: Downlink Burst Structure

FN	TS0	TS1	FN	TS2	TS3-6	TS7
0	FCCH	SDCCH0	0	TCH	---	TCH
1	SCH	SDCCH0	1	TCH	---	TCH
2	BCCH1	SDCCH0	2	TCH	---	TCH
3	BCCH2	SDCCH0	3	TCH	---	TCH
4	BCCH3	SDCCH1	4	TCH	---	TCH
5	BCCH4	SDCCH1	5	TCH	---	TCH
6	AGCH/PCH	SDCCH1	6	TCH	---	TCH
7	AGCH/PCH	SDCCH1	7	TCH	---	TCH
8	AGCH/PCH	SDCCH2	8	TCH	---	TCH
9	AGCH/PCH	SDCCH2	9	TCH	---	TCH
10	FCCH	SDCCH2	10	TCH	---	TCH
11	SCH	SDCCH2	11	TCH	---	TCH
12	AGCH/PCH	SDCCH3	12	SACCH	---	SACCH
13	AGCH/PCH	SDCCH3	13	TCH	---	TCH
14	AGCH/PCH	SDCCH3	14	TCH	---	TCH
15	AGCH/PCH	SDCCH3	15	TCH	---	TCH
16	AGCH/PCH	SDCCH4	16	TCH	---	TCH
17	AGCH/PCH	SDCCH4	17	TCH	---	TCH
18	AGCH/PCH	SDCCH4	18	TCH	---	TCH
19	AGCH/PCH	SDCCH4	19	TCH	---	TCH
20	FCCH	SDCCH5	20	TCH	---	TCH
21	SCH	SDCCH5	21	TCH	---	TCH
22	SDCCH	SDCCH5	22	TCH	---	TCH
23	SCH	SDCCH5	23	TCH	---	TCH
24	SDCCH0	SDCCH6	24	TCH	---	TCH
25	SDCCH0	SDCCH6	25	-------	---	-------
26	SDCCH0	SDCCH6	0	TCH	---	TCH
27	SDCCH1	SDCCH6	1	TCH	---	TCH
28	SDCCH1	SDCCH7	2	TCH	---	TCH
29	SDCCH1	SDCCH7	3	TCH	---	TCH
30	FCCH	SDCCH7	4	TCH	---	TCH
31	SCH	SDCCH7	5	TCH	---	TCH
32	CBCH	SDCCH0	6	TCH	---	TCH
33	CBCH	SDCCH0	7	TCH	---	TCH
34	CBCH	SDCCH0	8	TCH	---	TCH
35	CBCH	SDCCH0	9	TCH	---	TCH
36	SDCCH3	SDCCH1	10	TCH	---	TCH
37	SDCCH3	SDCCH1	11	TCH	---	TCH
38	SDCCH3	SDCCH1	12	SACCH	---	SACCH
39	SDCCH3	SDCCH1	13	TCH	---	TCH
40	FCCH	SDCCH2	14	TCH	---	TCH
41	SCH	SDCCH2	15	TCH	---	TCH
42	SACCH0	SDCCH2	16	TCH	---	TCH
43	SACCH0	SDCCH2	17	TCH	---	TCH
44	SACCH0	SDCCH3	18	TCH	---	TCH
45	SACCH0	SDCCH3	19	TCH	---	TCH
46	SACCH1	SDCCH3	20	TCH	---	TCH
47	SACCH1	SDCCH3	21	TCH	---	TCH
48	SACCH1	----------	22	TCH	---	TCH
49	SACCH1	----------	23	TCH	---	TCH
50	------------	-----------	24	TCH	---	TCH
			25	--------	---	--------

Table 8: Uplink Burst Structure

FN	TS0	TS1	FN	TS2	TS3-6	TS7
0	SDCCH3	SACCH1	0	TCH	---	TCH
1	SDCCH3	SACCH1	1	TCH	---	TCH
2	SDCCH3	SACCH1	2	TCH	---	TCH
3	SDCCH3	SACCH1	3	TCH	---	TCH
4	RACH	SACCH2	4	TCH	---	TCH
5	RACH	SACCH2	5	TCH	---	TCH
6	SACCH2	SACCH2	6	TCH	---	TCH
7	SACCH2	SACCH2	7	TCH	---	TCH
8	SACCH2	SACCH3	8	TCH	---	TCH
9	SACCH2	SACCH3	9	TCH	---	TCH
10	RACH	SACCH3	10	TCH	---	TCH
11	RACH	SACCH3	11	TCH	---	TCH
12	RACH	--------	12	SACCH	---	SACCH
13	RACH	-------	13	TCH	---	TCH
14	RACH	--------	14	TCH	---	TCH
15	RACH	SDCCH0	15	TCH	---	TCH
16	RACH	SDCCH0	16	TCH	---	TCH
17	RACH	SDCCH0	17	TCH	---	TCH
18	RACH	SDCCH0	18	TCH	---	TCH
19	RACH	SDCCH1	19	TCH	---	TCH
20	RACH	SDCCH1	20	TCH	---	TCH
21	RACH	SDCCH1	21	TCH	---	TCH
22	RACH	SDCCH1	22	TCH	---	TCH
23	RACH	SDCCH2	23	TCH	---	TCH
24	RACH	SDCCH2	24	TCH	---	TCH
25	RACH	SDCCH2	25	-------	---	-------
26	RACH	SDCCH2	0	TCH	---	TCH
27	RACH	SDCCH3	1	TCH	---	TCH
28	RACH	SDCCH3	2	TCH	---	TCH
29	RACH	SDCCH3	3	TCH	---	TCH
30	RACH	SDCCH3	4	TCH	---	TCH
31	RACH	SDCCH4	5	TCH	---	TCH
32	RACH	SDCCH4	6	TCH	---	TCH
33	RACH	SDCCH4	7	TCH	---	TCH
34	RACH	SDCCH4	8	TCH	---	TCH
35	RACH	SDCCH5	9	TCH	---	TCH
36	RACH	SDCCH5	10	TCH	---	TCH
37	SDCCH0	SDCCH5	11	TCH	---	TCH
38	SDCCH0	SDCCH5	12	SACCH	---	SACCH
39	SDCCH0	SDCCH6	13	TCH	---	TCH
40	SDCCH0	SDCCH6	14	TCH	---	TCH
41	SDCCH1	SDCCH6	15	TCH	---	TCH
42	SDCCH1	SDCCH6	16	TCH	---	TCH
43	SDCCH1	SDCCH7	17	TCH	---	TCH
44	SDCCH1	SDCCH7	18	TCH	---	TCH
45	RACH	SDCCH7	19	TCH	---	TCH
46	RACH	SDCCH7	20	TCH	---	TCH
47	----------	SDCCH0	21	TCH	---	TCH
48	----------	SDCCH0	22	TCH	---	TCH
49	-----------	SDCCH0	23	TCH	---	TCH
50	-----------	SDCCH0	24	TCH	---	TCH
			25	--------	---	--------

Protocol architecture of GSM was given according to table 9 and GSM network was according to figure 4.

Table 9: Protocol Architecture of GSM [5]

2G (Protocols Between)	
MS,BTS	LAPDm,RIL3-RR
MS, BTS,BSC	RIL3-MM,RIL3-CC
Target MSC/VLR	
MS,Anchor MSC/VLR	DTAP
BTS,BSC	LAPD,RSM,BSSAP
BSC,Target MSC/VLR	MTP1,MTP2,MTP3,SCCP
Anchor MSC/VLR,	
HLR,AuC,GMSC	
(sms gateway)	
Target MSC/VLR,	MAP/E,MAP/G
Anchor MSC/VLR,	
Target MSC/VLR,	TCAP
HLR/AuC	
Anchor MSC/VLR,	MAP/D
HLR/AuC	
HLR/AuC,GMSC	MAP/C
GMSC,PSTN/ISDN	TUP,ISUP

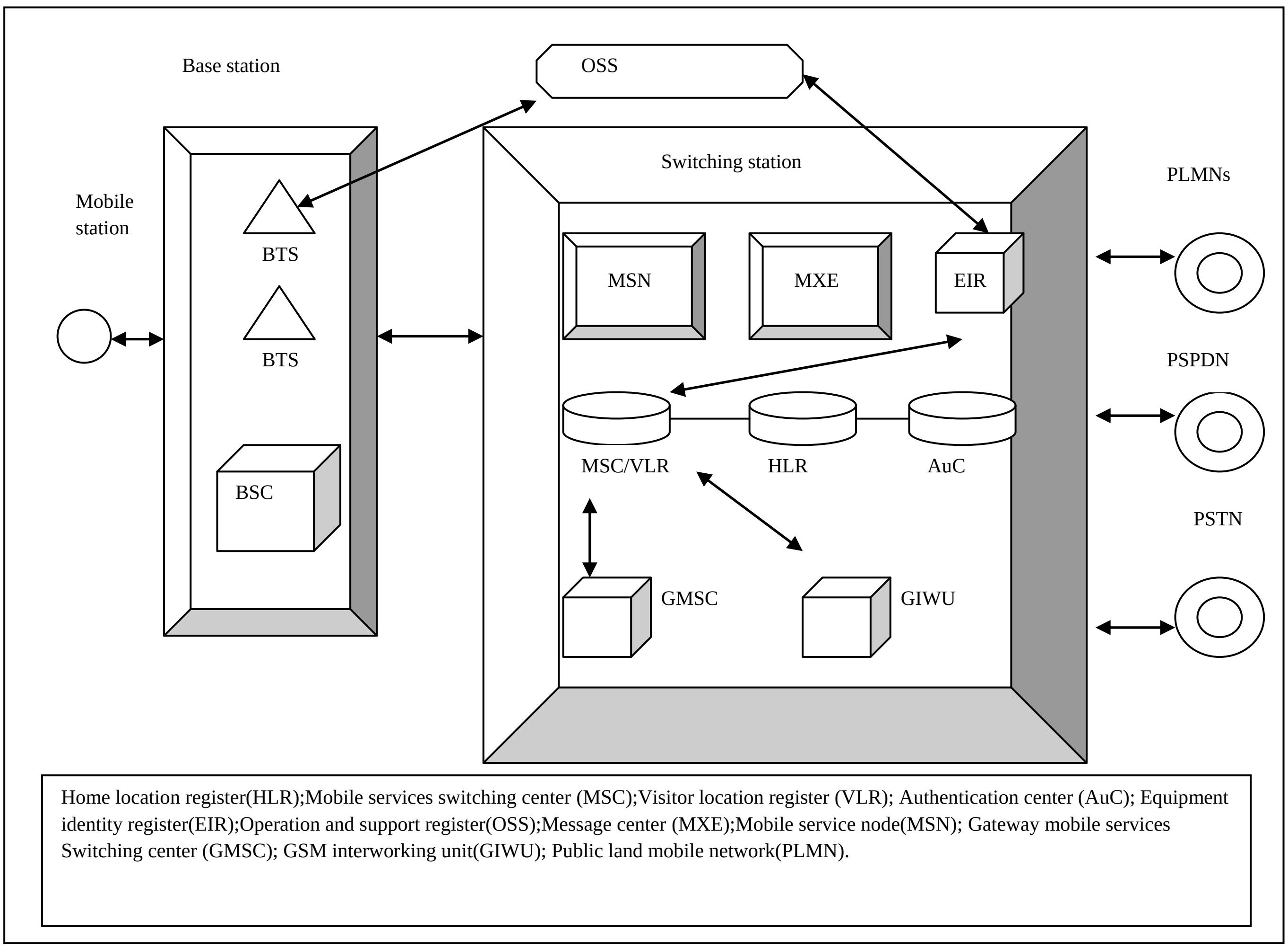

Figure 4: GSM Network

VI. 2.5 GENERATION NETWORK

GSM was circuit switched. For proper connectivity of data applications such as internet, packet switching was also added to GSM and thus there were some improvements in architecture of GSM, this was called general packet radio service or GPRS. This was 2.5 G because it was improvement in GSM. At base station PCU or packet control unit was added. At switching station GPRS support nodes or GSN were added. So that in type A connection, a costly and complex way, voice can be transferred through circuit switched connection and data through packed switched connection simultaneously. For type B, data suspended on continue voice and for type C, both were exclusively could be transferred. The data capacity for GPRS was 200kbps, frequency band 1850-1900 MHz [4], TDMA and supported services were voice, data, internet and MMS. For GPRS which is release 2+ of 3GPP standards, the 235 millisecond control channel multiframe is of 51 TDMA frames, which is given in table 10 below.

Table 10: Frame Mapping for Control Channels for Downlink

1	2	3	4	5	6	7	8	9	10
FCCH	SCH	4*BCCH	4*CCCH	FCCH	SCH	4*CCCH	4*CCCH	FCCH	FCH

11	12	13	14	15	16	17	18	19	20	21
4*CCCH	4*CCCH	FCCH	SCH	4*CCCH	4*CCCH	FCCH	SCH	4*CCCH	4*CCCH	IDLE

And for transmission of radio link control (RLC/MAC) blocks, GPRS sends flexible structures for different channels. There are 4 consecutive blocks in each RLC block of 20ms for packet transfer mode of MS. One TDMA frame is of 576.9 microsecond * 8=4.615 ms. One RLC block is of 4 TDMA frames. And 52-multiframe contain 12 RLC blocks and 4 idle blocks. Hence multiframe duration is 4.615 microsec*4*(12+4)=240 ms. Hence each RLC block is of 240/12=20ms,which is given in table 10 below. 2.5 generation network can be shown in figure 5.

Table 11: GPRS 52-Multiframe Structure, B0-B11 are RLC Blocks

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
B0	B1	B2	I	B3	B4	B5	I	B6	B7	B8	I	B9	B10	B11	I

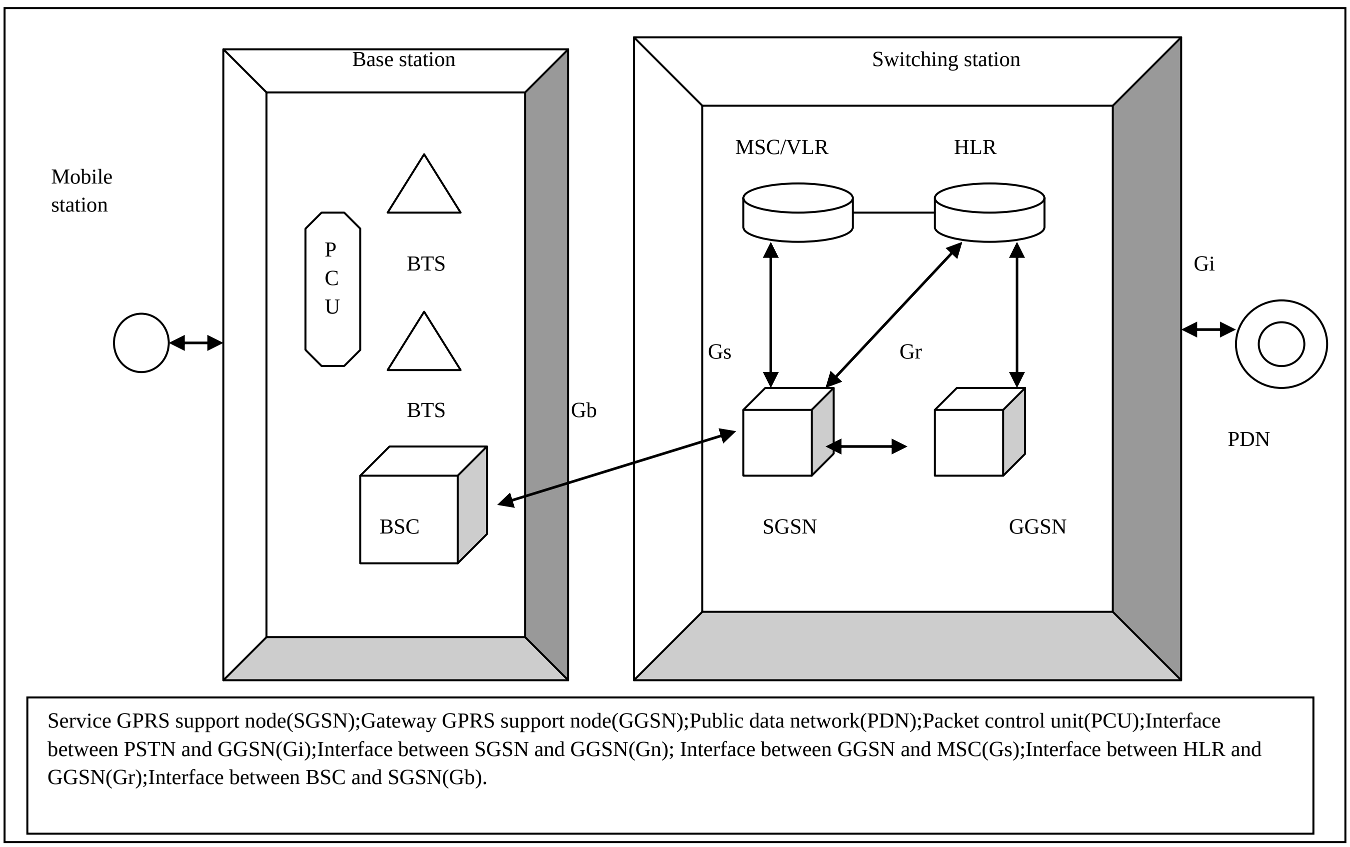

Figure 5: GSM Packet Radio Service (GPRS)

The protocol architecture of 2.5 generation is given in table 12 below.

Table 12: Protocol Architecture of GPRS

2.5G (Protocols Between)	
MS,BTS	GSM RF,MAC,RLC,LLC,
GGSN,SGSN	
MS,GGSN,SGSN	SNDP,IP/X.25GMM/SM,IP
	Applications
BTS,BSC	LLC Relay
BSC,SGSN	PHY,Q.922 CORE
	Network Service,BSSGP
CGF,SGSN,GGSN	PHY,L2,IP,TCP/UDP,GTP
GGSN,SGSN	MTP1,MTP2,MTP3,SCCP
	CAP,MAP

VII. THIRD GENERATION NETWORK

Third generation network was improvement on GPRS for real time data. The second generation CDMA system was improved for higher chip rate 3.84 Mcps which is three times of chip rate 1.2288 Mcps in IS-95.This higher chip rate gave more data rate and hence wider transmission bandwidth of 5MHz and 2GHz frequency band. This was 60 MHz wideband 1920 MHz - 1980 MHz for uplink transmission and 2110MHz - 2170 MHz for downlink transmission. And services were voice, live data, multimedia and global roaming [3].

The uplink frame of length 10 ms is of made of 15 slots with length 2560 chips [5] is given in table 13 below.

Table 13: DPCCH

PILOT	TFCI	FBI	TPC

And downlink frame structure for dedicated physical channel, in which control and data channels time multiplexed was given in table 14.

Table 14: WCDMA Downlink Frame Structure

DATA1	TPC	TFCI	DATA2	PILOT

Protocol architecture of third generation [5] network is given below in table 15.

Table 15: Protocol Architecture of Third Generation

3G(Protocols Between)	
3G-MS,Node B	L1,MAC
3G-MS,RNC	PDCP,RLC/MAC,RRC
3G-MS,3G-SGSN	GMM/SM
Node B,RNC	NBAP,AAL2 Signalling,Q.2130,
Node B,3G-SGSN	SSCOP,
RNC,3G-SGSN	RANAP,SCTP/M3UA,GTP,CIP
	Broadband SS7
	(SSCOP,Q.2140,MTP3B,SCCP)
3G-SGSN,3G-GGSN	MAP,TCAP,MTP2,MTP1
3G-CGF,3G-SGSN,	GTP
3G-GGSN	
3G-HLR/AuC/EIR,	MAP,TCAP,SCCP,MTP3,MTP2
3G-SGSN,3G-GGSN	MTP1
3G-MSC/VLR,	
3G-MSC/VLR,	RANAP,MTP2,MTP1
3G-SGSN	
3G-MSC/VLR,	SCCP,MTP3,MTP2,MTP1
3G-HLR/AuC/EIR,	
3G-MSC/VLR,RNC	AAL2 Signaling
3G-MSC/VLR,	SCCP,Q.2140,SSCOP
3G-GGSN	

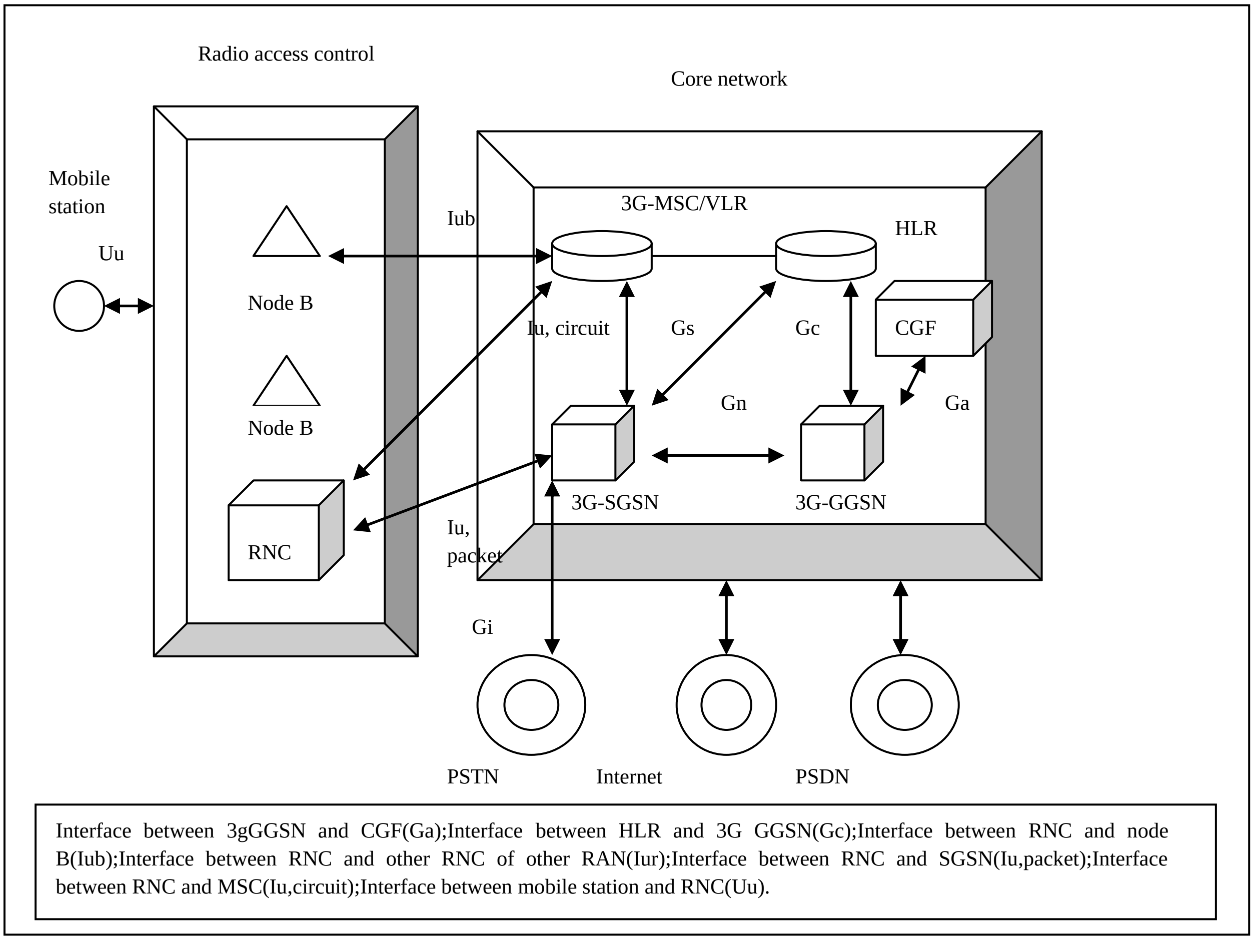

Figure 6: Third Generation Network

The development of software architecture was according to figure 7 [8-15].

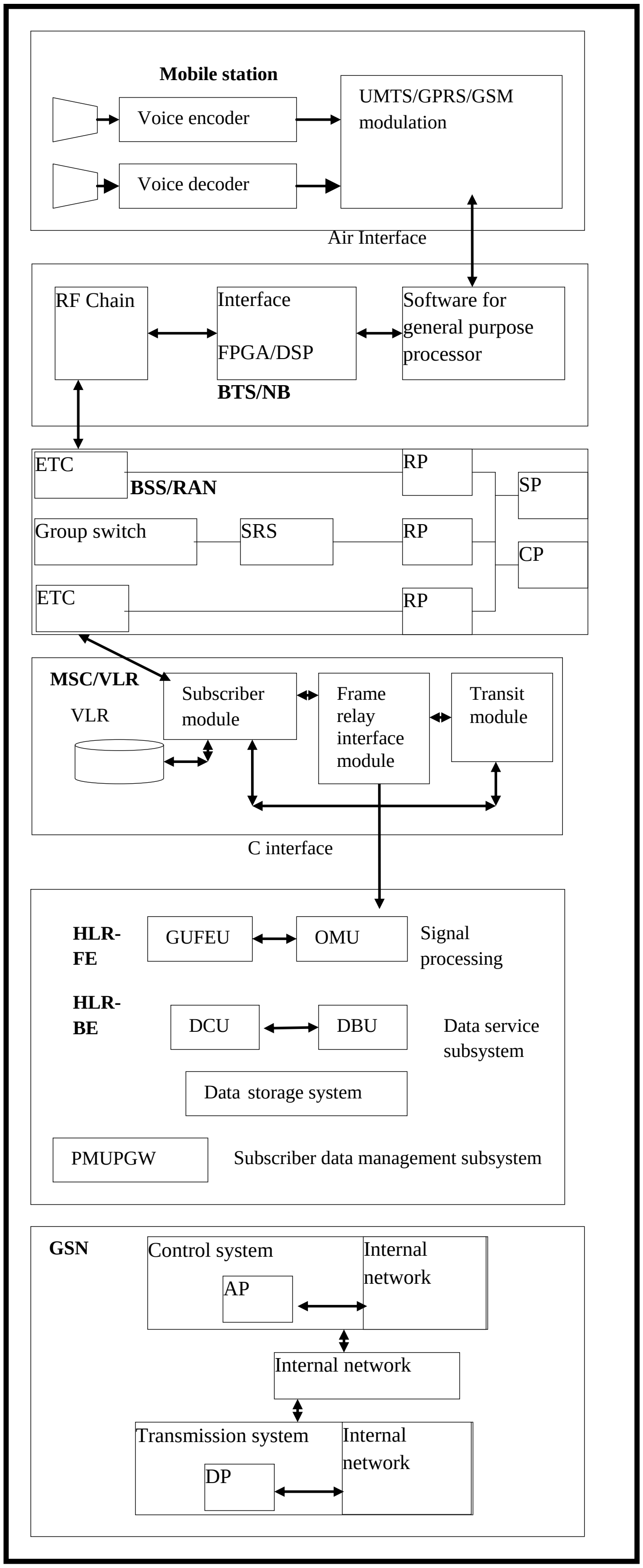

Figure 7: Development of Software Architecture from Second to Third Generation

VIII. FOURTH GENERATION NETWORK

Fourth generation was with transport mechanism packet switching only. Radio access network was developed into evolved UMTS terrestrial access network in which there was only one component evolved node B. And core network evolved into evolved packet core in which packet switched domains were MME, S-GW and P-GW. Voice was through voice over internet telephony or voip. Third generation partnership project decided the downlink rate 1Gbps and uplink rate 500Mbps for fourth generation. Long term evolution technique completed 4G requirements theoretically in version LTE-advanced. There was use of multiple input, multiple output, orthogonal frequency division multiplexing for downlink and suppressed carrier frequency division multiplexing for uplink was used to get the 4G requirements. Further enhancements included carrier aggregation, coordinated multipoint etc in release 11 of 3GPP. The bandwidth was 1.4,3,5,15,20 MHz [3].Typical frequency band for frequency division duplex was 3.4GHz to 3.5 GHz for uplink and 3.5GHz to 3.6GHz for downlink. And for time division duplex mode, it was 3.6GHz to 3.8GHz [8].Fourth generation block diagram is in figure 7 [6]. And protocol architecture is given in table 16 below.

Table 16: 4G Protocol Architecture [8]

4G (Protocols Between)	(For data exchange between mobile and external server)
UE,eNB	PHY,MAC,RLC,PDCP
eNB,S-GW,P-GW	L1,L2,IP,UDP,GTP-U
UE,P-GW	IP
P-GW,Server	L1,L2,IP
UE,Server	UDP/TCP,App

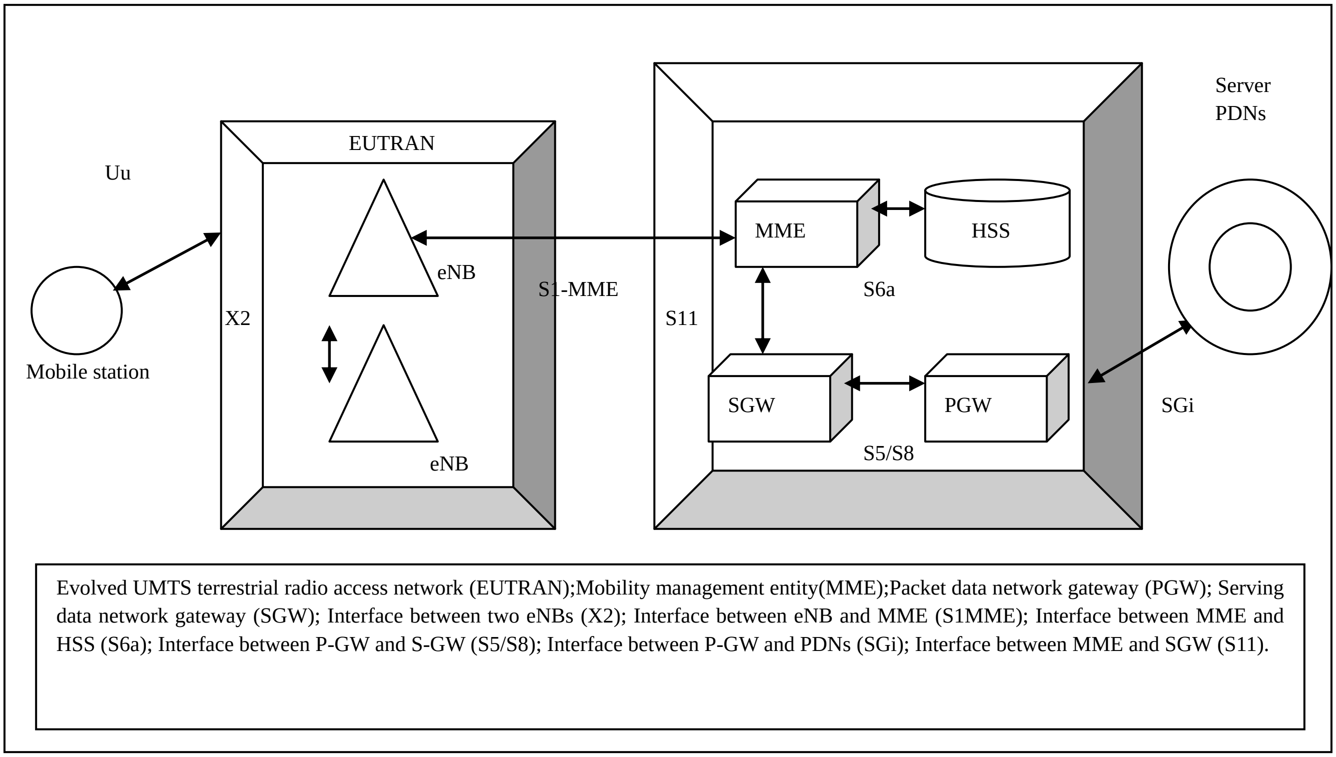

Figure 8: Fourth Generation Network

IX. Fifth Generation Network

Fifth generation network will consist of picometer size cells. Downlink data rate will be 10Gbps. Ultra wideband and intelligent pipe network will provide instantaneous connectivity [7]. Switching time between different radio access technologies will be 10ms.Standards will include IP broadband, local area network, wide area network and real world wireless or worldwide wireless web or wwww. Basic protocol will be IPv6. Services will include dynamic wearable mobile devices. There will be open wireless architecture that will include physical layer and data link layer, and open transport protocol will include session layer and transport layer for control of loss of higher bit rate. There will be upper network layer for mobile terminal and lower network layer interfaces. Data bandwidth will be 1Gbps at low cost [3].

X. Sixth Generation Network

The sixth generation will consist of telecommunication, earth imaging and navigation satellite network integrated with 5G wireless network. The satellite systems that are being developed are GPS by USA, COMPASS by China, Gallio by EU and Glonass by Russia [3]. Due to different standards used in these systems, handoff and roaming is still to be standardized.

XI. Conclusion

The network was developed rapidly after standards were defined in first generation and defining recommendations then restrictions in second generation GSM the development of wireless communication was fast because of possibility of many manufacturers for same standards. In fourth and further generations all communication will be through internet. This conclude that development of wireless system will grow rapidly as much more integration of different technologies will be allowed.

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