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Evolutionary trends in improving radio interfaces on GERAN/UTRAN/E-UTRAN networks

A T Alpeisov¹, B S Malsagov²

¹Satbayev University, 22 Satbaev str., Almaty, Kazakhstan

²Chechen State University named after A.H. Kadyrov, 364015, 17a Dudaev Boulevard, Groznyy, Russian Federation

E-mail: alpeisov73@mail.ru

Abstract. Mobile communications are the modern drivers of the rapid development of information communication technologies. This development is provided by the expansion of the range of user services and an increase in the volume of transmitted traffic. Mobile radio-access technologies, services, standards with different types of radio interfaces are used worldwide nowadays. The article discusses the important features of the functioning of such interfaces, presents data on functional characteristics. This research also shows the main directions of development of radio interfaces intended for use in mobile communication systems.

1. Introduction

Domestic operators and their communication networks presently involve radio access networks conditioned by using mobile communication standards UTRAN– UMTS, GERAN– GSM, LTE E-UTRAN demonstrated in Figure 1 below. The diagram shown in Figure 1 demonstrates the interaction of different generations of mobile communication networks [1, 5].

With the GSM voice traffic symmetry, the frequency duplex method is the basis of the radio access network and increasing system users force leaders in the communication equipment market to use the Circuit Switching (CS) method in switching channels and SS7 protocols responsible for signalling [6, 7] when communication services require background, interactive communication because users need additional asymmetric traffic types [8, 9].

2. Materials and methods

Physical and channel layers differ in Open Systems Interconnection – OSI model by radio interface protocols. This is specifying the communication channel peculiarities.



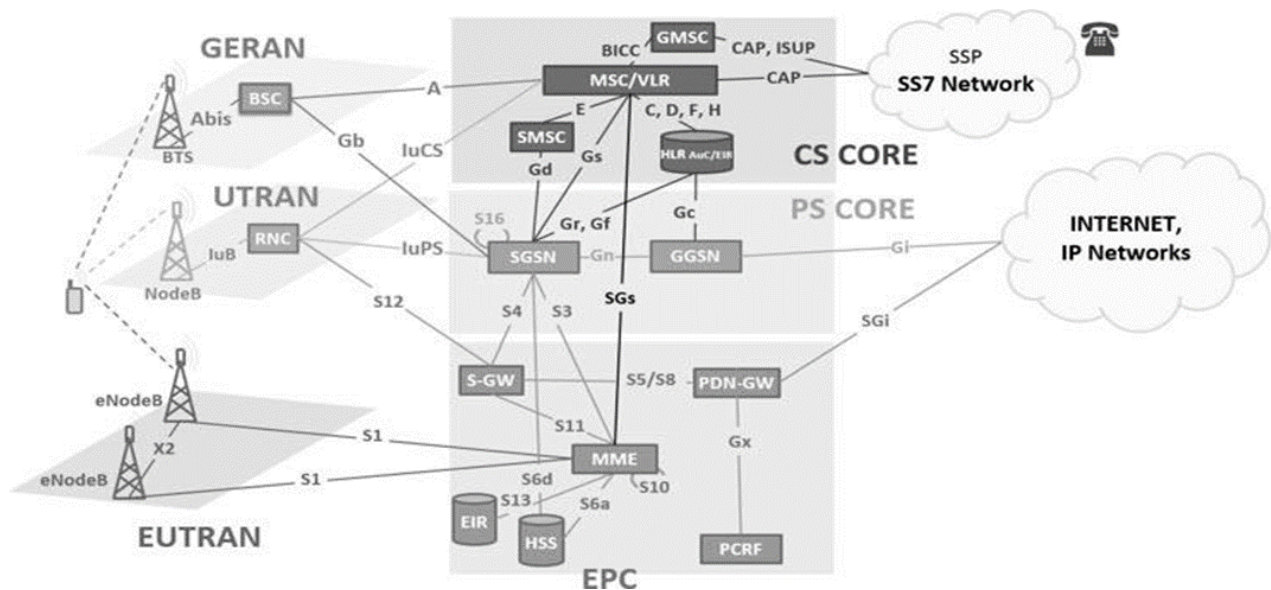


Figure 1. Modern mobile network diagram.

Improving the radio channel characteristics upgrades certain technologies, varying the modulation types and converting analogue (primary) into digital information, when encoders and vocoders are used.

Significant peculiarities exist in GSM with application of a narrowband signal with MSK modulation, cascade error-correcting coding. The 200 kHz bandwidth is an ordinary mode for MSK modulation [3].

The throughput and information transfer rates, using the General Packet Radio Service (GPRS) technology, accelerated up to 171 kbps thanks to telecom operators with modernized components and devices of cellular networks by GPRS technology. Subscribers browse small web-pages (small information volume) at the high speed small files exchange quickly in the mobile network with a several-second delay in sending requests to the chosen web-site and data receiving. As result this reducing delays in transmission of data [15-18].

The GSM Evolution technology Enhanced Data rates belong to the new generation of more advanced mobile communication technologies in the manufacturing line, when its use increased data transfer rate 2 times as compared to the GPRS rate up to 384 Kbps [2]. The new signal modulation method (8-PSK) for the radio interface made system radio resources more effective and attractive. However it decreasing transmitted signals sensitivity. Also it decreasing immunity of noise where the information transfer rate depends on the communication channel quality [19-23].

The EDGE technology improved cheaply the services quality provided, decreasing the latency and speed increasing. This is being decisive for 94% of GERAN networks mobile operators. The listed protocols could be used in a various applications, including indoor positioning [24-25] and industrial IoT applications [26-29].

3. Results and Discussion

3.1. The radio access network UTRAN is a Universal Mobile Telecommunications System network.

It belongs to third generation communications networks developed to change GSM standart networks. Network UTRAN is part of UMTS being a worldwide popular network access domain. UTRAN has appropriate software and hardware.

The third-generation networks differ by the signal bandwidth expansion, complex modulation application, code division multiplexing multiple access (CDMA). In addition, third-generation networks have a higher data transfer rate.

UTRAN has a high power sensitivity of the received signals. UTRAN requires adaptive control of radio-signal emission power in the radio access network. But frequency redundancy increases the UMTS spectral efficiency resulted in multipath propagation resistance and noise immunity.

Table 1. Rates of Information transfer.

Standard	Technology	Modulation	Transmission speed	Strip signal, MHz
Gsm	GPRS	GMSK	20/20 kbps	0.2
	EDGE	8PSK	592/592 kbps	0.2
UMTS	R99	QPSK	384/384 kbps	5
	WCDMA			
	HSDPA	16QAMQPSK	14.4/5.76 Mbps	5
	HSPA +	64QAM16QAM	21/11.5 Mbps	5
	DC HSPA +	64QAM16QAM	42/23 Mbps	10
LTE	MIMO 2x2	64QAM	150/75 Mbps	10

The data transfer rate has been increased and information transfer delays have also been minimized. This is done through the following things:

- UMTS radio technologies using complex 16 QAM and 64 QAM modulation options
- changing GSM to UMTS
- bandwidth increase from 0.2 to 10 MHz
- increase in channel capacity.

In Table 1 shows a comparative description of mobile communication standards [2] and technologies that reduce the cost of Internet traffic [1, 6–8].

3.2. The E-UTRAN radio access network (Long Term Evolution - LTE) is a fourth generation network.

This network develops data transmission technology by providing access via IP protocol (4G standard). Data transmission between the mobile terminal - UE and the base station - BS is carried out due to the algorithms of this 4G standard. Data transmission between the mobile terminal and the base station is carried out in frequency (FDD) and time (TDD) options. This is done when 15 paired frequency bands (from 0.8 to 3.5 GHz) are defined for FDD and 8 for TDD with a radio channel width reaching 1.4/3/5/10/15/20 MHz [3].

Single carrier frequency division multiple access - SC-FDMA in the uplink and orthogonal frequency division multiple access - OFDMA in the downlink are applied in the UMTS radio network of the terrestrial radio access network (E-UTRAN). The spectrum of this network has several subcarriers orthogonal to each other, varying within 72, 180, 300, 600, 900 or 1200, using channels with different bandwidths and modulation types QPSK, 16QAM, 64QAM [1].

Subscribers can be assigned different subcarriers by the base station, where categories of mobile terminals UE are defined according to 3GPP TS 36.306 [4], but specific categories have particular maximum transmission rates in downstream and upstream channels, whose values and modulation types for Multiple Input Multiple Output (MIMO) are in Table 2, allowing calculating a maximum transmission speed for various categories of subscribers in the Downlink of 10, 50, 100, 150, 300 Mbps, and 3Gbps and in the Uplink of 5, 25, 50, 75, 100 Mbps and 1.5 Gbps [2].

The 20 MHz channel support all categories of mobile terminals used in the E-UTRAN network excluding very low-power devices using category 0. The MIMO transmission technology of the fourth generation networks increases spectral efficiency and data transmission speed, when channel widths contribute to supporting all categories of mobile terminals in the E-UTRAN network and four pairs of BS and UE antennas anticipates the maximum supported 4x4 MIMO scheme in LTE. The transmission rate, excluding pilot signals, can increase 4 times and 20 MHz frequency band signals, MIMO technology provide data exchange rates of up to 300 Mbps in Downlink and 170 Mbps in Uplink [2].

Using the OFDMA technology in E-UTRAN networks suppresses negative effects from multipath propagation. Large harmonic distortions of an operating amplifier in a mobile terminal result in a high crest factor, increasing the UE power consumption and decreasing its operation resource without battery recharging, whereas the upstream channel employs the SC-FDMA multiple access technology differing from OFDMA technology by the fast Fourier transform method reducing PAPR.

Table 2. Radio resources distribution in E-UTRAN networks with subscriber terminals (UE) of different categories in DL and UL modes.

UE Category	Downlink			Uplink	
	Maximum of bits in TTI	Maximum of bits in the transport block	MIMO	Support 64QAM	Maximum of bits in the transport block
0	1000	1000	-	-	1000
1	10296	10296	-	-	5160
2	51024	51024	2x2	-	25456
3	102048	75376	2x2	-	51024
4	150752	75376	2x2	-	51024
5			2x2		
	299552	149776	4x4	+	75376
6		149776 (4x4)	2x2		102048
	301504	75376 (2x2)	4x4	-	
7		149776 (4x4)	2x2		
	301504	75376 (2x2)	4x4	-	102048
8	2998560	299856	8x8	+	1497760

9		149776 (4x4)	2x2	-	51024
	452256	75376 (2x2)	4x4		
10	452256	149776 (4x4)		-	102048
		75376 (2x2)	2x2		

Table 2 Continuation.

UE Category	Downlink		MIMO	Uplink	
	Maximum of bits in TTI	Maximum of bits in the transport block		Support 64QAM	Maximum of bits in the transport block
11	603008	149776		-	51024
		(4x4.64QAM),	4x4		
12	603008	149776			
		(4x4.64QAM),			
		95816 (4x4,	2x2		
		256QAM)			
		75376 (2x2,		-	102048
		64QAM),			
		97896 (2x2,			
		256QAM)	4x4		
13	391632	195816 (4x4)	2x2	+	150752
		97896 (2x2)	4x4		
14	3916560	97896	2x2	+	1497760
		(2x2.256QAM)	4x4		
15	749856–	149776	2x2	n/a	n/a
	798800	(4x4.64QAM),	4x4		
		95816 (4x4,			
		256QAM)			
		75376 (2x2,			
		64QAM),			
		97896			
		(2x2.256QAM)			
16	978960–	149776	2x2	n/a	n/a
	1051360	(4x4.64QAM),	4x4		
		95816 (4x4,			
		256QAM			
		97896 (2x2,			
		256QAM)			

The requirements for E-UTRAN [4] spectral efficiency parameters are 5 bit/s/Hz for the Downlink channel and 2.5 bit/s /Hz for the Uplink channel providing service for subscriber terminals moving at 300 km/h, whereas the LTE Advanced (LTE-A) technology networks enhance LTE networks differing by frequency aggregation.

The data transmission speed increases with simultaneous use of separate frequency bands (frequency aggregation) where the subscriber terminal receives and combines up to 5 carriers 20 MHz wide each, forming a wide channel with a 100 MHz bandwidth.

4. Conclusion

The MIMO technology increases the data transmission speed and efficiency, available antennas and multi-stream information transmission improving mobile communication technologies along with modernized generations of radio access networks. New technological capabilities characterize every subsequent generation by expanding the transmitted information speed and volume, the range of services etc.

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