**MINISTRY OF DEVELOPMENT OF INFORMATION TECHNOLOGIES AND COMMUNICATIONS OF THE REPUBLIC OF UZBEKISTAN**

**TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES**

To allow to protection
Head of TI chair,
Ph.D., docent Eshmuradov A.M.

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# FINAL QUALIFICATION WORK

On a subject : CALCULATION OF THE CHANNEL THROUGHPUT DEPENDING ON LOADING IN SECTOR IN NETWORKS 4G/LTE


Graduate _____ Karimov Sh.Sh.

Head _____ Sadchikova S. A.

Reviewer _____

Consultant _____ Qodirov F.M.
on Safety engineering and Ecology


**Tashkent 2015**

**MINISTRY OF DEVELOPMENT OF INFORMATION TECHNOLOGIES AND COMMUNICATIONS OF THE REPUBLIC OF UZBEKISTAN**
**TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES**

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**TASK**

For final qualification work of the student

Karimov Shoxruxjon Shuxratovich
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1. Architecture of a package network 4G/LTE
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3. Calculation of the channel throughput depending on loading sector in networks 4G/LTE
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| Section 1-4<br><br>Section 5 | Sadchikova S.A.<br><br>Qodirov F.M. | | |

8. Schedule of performance of work

| № | Name of the section | Performance term | Signature of the head (consultant) |
|---|---|---|---|
| 1. | Architecture of a package network 4G/LTE | 25.01.2015 | |
| 2. | Main protocols of media gateways | 20.03.2015 | |
| 3. | Calculation of the channel throughput depending on loading sector in networks 4G/LTE | 15.04.2015 | |
| 4. | Safety engeneering and ecology | 25.05.2015 | |

Graduate _____ "____" _____ 20 ___.

Head _____ "____" _____ 20 ___.

In this final qualification work architecture of a package network 4G/LTE, main protocols of media gateways such as WiMAX 802.16e, LTE, coding of a sound signal. Capacity of connection depending on loading in sector in networks 4G LTE is calculated.

Matters of safety issues and ecology are also considered.

Ушбу битирув малакавий ишида 4G/LTE тармоқларидаги пакетли архитетураси , медиашлюзларнинг асосий протоколлари WiMAX 802.16e, LTE, овозли сигнални кодлаштириш кўриб чиқилган. 4G/LTE тармоқларидаги каналнинг ўтказиш кобилияти уланишда секторга тушаётган юкламани хисоблаш кетма-кетликлари келтириб ўтилган .

БМИда ҳаёт фаолияти хавфсизлиги ва экология масалалари кўриб чиқилган.

В данной выпускной квалификационной работе рассмотрены вопросы архитектура пакетной сети 4G /LTE, основные протоколы медиашлюзов WiMAX 802.16e, LTE, кодирование звукового сигнала. Произведён расчёт пропускной способности соединения в зависимости от нагрузки в секторе в сетях 4G LTE.

В работе также рассмотрены вопросы безопасности жизнедеятельности.

## CONTENTS

# INTRODUCTION

In the report of the President of the Republic of Uzbekistan devoted to results of social and economic development of the country in 2014 and to the most important priorities of the economic program for 2015 it is noted that the tasks of acceptance of the necessary measures aimed at providing in 2015 steadily high rates of economic development, growth and improvement of investment process, input in a system of the major hi-tech and modern objects and capacities in the industries, and also formation in the country of the full-fledged competitive environment which is a key factor of technical and technological updating and modernization of production, an entry into the world markets are set for heads of the ministries, departments, economic associations and local executive authorities. At all this the head of state declared the following "New modern productions on release of the telecommunication equipment, the computer equipment and a cellular telephony, the wide range of consumer electronics are created. Are modernized, as a matter of fact, anew practically all branches of our economy technologically are updated. Extremely important significance in the expired year was attached to widespread introduction of information and communication technologies in all spheres of economy and in our everyday life. In the center of our attention there was an implementation of such large investment projects as "Modernization and expansion of the long-distance centers of switching for technology of networks of new generation (NGN)", "Development of optical networks of broadband access in the FTTx technology", "Development of the mobile CDMA-450 network with introduction of the EVDO technology in regions of the Republic of Uzbekistan" and others. Their successful completion will allow us to be among the countries of the world with a high level of development of modern means of communication and information, to expand one more corridor of business communications. Transition to digital television by installation of 5 digital television transmitters in the Dzhizak, Tashkent, Fergana and Khorezm

areas with ensuring coverage with digital telecasting more than 45 percent of the population of the republic is step by step carried out. Consistently, on a system basis electronic forms and systems of data transmission, statistical, financial and tax statements take root into our life. Already today in an electronic format over 89 percent of subjects of business, and the statistical reporting – about 86 percent hand over the tax reporting. The system of government procurements at the exchange through the electronic auction deserves all attention and support introduced in 2011 modern, providing the high competition and fairness of bidders. In 2014 the volume of the government procurements made at the electronic auction made 417 billion sum, the economy of budgetary funds reached following the results of the auction made 83 billion sum" . The system of payment of goods and services through the Internet and mobile phones with use of the bank account and amount-based plastic cards without additional commission charges for the population is introduced. However all this is only initial steps in system of large-scale measures for introduction of modern information and communication technologies which should be carried out in the next years". Having approved UMTS, the project 3GPP continued to work successfully in the direction of further development of the networks, namely, in creation of networks of the fourth generation. Networks 4G provide data transmission with a speed to 1gbit/s. It is focused on further evolution of already existing technologies. So there was a project 3GPP LTE (Long Term Evolution) which initiators were leading telecommunication companies Alcatel-Lucent, Ericsson, France Telecom/Orange, Motorola, Nokia, Nokia Siemens Networks, Nortel, T-Mobile and Vodafone which in a consequence the Asian companies China Mobile, Huawei, LG Electronics, NTT DoCoMo, Samsung joined. A main objective of this association is support of development of high-performance networks of mobile communication of the next generation, technologies of broadband access, introduction of advanced technologies 3GPP LTE. Within 3GPP the main characteristics to which future standard has to answer were defined: improvement of efficiency of a network and the provided services, increase of speed of exchange of information, integration of

technology into other standards of communication, reduction of energy consumption and cost of the user terminals. As a rule, refer technologies which allow to transfer data in cellular networks with a speed over 100 Mbps to family 4G. In broad understanding 4G — it also technologies of wireless transfer of Internet and data of Wi-Fi (high-speed versions of this standard) and WiMAX (in the theory speed can exceed 1 Gbit / c). In the most widespread now in the world the standard of cellular communication of GSM/EDGE (2G) the limit of speed of data transmission makes all 240kbit/page. In the networks of the third generation (3G) developed in Europe, the USA and some countries of Asia (Japan, Taiwan, Singapore), speed makes to 7-14 Mbps. The main difference of networks of the fourth generation from previous, the third, is that the technology 4G is completely based on protocols of a packet transmission of data while 3G unites transfer of both a voice traffic, and packages of data. MSE defined 4G as technology of a wireless communication which allows to reach data transmission speed to 1 Gbit / with in traffic conditions of a source or the receiver and to 100 Mbps in terms of the exchange data between two mobile devices. Transfer of data in 4G is carried out under the IPv6 protocol (version 6 IP). It considerably facilitates work of networks, especially if they various types. Founders of the send-receive equipment for 4G applied the reception experienced in a digital broadcasting — technology of multiplexing with orthogonal division of frequencies - OFDM. Such technique allows "to condense" considerably data without mutual hindrances and distortions. Thus there is a splitting on frequencies to orthogonality observance: the maximum of each bearing wave is necessary at that time when next have zero value. It excludes their interaction, and also the frequency range is more effectively used — protective "ant interferential" strips aren't necessary. Modulation is applied to a signal transmission with shift of a phase (PSK and its version), or quadrature and amplitude modulation (QAM), more modern and allowing to squeeze out a maximum of channel capacity. The concrete type gets out depending on the demanded speed and conditions of reception. The signal breaks into a certain quantity of parallel streams by transfer and gathers at reception. This final

qualification work is devoted for calculation of capacity of the channel depending on loadings in sector in networks 4G/LTE.

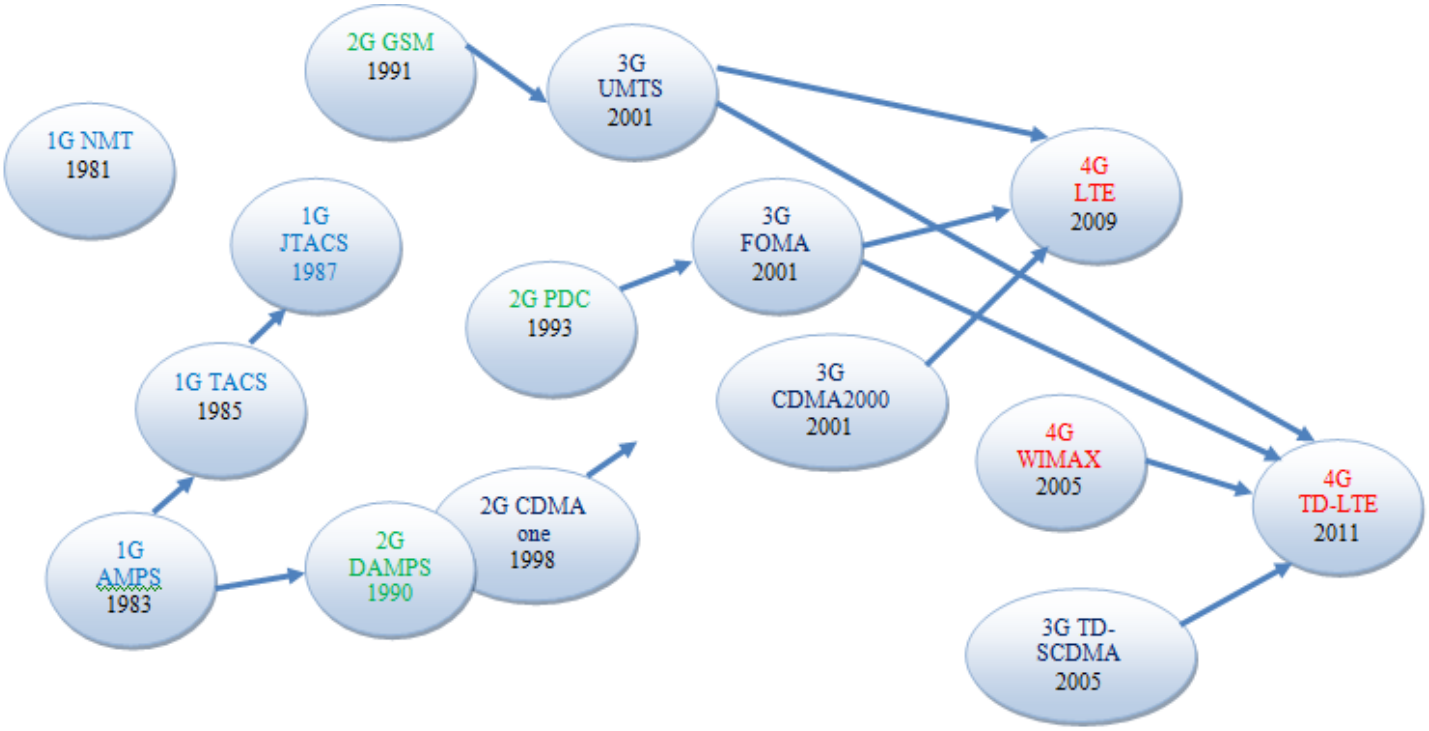
# 1. ARCHITECTURE OF THE PACKAGE NETWORK 4G/LTE

## 1.1. History of development 4G

Many countries of the world actively operate networks 3G, and in many networks the technology which received designation 3,5G is already applied. In commercial operation already more than 1000 corresponding networks. According to analysts of the telecommunication industry, a number of the countries where recently came to need to introduce networks 3G, will prefer "to jump" on generation forward now, having begun partial operation 4G. In 2005 Japanese NTT DoCoMo reported about progress in work on the new standard of a wireless communication — successful experiments on data transmission at a speed of 100 Mbps on wireless channels of a network 4G were made. In the second half of 2006 large national and international operators began official cooperation for development of the standard 4G. The Next Generation Mobile Network Cooperation working group (NGMNC) gathered GSM-and CDMA operators from around the world to define their requirements to mobile networks 4G. The main members of group of Sprint Nextel, T-Mobile, Vodafone, KPN and Orange steel, NTT DoCoMo and China Mobile joined them. One of technological tasks of group is preparation of smooth transition on 4G from all 3G-technologies including UMTS and EV-DO.

## 1.2. Geography 4G Area of introduction of technology

In China as it often happens recently, adhered to other views of development of technologies. On January 28, 2008 after several months of tests the first-ever network of mobile communications of the fourth generation was officially brought into operation here — it started functioning in the Shanghai area Changning.




FDMA – Frequency Division Multiple Access
TDMA- Time Division Multiple Access
CDMA – Code Division Multiple Access
OFDM – Orthogonal Frequency Division Multiplexing

Fig 1.1 History of development 4G/LTE

The system provided the speed of wireless data transmission in 100 Mbps that is comparable to the speed which fiber-optical technologies allow to reach. It is necessary to notice that the research project on transition from 3G to 4G was started by China in 2001. Start of the operating system cost $19,2 million. Widespread introduction 4G in China happened during the Olympic Games of 2008 in Beijing.In Europe also actively joined in development of networks of mobile communication of the fourth generation. Here it was from the very beginning focused on the LTE technology though the WiMAX networks also took root. The large European operators T-Mobile International, TeliaSonera, Orange and Vodafone Group, and also producers of the mobile equipment Alcatel-Lucent, Nokia Siemens Networks, Nortel Networks and Ericsson actively participated in the project of development of LTE. Test start of LTE system was begun in May 2007goda, and the first LTE networks were brought by the Swedish-Finnish operator TeliaSonera in December, 2009 into commercial operation. In the cities of Stockholm (Sweden) and Oslo (Norway) on the basis of the equipment Ericsson. This date is considered the beginning of an era of LTE systems. In the USA the Nextel mobile operator made the interesting decision: to refuse networks 3G in favor of system 4G of the Flarion company. According to plans of Nextel, check of viability of networks 4G had to capture 150 base stations in the largest cities of the South of America, further expanding testing area. The Verizon Wireless company develops the LTE network in the range 700mgts. Having begun with test zones in the cities of Boston and Seattle, the company by 2013 practically covered all territory of the USA. The CIS country didn't lag behind in this plan also. In Russia, for example, in April, 2011 expansion of test zones of the LTE networks in four regions of the country was begun. The WiMAX networks functions here since 2007, and the largest operator – the Yota company develops parallel to the LTE and WiMAX network. In Ukraine in the IV quarter 2007 at once four companies declared the beginning of rendering of services of communication of the fourth generation in several large cities of the country on the basis of the WiMAX

technology. Introduction of the LTE networks in Ukraine was begun since 2011. Expansion of the LTE networks is actively conducted also in Armenia, Kazakhstan, Azerbaijan and Belarus.

### 1.3. Problems on the way of development 4G

Experts note that on the way of introduction to operation of networks 4G there is a number of obstacles. First, in the market will not enough subscriber devices. Such phones would consume too much energy and can't work still long at accumulators (now similar problems are and at 3G-devices). Secondly, high-speed Internet access and video services will demand big by the size and better displays, than what are established in phones now. But the main problem nevertheless has essentially other character. The matter is that capital investments in expansion of networks of the fourth generation have to be much more solid, than in 2G and even in 3G. Meanwhile, investors including venture while are very cautious — they aren't sure of due economic return from 4G-projects. Besides, some producers suggest "to cross" 4G and wireless broadband networks. In different situations the user will have opportunity to choose the most suitable ways of connection.

### 1.4. The new services provided in networks for 4G

New opportunities in transfer of huge volumes of data which are provided by technologies of group 4G, already now set suppliers of mobile content thinking on expansion of the business. If today the main goods in this market are melodies and unpretentious games, emergence 4G will make much more actual mobile television, video-on-demand (VOD — "videos on demand"), the "advanced" games, etc. Besides, thanks to 4G will become possible mobile videoconferences (video chats) and mobile peer-to-peer-networks. Analysts believe that potentially services of mobile TV can make much bigger profit, than games and music for cellular devices. The size of the market of mobile games makes about 1,6 billion

euros now, and 50% from this sum are the share of South Korea and Japan. In 2011 this market was estimated at 2 billion euros. The reason of so insignificant growth experts of Screen Digest call aspiration of mobile network operators to be focused on musical and television mobile services, but not at the games. In the market of musical mobile content within the next five years, on the contrary, explosive growth will be observed. The market size in comparison with indicators of 2006 will increase by 8 times and will make 1,47 billion euros. Availability of subscription services which offer users not only audio tracks, but also accompanying (including multimedia) materials will become one of major factors of growth. Though the majority of musical compositions cellular subscribers will be, as well as today, to load on mobile phones from personal computers.

## 1.5. Architecture of a network of the LTE standard

Considering architecture of the LTE networks, it should be noted that the LTE standards define, first of all, the principles of the organization of the radio interface and a network of a radio access which currently allow to provide data transmission with the speeds conforming to requirements to standards 4G (within the LTE-Advanced standard).

It is accepted to call architecture of the basic LTE network evolution of system architecture of SAE or the developed package basic EPC network (Evolved Packet Core). The SAE network represents evolutionary development of the domain of the GSM/UMTS networks also uses some of its elements.

It is accepted to call a network of a radio access of LTE the developed UTRAN network (evolved UTRAN, eUTRAN). The combination of the eUTRAN and EPC networks, i.e. the full-fledged network of mobile radiotelephone communication including both a radio access network, and a kernel carries designation of the developed package EPS system (Evolved Packet System).

The architecture of SAE is presented in figure 1.2. The architecture of the eUTRAN network is presented in figure 1.3.

The architecture of SAE presented in fig. 1.2 and fig. 1.3 uses some elements, characteristic for architecture of the GSM/UMTS networks, but also includes the following new elements:

• UE (User Equipment) – subscriber (radio) station;

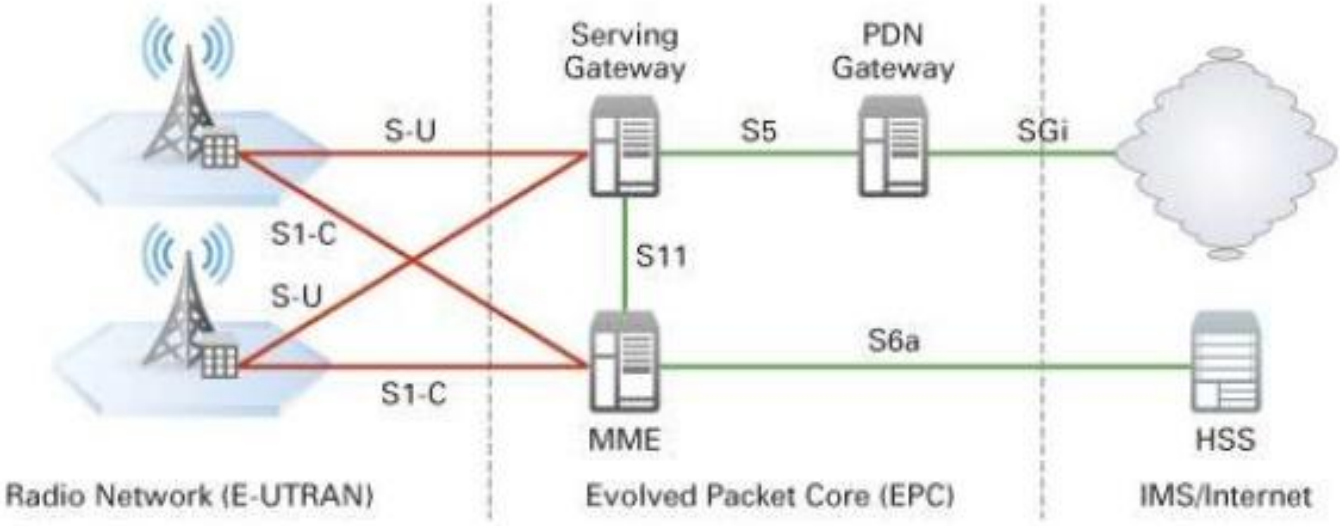



Fig. 1.2. Architecture of SAE

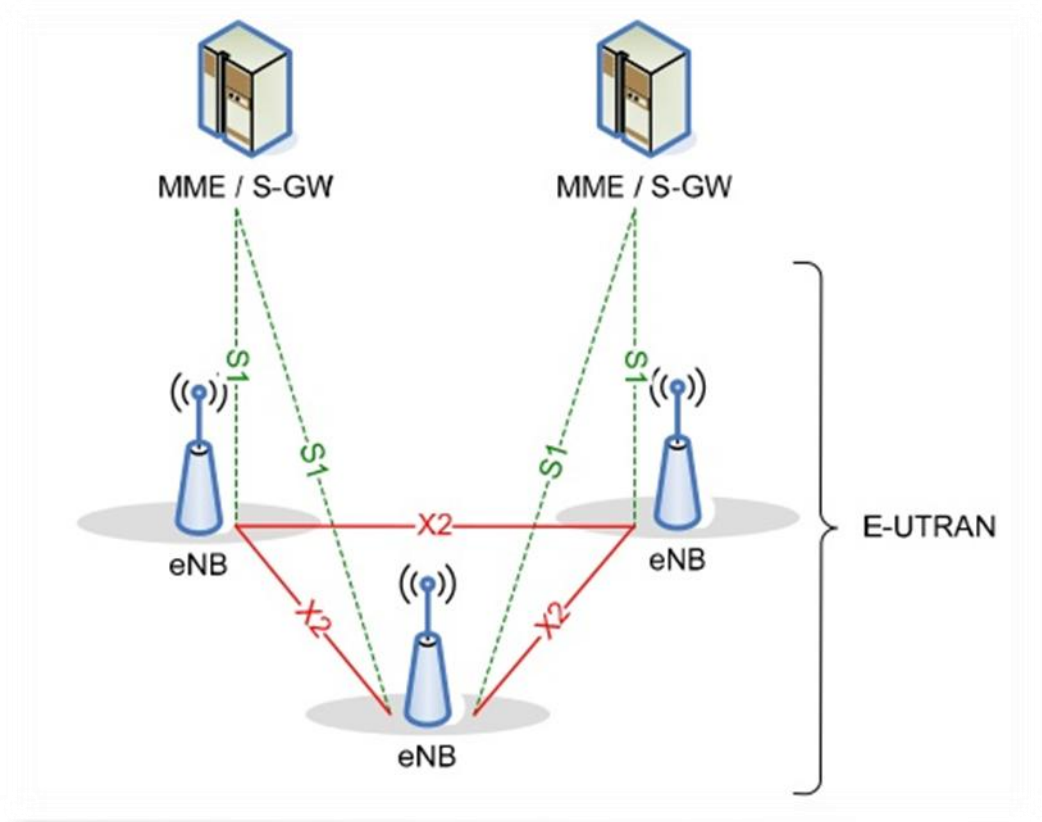



Fig. 1.3 – Architecture of eUTRAN

• the network of a radio access of eUTRAN consists of the interacting base stations of the LTE standard – eNodeB (E-UTRAN NodeB, eNB) and is a peer network;

• the basic EPS network – EPC represents the network which is completely functioning on the basis of switching of packages. Thus, apparently from figure 1.3. Possibility of interaction with the GSM/UMTS networks for what the S-GW and SGSN elements are used is provided in it.

The kernel of the EPC network includes the following new elements:

• MME (Mobility Management Entity) – the module of management of mobility provides storage of office information on the subscriber and management with it, authorization of terminal devices in land networks of mobile communication and the general management of mobility, roaming support, authentication support, control of channels of transfer, including establishment of the allocated channels;

• S-GW (Serving GW) – the serving lock, includes the following functions: ensuring mobility at a handover between the eNB hubs, ensuring mobility between networks of standards 3GPP, routing and readdressing of packages of data, support of roaming for networks of the standards other than 3GPP and maintaining the account on users and identifiers of the class QoS;

• PDN GW (Packet Data Networks Gateway) – an interaction lock with the networks using technology with switching of packages includes the following functions: an individual filtration of packages, including in-depth study of packages, purpose of IP addresses to subscribers, marking of packages at the level of transport for the ascending and descending channels and participation in calculations for service of the ascending and descending channels, implementation of restrictions according to characteristics of connection; • SGSN (Serving GPRS Support Node) – knot of the current support of a packet transmission of data via the radio interface, includes the following functions: support of an exchange of alarm messages of the EPC elements for realization of mobility between networks of access 2G, 3G of standards 3GPP and eUTRAN, MME choice for a handover in a network of access of eUTRAN;

PCRF (Policy and Charging Rules Function) – functions of implementation of rules of policy and tariffing;

• HSS– server of subscriber data. Includes functionality of HLR/AUC, i.e. the basic register of location and the center of authentication.

The main task of architecture of the basic SAE network is creation of the PS domain of LTE system which has opportunity to provide both voice services, and all set of the services IP on the basis of technologies of package switching of data. The basic principle of creation of architecture of the basic SAE network is the concept of "all IP", and also that access to the LTE network can be provided not only through the UTRAN and GERAN networks, but also through Wi-Fi, WiMAX, or other networks using wire IP technologies. As the SAE developers offered by them architectural changes note will allow reducing considerably data transmission delays which are especially critical for such appendices as VoIP or on-line interactive games. In particular, radio network delays at data transmission of the user not have to exceed 10 ms (5 ms for short IP packages at small network loading). These values, at least, it is 50% better than similar indicators of the most perfect networks 3G. The next generation of wireless communications systems, commonly known as fourth-generation (4G) network [1], is envisaged to encompass a multitude of cellular and wireless networking technologies which include Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN) and third-generation (3G) cellular network. These wireless networking technologies are seamlessly interconnected by the Internet Protocol (IP) backbone network. In essence, 4G aims to transform communications architectures from traditional vertical stove piped to horizontal integrated systems. Personal Networks are one such network architecture that can fulfill the aim of 4G with user-centric perspectives. It is a dynamic network building on the above mentioned

wireless networking technologies, to facilitate personalized ubiquitous communications anywhere at any time. Figure 1 show the network architecture of a personal network which begins from a WPAN bubble that can be expanded or shrunk depending on the user’s demands and environment. The WPAN expansion

can physically be made via interconnecting structures, e.g. Universal Mobile Telecommunications System (UMTS) and the Internet, to remote networks such as home area networks, corporate area networks or vehicular area networks. A WPAN is a network of devices which could consist of a mobile phone, a PDA, a notebook PC, a digital camera, etc. All or a parts of these devices are carried around by a person in everyday life for both work and pleasure. This paper considers the first step toward building a personal network by enabling the co-operation between the UMTS, and WPAN and WLAN technologies. This co-operation poses a new set of problems. Current cellular and wireless networking technologies consider terminals only in isolation. In personal networks, we no longer have single terminals, but a very dynamic WPAN wanting to establish co-operation with UMTS so that it can connect with remote devices or remote WPANs. That means, current technologies are insufficient or have to be enhanced to accommodate new requirements. The major issues that need to be addressed are self-organization, establishing and maintaining quality of service for particular applications, routing and mobility management. The work presented in this paper will address all of these issues. Firstly, the state-of-the-art technologies are evaluated in view of building a personal network. We will point out the limitations with the current state-of-the-art technologies. Then, we propose solutions to these limitations within the realm of an interconnecting architecture for personal network. Finally, we present a number of ongoing key projects related to personal networks.

### 1.6. LTE standard prospects

The LTE standard has advantages within the LTE project it was succeeded to reach signal capacity at the level of 108 Mbit / c as for motionless and moving users in laboratory and city conditions. It was succeeded to achieve reduction of a delay between sending inquiry and data acquisition. The terminal supporting LTE will be able to function in any frequencies provided by various operators (from 450

MHz to 2,6 GHz). The DTM mode (Dual Transfer Mode) gives the chance at the same time to keep in a voice communication and data transmission. The LTE standard has shortcomings to most of operators it is necessary to license a new range of radio frequencies as the technology 3G for transfer and reception of a signal uses strips on 5 MHz, and LTE will be required twice a big strip. How fast LTE will prove to be, will depend in many respects on that, how many base stations operators will establish and how many people will contact one BS. Investments into the new equipment will be essential, and without them in hundreds of megabits a second it is necessary to forget about speeds (the transit canals used today have the capacity of only 1,5 Mbit / c). How specified problems will be able to brake advance of new technology, it is possible to see already today when passed initial expansion of the LTE networks. Within the project 3GPP passes joint test of various development during which all are shown strong and weaknesses of the new standard. A growing demand in mobile data transmission and emergence of external USB adapters, portable computers with the built-in decisions and the smartphones created on iPhone sample demand much higher speed of data transmission, than operators assumed. Operators faced need to pass on 4G earlier, than was planned initially. The main players, such as China Mobile, NTT DoCoMo and Verizon already declared aggressive plans for expansion of the LTE technology. LTE technology will provide evolutionary transition for the existing networks of cellular communication and will allow mobile network operators to create a high-speed high-performance mobile network of broadband access which not only will increase the speed of connections, but also will allow to expand a set of functions.

## Summary

Proceeding from it we got acquainted as in general the network 4G/LTE looks. That architecture in many respects differs in several key elements. And at everything thus it is possible to tell it works quicker than other generations of

mobile communication. Examined that can prevent our technology and what it has a quality to improve communication of the next generation.

# 2. MAIN PROTOCOLS OF MEDIA GATEWAYS

## 2.1. WiMAX standard

The term WiMAX was offered by branch consortium WiMAX Forum for the purpose of promoting of family of standards of the broadband wireless systems of access 802.16 developed by Institute of electrical equipment and radio electronics (IEEE). Early versions of these standards described the systems working in a zone of direct visibility (LOS) in the high-frequency ranges from 6 to 66 GHz. Later the accent was displaced on elaboration of additions to earlier accepted standards for the purpose of support of the systems working out of a zone of direct visibility (NLOS) in the ranges from 2 to 11 GHz. In the standard 802.16-2004 also known under the name 802.16d, improvements of the systems of a radio communication described in the previous versions of standards were fixed. It allowed to improve a radio covering in buildings that, in turn, gave the chance to create the desktop subscriber equipment. Work on the standard 802.16e was complete in December, 2005, and at the moment it is the most actual standard of family 802.16. The standard 802.16d is calculated on work with the fixed decisions, and 802.16e supports the fixed, portable and mobile decisions. Emergence of the WiMAX standard allowed to expand considerably possibilities of branch of communication regarding granting highly effective and inexpensive broadband communication channels, both in the large cities, and in earlier inaccessible distant areas. When using as the broadband solution of "the last mile" systems of the WiMAX standard allow to free lines which were attached to wire networks earlier, and to provide mobility and a wireless communication. One of major factors in realization of potential of WiMAX is the subscriber equipment (SE). Having correctly chosen JSC WiMAX, private and corporate subscribers can easily be connected to a wireless network, without spending time and forces for installation and control. Such, JSC has to provide high quality of a broadband

wireless communication for the stationary, mobile and migrating subscribers, providing reliable and high-speed access to such resource-intensive systems as music, video and games.

## 2.2. WiMAX prospects

The WiMAX market also remains very dynamic, and the markets of regions with the insufficient level of security with broadband communication and the most active telecom operators in the developed markets become key segments for this technology. The WiMAX technology will provide to far-sighted participants of the market of wireless broadband communication opportunity quickly and canonically to increase a cover zone and will provide functionality of mobile broadband communication. In process of increase in level of a giper connection growth of number of the connected devices leads to increase in a traffic in wireless networks, and users wait from mobile communications of the same speed and opportunities, as well as from land communication lines.

## 2.3. Prospects of development of technologies 4G

Without waiting for completion of works over the 3GPP Release 8 standard, many leading producers of the telecommunication equipment already presented the first prototypes of the devices supporting LTE. So, in February
2007 Ericsson company for the first time in the world showed work of the equipment LTE with a speed of transfer of 144 Mbps.
In September, 2007 the NTT Docomo company presented the equipment LTE with a speed of transfer of 200 Mbps and with a power consumption less than 100 MW. In April, 2008 LG and Nortel corporations showed data transmission on the LTE technology with a capacity of 50 Mbps at a speed mobile of subscribers of 110 km/h. On September 18, 2008 the mobile operator T-Mobile and Nortel Networks declared a progress of speeds of transfer of 170 Mbps for the descending

connection and 50 Mbps for the ascending connection. Tests about -were found in the car at an average speed of 67 km/h in a radius of action of three base stations.

Further development of the LTE technology will proceed within works on the 3GPP Release 10 (LTE Advanced) new standard. For today the main requirements to which will have to satisfy LTE Advanced are already formulated In fact, it requirements to the standard of mobile networks of the fourth generation (4G):

• The maximum speed of data transmission in the descending radio channel to 1 Gbit / with, in the ascending – to 500 Mbps (average capacity on one subscriber – is three times higher, than in LTE);

• A pass-band in the descending radio channel – 70 MHz, in ascending – 40 MHz;

• Maximum efficiency of use of a range in the descending radio channel – 30 bits / with/Hz, in ascending – 15 bits / with/Hz (is three times higher, than in LTE);

• Full compatibility and interaction with LTE and other 3GPP systems.

For the solution of these tasks it is supposed to use wider radio channels (to 100 MHz), asymmetric division of pass-bands between the ascending and descending channel in case of frequency duplex; more with -

topmost systems of coding and correction of mistakes;

the hybrid OFDMA and SS-FDMA technology for the ascending channel, and also the advanced decisions in the field of antenna systems (MIMO).

## 2.4. Standart IEEE 802.16 – WiMAX

The WiMAX non-profit organization (World Interoperability for Microwave Access – interaction of the equipment of network access at ultrahigh frequencies around the world) is formed for the purpose of assistance to development of the wireless equipment of access to broadband networks on the basis of the IEEE 802.16 specification for wireless zone networks, certification of such equipment on compatibility and interaction, and also to acceleration of its entry into the market.

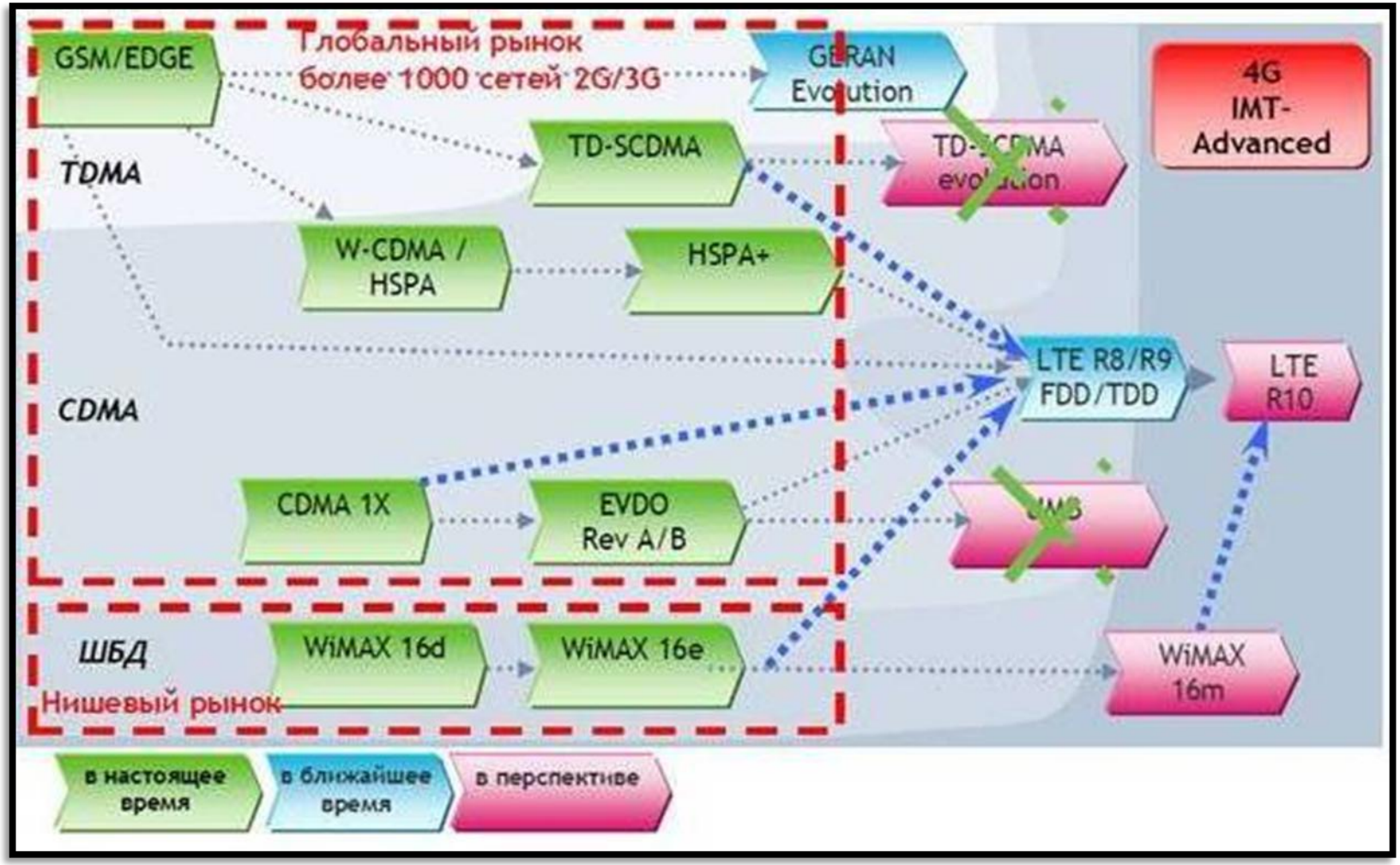



Fig. 2.1. Prospects of development of technologies 4G

Work in the ranges of 2 … 11 GHz and 10-66 GHz is provided in the standard 802.16. In the range of 10-66 GHz the radio communication is possible only in case of direct visibility between points. In this range use direct modulation bearing (the mode with one bearing). In the range of 2 … 11 GHz of the specification of the radio interface, allow possibility of the solution of a problem of a radio communication in the conditions of multiband distribution and in the absence of direct visibility (NLOS - Non-Line-Of-Sight). The WMAN-SC2 radio interface uses modulation one bearing, the WMAN radio interface – OFDM – orthogonal frequency modulation (OFDM - Orthogonal Frequency Division Multiplexing) with fast transformation of Fourier on 256 points and to 2048 points. The certified ranges of frequencies for the fixed and mobile WiMAX of profiles are specified below.

The profiles fixed by WiMAX – 3,5 GHz (FDD): 3,5; 7; (256)

3,5 GHz (TDD): 3,5; 7; (256)

5,8 GHz (TDD): 10 (256)

Mobile WiMAX profiles - 2,3 – 2,4 GHz: 5 (512); 10 (1024); 8.75 (1024);

in total TDD of 2,305 - 2,320 GHz: 3,5 (512); 5 (512)

2,345 – 2,360 GHz: 10 (1024)

2,496 – 2,69 GHz: 5 (512); 10 (1024)

3,3 – 3,4 GHz: 5 (512); 7 (1024); 10 (1024)

3,4 – 3,8 GHz: 5 (512)

3,4 – 3,6 GHz: 7 (1024)

3,6 – 3,8 GHz: 10 (1024)

Except specified, allocation of channels in the ranges of 5,7 GHz is possible,

1,710 – 1,755: 2,110 – 2,155 GHz.

In the standard 802.16 use the following interfaces:

1. Wireless MAN-SC (10 – 66 GHz)
2. Wireless MAN-SCa (2 – 11 GHz; license ranges)
3. Wireless MAN-OFDM (2 – 11 GHz; license ranges)
6. Wireless MAN-OFDMA - Orthogonal Frequency Division Multiple Access

(2 – 11 GHz; license ranges)

5. Wireless HUMAN (2 – 11 GHz; counterfeit ranges)

Interfaces 3 and 5 provide possibilities of Mesh – the organization of networks with sound topology for acceleration of transfer of a traffic.

The return transformation of Fourier defines OFDM signal form. The useful duration of a symbol the size Tb is considered. The last part of $T_g$ of the period of a symbol called a protective interval is used to eliminate influence of multiband distribution of orthogonal components of a signal rice on figure 2.2.

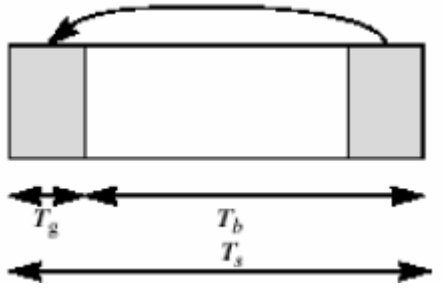



Fig. 2.2. A symbol format at one frequency

In frequency area the signal is characterized by spectral characteristics (fig. 2.3.) Are present at it sub bearing for data transmission, pilot signals, and at the edges of a strip protective intervals are located.

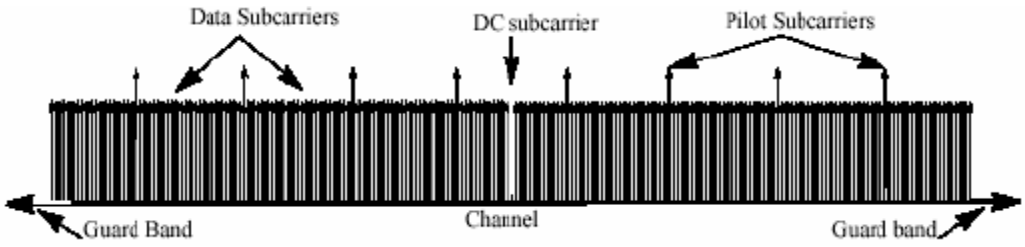



Fig. 2.3. The description of a signal in frequency area

The OFDM symbol is characterized by the following parameters:

- BW – the nominal width of a strip of the channel.

- $N_{used}$ - number used sub bearing.

- n-selection coefficient. This parameter, in connection with BW and Nused defines a diversity sub bearing and symbol duration. The demanded values of this parameter are defined in tab. 6.6.

- G - relation of duration of a protective interval (prefix) to useful time. This size can make 1/4, 1/8, 1/16, 1/32 Tb.

- NFFT: number of points of transformation of Fourier,

- Frequency of following of parcels: Fs=floor (n*BW/0.008) *0.008 (BW-strip width in MHz),

- Δf: a diversity sub bearing, defined as: Fs/NFFT,

- Tb = 1 / Δ f – duration of transformation of a symbol,

- Tg=G*$T_b$ – duration of a protective interval (CP),

- $T_s$=$T_b$+$T_g$ – OFDM symbol duration,

- $T_s$/NFFT - a sampling interval.

Sizes of speeds of transfer depending on a type of modulation and code speed are specified in tab. 2.1. and requirements to the relation signal/noise on a receiver

Table 2.1.

Sizes of speeds of transfer depending on a type of modulation and code speed

| MHZ STRIP | SPEED OF TRANSFER OF MBPS | | | | | |
|---|---|---|---|---|---|---|
| | QPSK, 1/2 | QPSK, 3/4 | 16-QAM, 1/2 | 16-QAM, 3/4 | 64-QAM, 2/3 | 64-QAM, 3/4 |
| 1,75 | 1,04 | 2,18 | 2,91 | 4,36 | 5,94 | 6,55 |
| 3,5 | 2,08 | 4,37 | 5,82 | 8,73 | 11,88 | 13,09 |
| 7,0 | 4,15 | 8,73 | 11,64 | 17,45 | 23,75 | 26,18 |
| 10,0 | 8,31 | 12,47 | 16,63 | 24,94 | 33,25 | 37,4 |
| 20,0 | 16,62 | 24,94 | 33,25 | 49,87 | 66,49 | 74,81 |

Table 2.2.

Requirements to the relation signal/noise on a receiver entrance for various schemes of modulation and coding

| MODULATION | CODING SPEED | SNR, DB |
|---|---|---|
| QPSK | ½ | 9,4 |
| | ¾ | 11,2 |
| 16-QAM | ½ | 16,4 |
| | ¾ | 18,2 |
| 64-QAM | 2/3 | 22,7 |
| | ¾ | 24,4 |

entrance for various schemes of modulation and coding to tab. 2.2. Data at the physical level transfer in a type of continuous sequence of shots. Each shot has the fixed duration (2 (2,5) … 20 ms) therefore its information capacity depends on the symbolical speed and a method of modulation. The shot consists of a preamble, the operating section and sequence of packages with data. IEEE 802.16 networks duplex. Perhaps both frequency FDD, and temporary TDD division of the ascending and descending channels.

At temporary duplexing of channels the shot is divided into the descending and ascending sub shots (their ratio can flexibly change in the course of work depending on requirements of a pass-band for the ascending and descending channels) divided by a special protective interval. At frequency duplexing the ascending and descending channels transfer on two bearing (fig. 2.4.) In the descending channel information from a base station is transferred in a type of sequence of packages. For each package it is possible to set a method of modulation and an encoding scheme of data – i.e. to choose between the speed and reliability of transfer. TDM – packages transfer at the same time for all subscriber

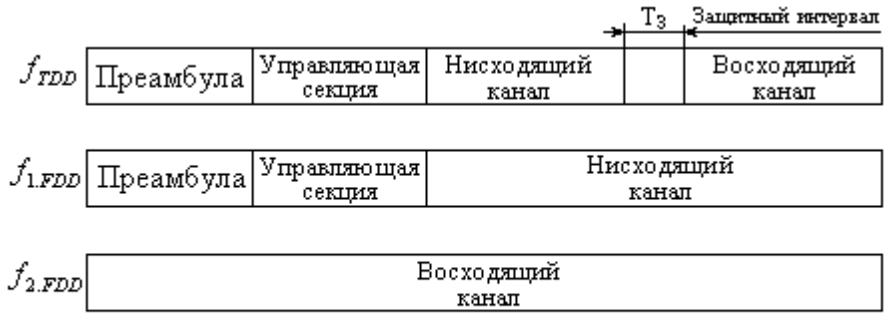



Fig. 2.4. Structure of shots for TDD and FDD

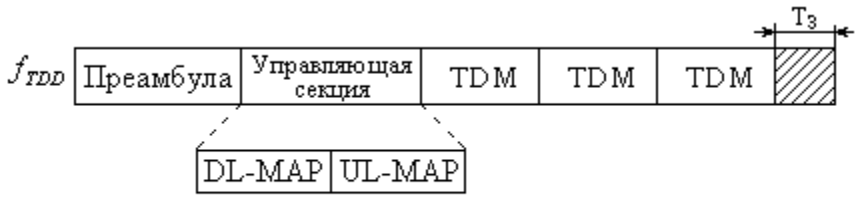



Fig. 2.5 Structure of the descending channel.

stations, each of them accepts all information stream and chooses "the" packages. That subscriber stations could distinguish one package from another, in the operating section transfer cards of descending (DL-MAP), and ascending (UL-MAP) of channels (fig. 2.4.).

In the map of the descending canal the shot duration, number of a shot, number of packages in the descending sub shot is specified, and also the point began also type of a profile of each package. The point of the beginning is counted in so-called physical slots, each physical slot is equal to four modulation symbols.

The profile of a package is a list of its parameters, including a modulation method, the FEC type – codings (with parameters of encoding schemes), and also the range of values of the relation signal/noise in the reception channel of concrete station at which this profile can be applied. The base station periodically broadcasts the list of profiles in the form of special managing directors of messages (descriptors of the descending and ascending DCD/UCD channels), and to each profile assign number which use in the map of the descending canal.

Subscriber stations get access to the transfer environment by means of the mechanism of temporary division of TDMA channels (Time Division Multiple Access). For this purpose in the ascending sub shot for the EXPERT the base station reserves special time intervals – slots (fig. 2.4.). Information on distribution of slots between the EXPERT is written down in the card of the ascending UL-MAP channel broadcast in each shot. UL-MAP – is functionally similar to DL-MAP – in it report, how many slots in a sub shot, a point of the beginning and the identifier of connection for each of them, and also types of profiles of all packages. The message of UL-MAP of the current shot can belong both to this shot, and to the subsequent. Modulation speed (frequency of symbols) in the ascending channel has to be same, as well as in descending. We will note that, unlike the descending TDM – packages, each package in the ascending channel begins with a preamble – a synchro sequences 16 or 32 QPSK long - a symbol.

Examples of structure of a shot with TDD it is given in fig. 2.6. In the ascending canal, except the appointed BS of slots for defined the EXPERT, intervals during which the EXPERT can transfer the message for primary registration to networks or for inquiry of change of a pass-band of the channel (granting channels on request of DAMA - Demand Assigned Multiple Access) are provided. Physical level of the IEEE 802.16 standard provides direct delivery of data flows between BS and the EXPERT. All tasks connected with formation of structures of these data and also management of work of system are solved on MAC (Medium Access Control) - level. The equipment of the IEEE 802.16 standard forms the transport environment for various appendices (services).

The WiMAX networks support 4 types of a traffic differing in requirements to reliability and delays:

UGS – Unsolicited Grant Service – transfer in real time of signals and streams of a telephony (E1) and VoIP. An admissible delay less than 5 - 10 ms in one direction at BER = 10-6 … 10-6.

rtPS – Real Time Polling Service – streams of real time with packages of variable length (video MPEG).

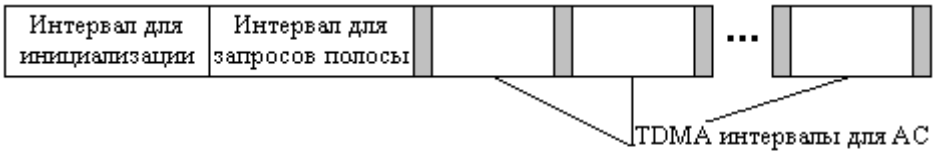



Fig. 2.6. Structure of the ascending channel

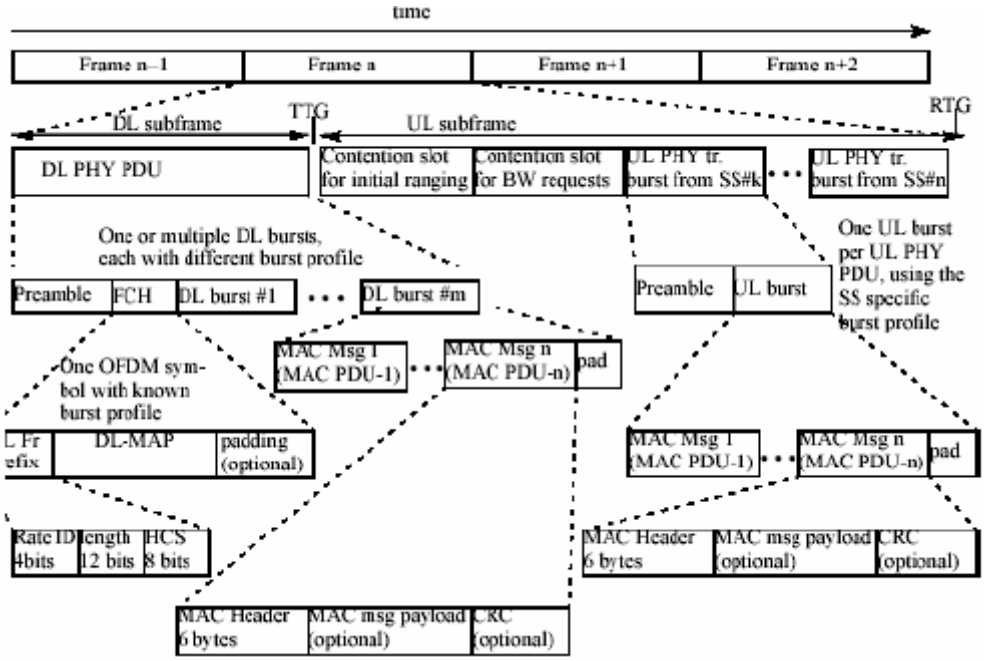



Fig. 2.7. An example of structure of a shot of OFDM with TDD

nrtPS – Non-Real-Time Polling Service – support of streams of variable length for a file transfer in the broadband mode.

BE – Best Effort – other traffic.

## 2.5. Characteristics of the standard 802.16e.

In the standard 802.16e use variable number of OFDM of the frequencies sub bearing in various strips for distribution of PUSC (tab. 1.4.)

Specifications established the following nominal strips of frequency channels: 1,25; 1,75; 3,5; 5; 7; 8,75; 10; 14; 15.

Distribution of the sub bearing for data transmission and pilot messages is shown in fig. 2.7. Sub bearing, forming one channel, can, but to be optional adjacent (fig. 2.7.)

Table 2.3.

Variable number of OFDM

| PARAMETR | CHARCTERISTICS OF OFDMA | | | |
|---|---|---|---|---|
| Number of the sub bearing | 128 | 512 | 1024 | 2048 |
| Number of the sub bearing data | 72 | 360 | 720 | 1440 |
| Number of the pilot sub bearing | 12 | 60 | 120 | 240 |
| Number of the protective sub bearing | 44 | 92 | 184 | 368 |
| $T_g/T_b$ relation | 1/32, 1/16, 1/8, 1/4 | | | |
| Expansion of a strip | 8/7 for strips, multiple 1,75mgts; 28/25 for strips, multiple 1,25; 1,5; 2; 2,75 | | | |
| Strip of the frequency channel, MHz | 1,25 | 5 | 10 | 20 |
| Rating sub bearing, kHz | 10,94 | 10,94 | 10,94 | 10,94 |
| Active length of a symbol, microsec | 91,4 | 91,4 | 91,4 | 91,4 |
| Protective interval, microsec | 11,4 | 11,4 | 11,4 | 11,4 |
| Length of OFDM of a symbol, microsec | 102,9 | 102,9 | 102,9 | 102,9 |

On everyone sub bearing a signal it can be modulated by various schemes of modulation. Structures of signals of QPSK, 16 QAM and 64 QAM are shown in fig. 2.8.

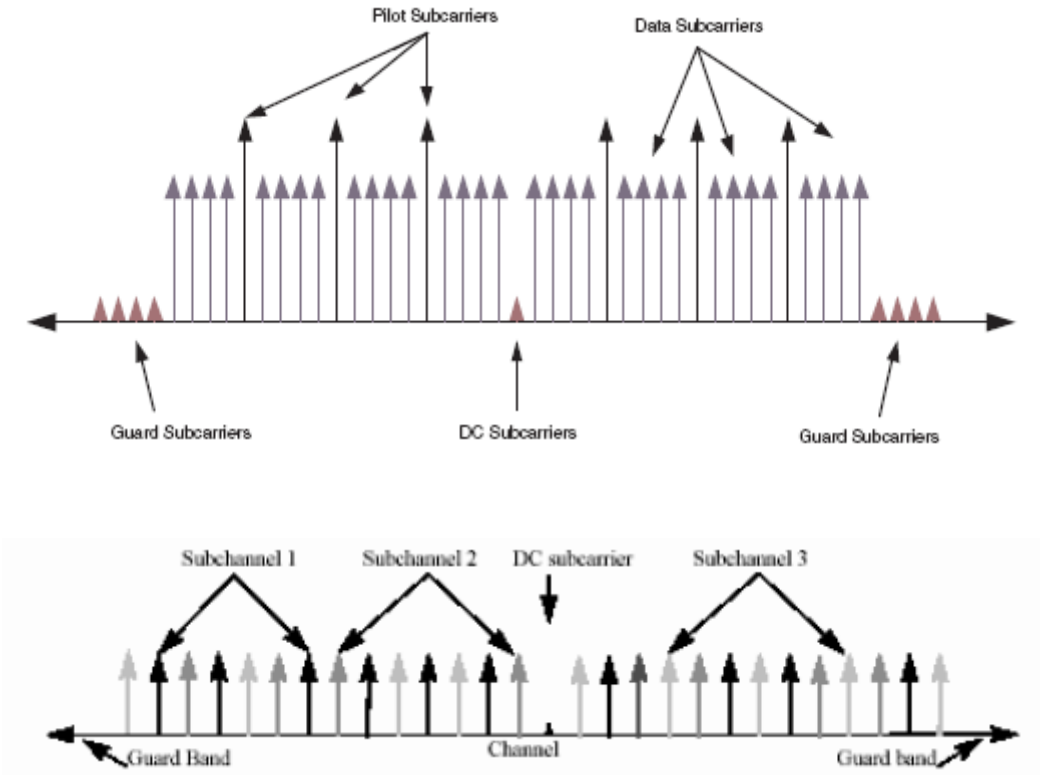



Fig. 2.8. Distribution of the subbearing

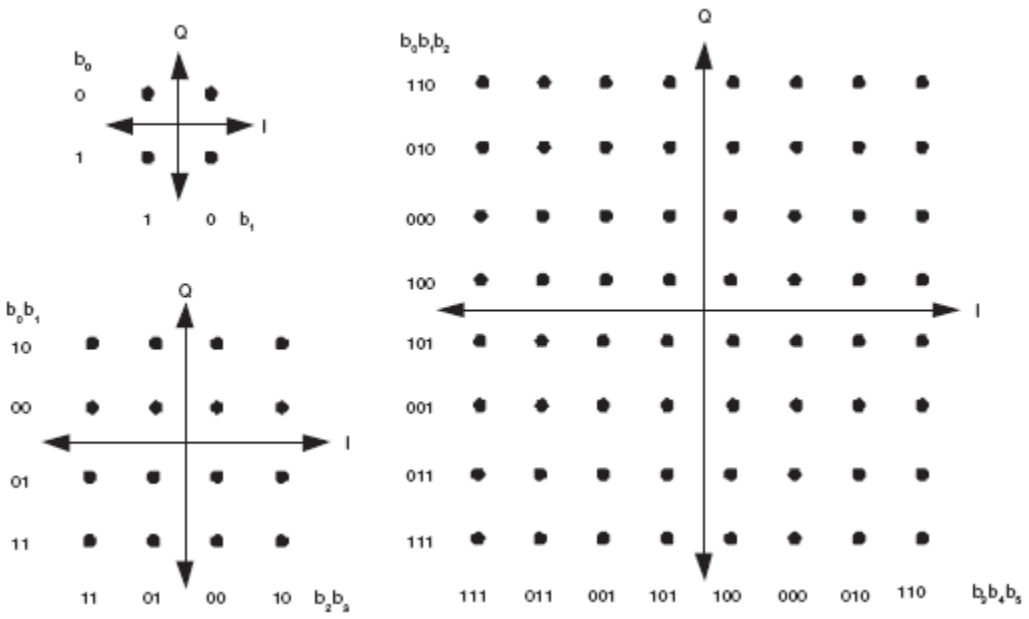



Fig. 2.9. Modulation constellations in WiMAX

Partial use of a channel resource can be organized variously. In FUSC option (Full Usage of Subcarriers) for creation of separate sub channels use all channel resource. One sub channel consists from 48 sub bearing, used for data

transmission, additional number pilot sub bearing and protective sub bearing, located at the edges of the frequency channel. Options of distribution of the sub bearing for data transmission and pilot signals are given in tab. 2.4 also fig. 2.9 is illustrated. At PUSC (Partial Usage of Subcarriers) the minimum channel unit in a downward direction is the cluster. Actually each cluster is made of 14 nearby sub bearing. Formally one cluster is always made of 2 consecutive OFDM of symbols, i.e. from 28 sub bearing where on 24 transfer data, and to 4 pilot signals. Further all channel resource is divided into 6 groups so sub channels will always organize from sub bearing, belonging to one group. Distribution sub bearing to destination is given in tab.2.5. and illustrated with fig. 2.10. As it was told, all clusters are carried on 6 groups, and the first 1/6 clusters treats group 0, etc. The sub channel will be organized, using 2 clusters from one group, as shown in fig.2.9.

Table 2.4.

Options of distribution of the sub bearing for data transmission and pilot signals

| NUMBER OF THE SUB BEARING | 128 | 512 | 1024 | 2048 |
|---|---|---|---|---|
| Number sub bearing in the sub channel | 48 | 48 | 48 | 48 |
| Number of sub channels | 2 | 8 | 16 | 32 |
| Number sub bearing for data transmission | 96 | 384 | 768 | 1536 |
| Constants the pilot sub bearing | 1 | 6 | 11 | 24 |
| Variables the pilot sub bearing | 9 | 36 | 71 | 142 |
| Protective sub bearing (at the left/on the right) | 11/10 | 43/42 | 87/86 | 173/172 |

Table 2.5.

Distribution sub bearing to destination

| NUMBER OF THE SUB BEARING | 128 | 512 | 1024 | 2048 |
|---|---|---|---|---|
| Number sub bearing in a cluster | 14 | 14 | 14 | 14 |
| Number of sub channels | 3 | 15 | 30 | 60 |
| Sub bearing, used for data transmission | 72 | 360 | 720 | 1440 |
| The pilot sub bearing | 12 | 60 | 120 | 240 |
| The protective sub bearing | 22/21 | 46/45 | 92/91 | 184/183 |

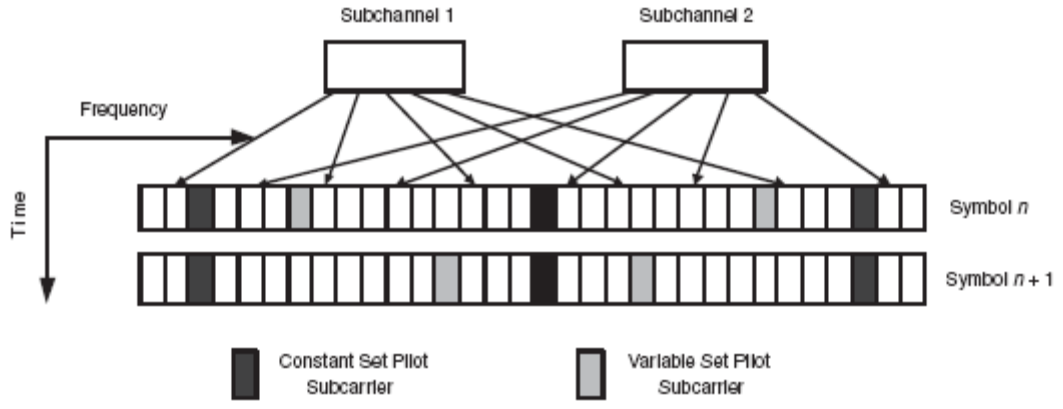



Fig. 2.10. Distribution sub bearing in FUSC

At PUSC of one base station all channels or their part (one or several groups) can be allocated. It allows to use a frequency diversity of channels in the allocated strip and to construct the segmented WiMAX network similar to networks of cellular communication.

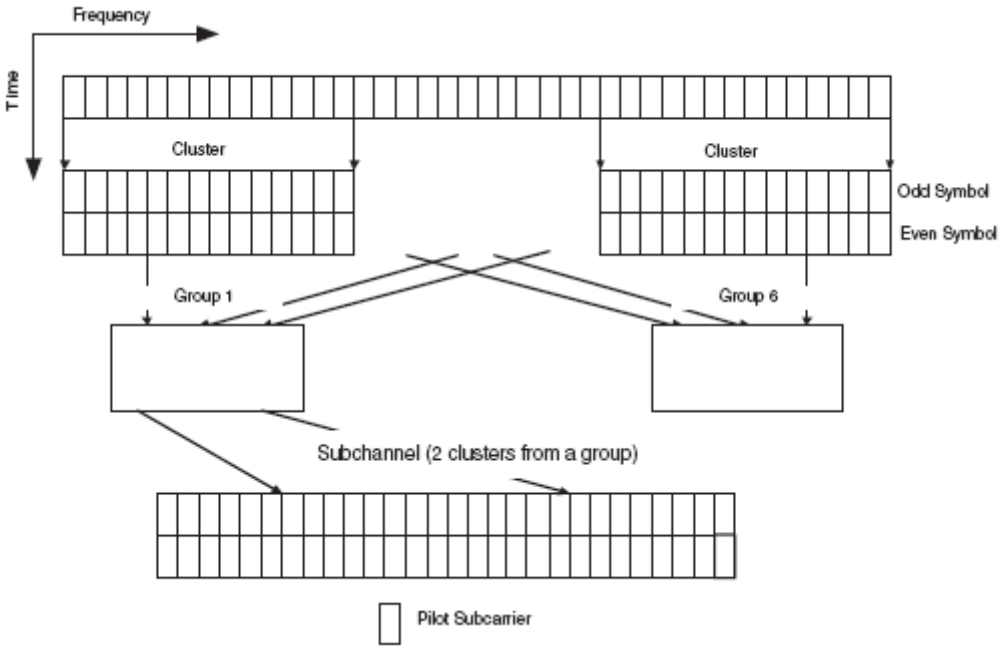



Fig. 2.11. Formation of sub channels in PUSC

In the direction up at PUSC the minimum unit of a channel resource is the element (tile). Each element is made of 4 sub bearing symbols lasting 3 OFDM. On 8 sub bearing in an element transfer data, 4 sub bearing use for transfer of pilot signals. Formation of sub channels illustrates fig. 2.10 up.

At allocation of a channel resource for a burst broadcast use both temporary and frequency division of bank of channels (fig. 2.11.)

The approximate model of a network is given in fig. 2.13. In fig. 2.13. MSS – Mobile Subscriber Station, ASA Server – Authentication and Service Authorization Server, actually the AAA-server.

At service of BSS in OFDMA networks use such procedures as preliminary authentication, management of BSS power, determination of range to BS.

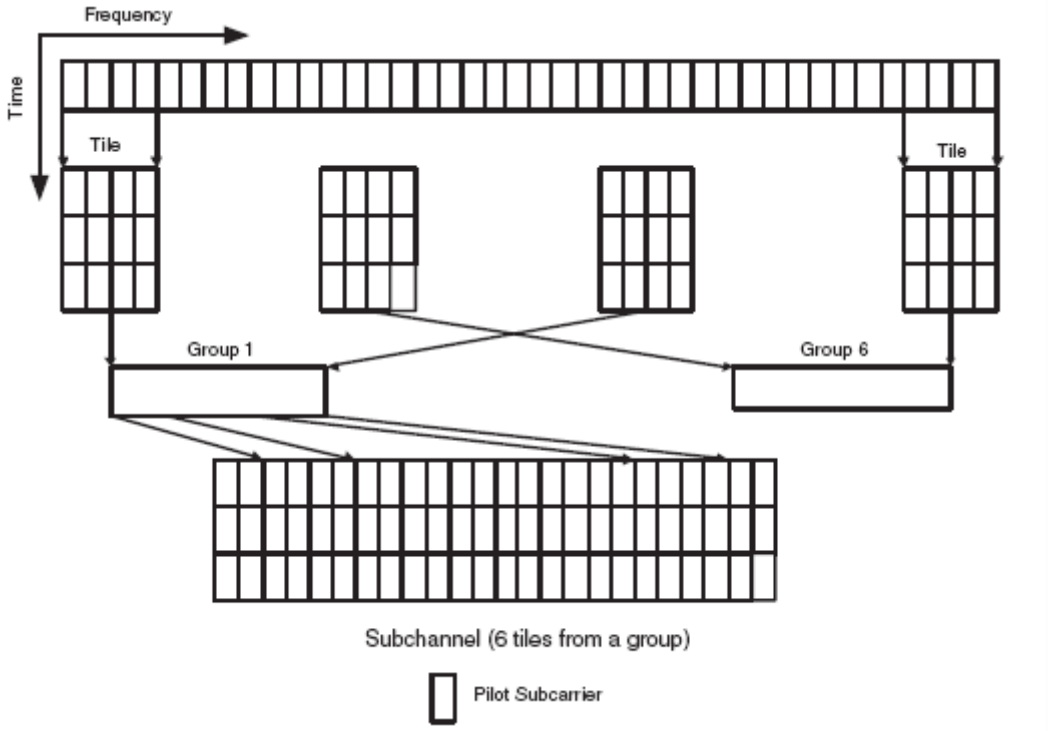



Fig. 2.12. Formation of sub channels up

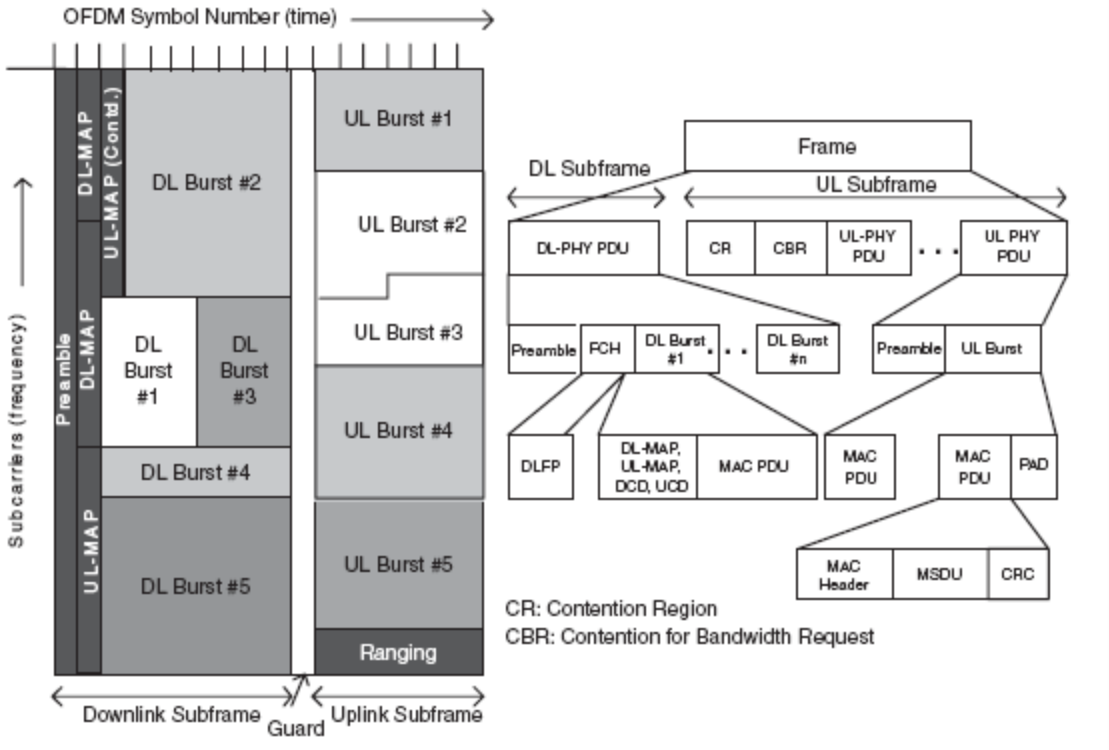



Fig. 2.13. Structure of a shot

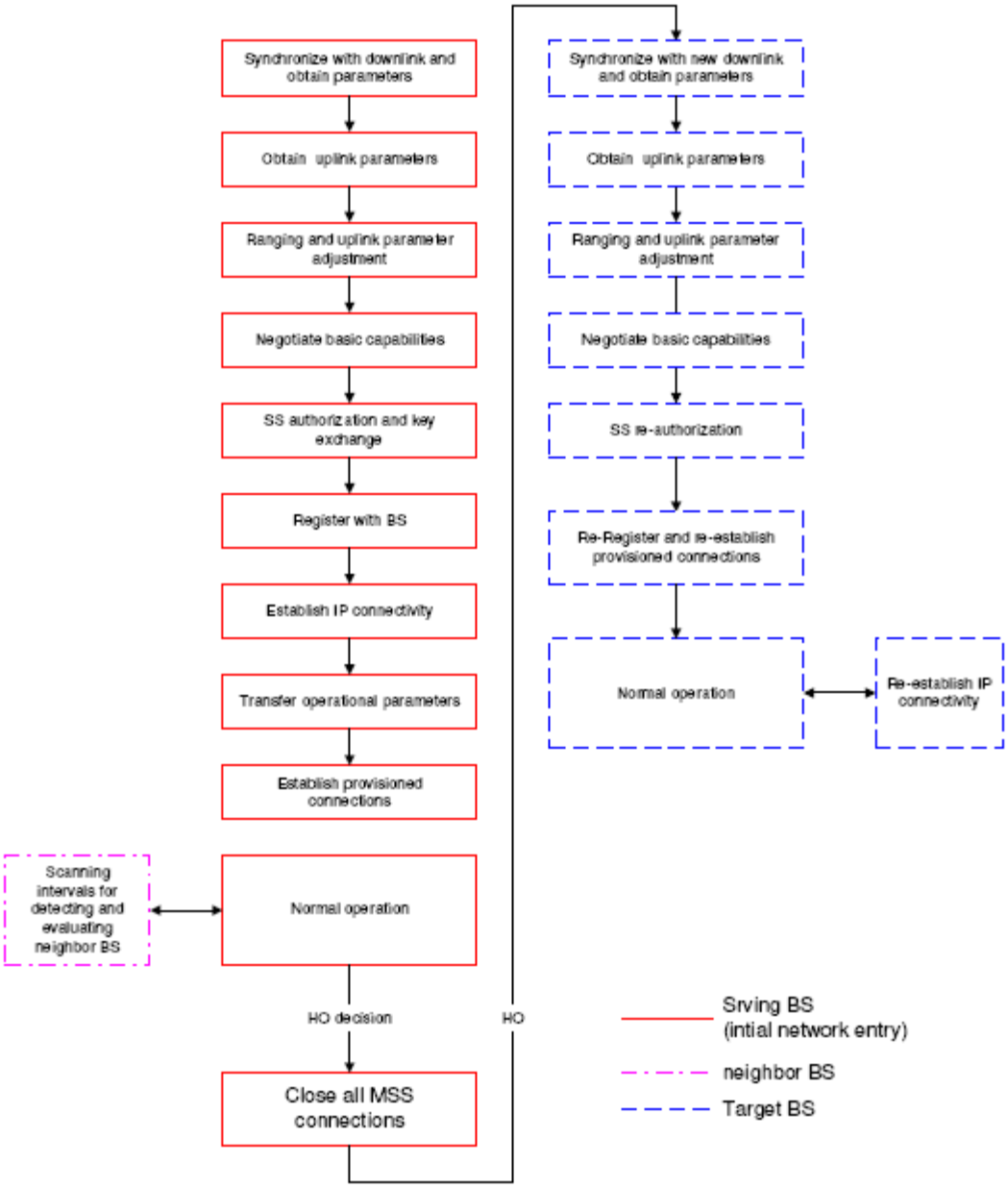



Fig. 2.14. Connection to a network and handover

When moving the subscriber the network supports procedure of a handover. The main stages of algorithm of entry of BSS into a network and the subsequent handover are shown in fig. 2.12.

Specifications provided 2 options of a handover: rigid and soft. Duration of deduction of information at a handover makes by default 200 ms.

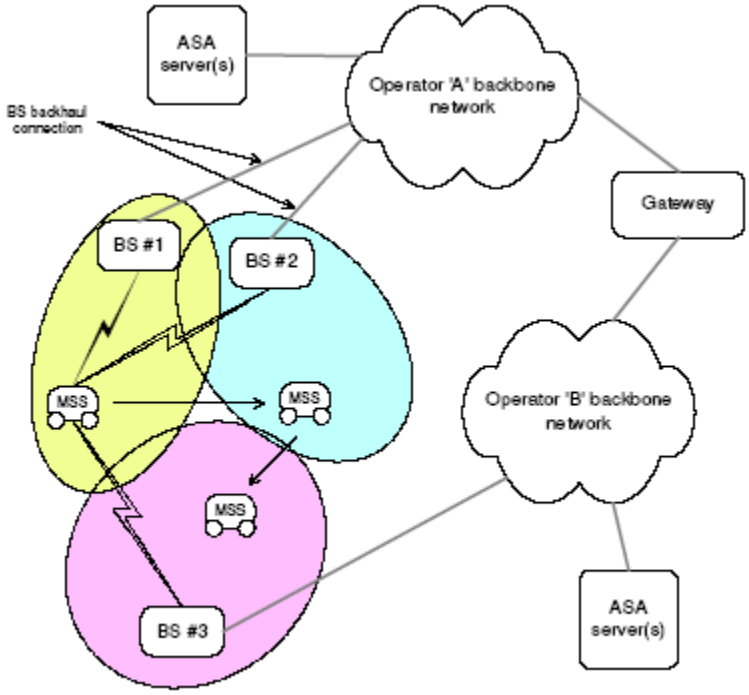



Fig. 2.15. Structure of the WiMAX network

## Summary

This shows us **t**he WiMAX technology will provide to far-sighted participants of the market of wireless broadband communication opportunity quickly and canonically to increase a cover zone and will provide functionality of mobile broadband communication. In process of increase in level of a giper connection growth of number of the connected devices leads to increase in a traffic in wireless networks, and users wait from mobile communications of the same speed and opportunities, as well as from land communication lines. LTE technology will proceed within works on the 3GPP Release 10 (LTE Advanced) new standard. For today the main requirements to which will have to satisfy LTE Advanced are already formulated In fact, it requirements to the standard of mobile networks of the fourth generation (4G).

# 3. CALCULATION OF THE CHANNEL THROUGHPUT DEPENDING ON LOADING SECTOR IN NETWORKS 4G/LTE

## 3.1. Calculation of quantity of base stations and subscribers of a network

Parameters:

$\Delta f = 50$ MHz – the strip of frequencies allocated for work of system;

$\Delta f_{rk} = 180$ kHz – a strip of frequencies of 1 radio channel;

$M_{cek} = 3$ number of sectors of a base station;

$N_{kl} = 3$ – dimension of a cluster.

We will determine total number of the frequency $N_{rk}$ channels allocated for expansion of a network by a formula (3.1):

$$N_{rk} = \frac{\Delta f}{\Delta f_{rk}} \qquad (3.1)$$

$N_{rk} = 50 \cdot 106/180 \cdot 103,$

$N_{rk} = 227$

After we will define number of radio channels of $N_{rkcek}$ which needs to be used for service of subscribers in one sector one honeycomb (3.2):

$$N_{rksek} = N_{rk} /(N_{kl} * M_{cek}) \quad (3.2)$$

Effective way of decrease in the general level of the hindrances influencing BS is the divides in sectors of honeycombs for the account use of sector antennas.

BS will be developed in a three-sector configuration with a width of directional pattern (DP) of 120 ° which is optimum for expansion of the LTE networks. Such BS allows using most effectively allocated frequency resource that is reached by

application of scalable frequency plans. Three-sector BS represents the platform allowing to increase over time network capacity in process of growth of subscriber base; narrow width of DN, in comparison with antennas with circular DN, allows to increase coefficient of strengthening of the antenna (G), thereby increasing territory covering radius. Thus, BS number necessary for service of subscribers in the set territory is considerably reduced.

$N_{rkcek} = 227 / (3 \cdot 3)$;

$N_{rkcek} = 26$.

Definition of a permissible load in sector one honeycombs ICQ at admissible value of probability of blocking of a call of equal 3% and calculated above $N_{rkcek}$ value will be the following step.

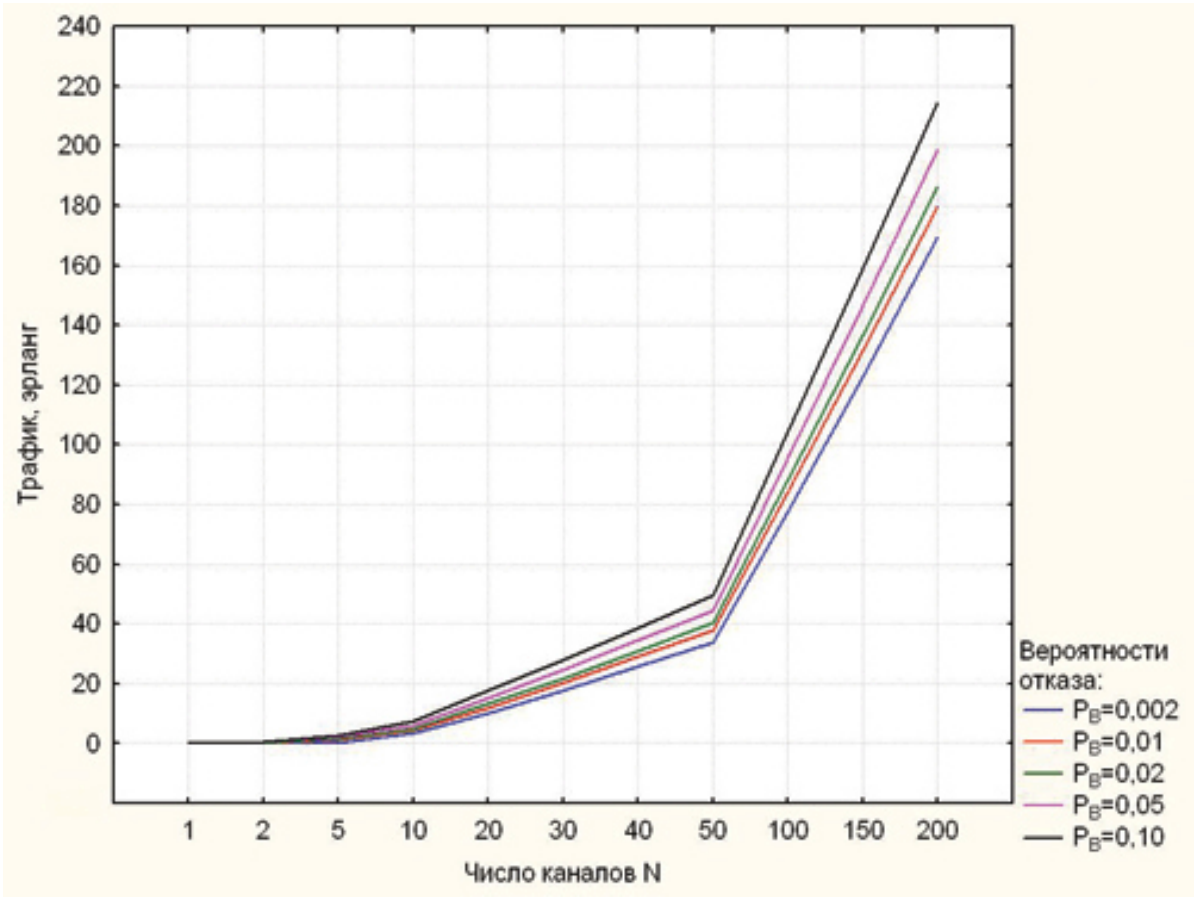



Fig.3.1. Dependence of a permissible load in sector from number of channels of a traffic and probability of blocking

We determine by the monogram of the Erlang that ICQ = 18 Earl.

The number of subscribers which will be served by one base station is determined by a formula (3.3):

$$N_{abbc} = M_{cek}(ICQ / A_1) \quad (3.3)$$

Where: $A_1$ – average subscriber loading from one subscriber. $A_1$ value can make (0,04... 0,2) Earl. As the projected network is planned to be used for high-speed exchange of information, we will accept $A_1$ value equal 0,1 Earl. Thus:

$N_{abbc} = 3*(21/0.1)$,

$N_{abbc} = 630$.

We will calculate number of base stations in the projected network on a formula (3.4):

$$N_{bc} = (N_{abpot} / N_{abbc}) + 1 \quad (3.4)$$

Where: $N_{abpot}$ – number of potential subscribers which pays off on a formula (3.5):

$$N_{abpot} = K * N_{ab} \quad (3.5)$$

Where: $T_o$ – service penetration coefficient (for the beginning of 2014 of 12,5% for averages on population of the cities)

$N_{ab} = 220362$ - population of the city district of alleged city.

We determine number of potential subscribers by a formula (3.5):

$N_{abpot} = 0.125 \cdot 220362$,

$N_{abpot} = 27545,25$ potential subscribers

Substituting value in (3.4), we will receive number of the base stations necessary for a territory covering:

$N_{bc} = (27545,25/630) + 1$;

$N_{bc} = 45$.

For the territory of alleged city with population of 220362 inhabitants and number of potential subscribers 27545,25 we will choose a working strip of the channel of one sector of equal 10 MHz Creation of a three-sector base station requires 30 MHz, on 10 MHz on each sector.

### 3.2. Dependence of speed of connection on loading in sector

Table 3.1 and Fig 3.2. show number of active subscribers on sector when loading in several values to recognize minimum speed of connection. In Fig 3.2. blue line is assigned with optimal number of BS calculated in formula (3.2). If number of active users in sector decrease from 15 to 300 minimum speed of connection increase from 1721 kbps to 86 kbps.

Green line is assigned less than optimal number of BS. In this case voice calls don't accept to the system but packet service is delayed.

Tab.3.1.

Number of active subscribers on sector when loading in several values to recognize minimum speed of connection

| NUMBER OF ACTIVE SUBSCRIBERS ON SECTOR | LOADING, % | MINIMUM SPEED OF CONNECTION, KBPS |
|---|---|---|
| 300 | 100 | 86 |
| 225 | 75 | 115 |
| 150 | 50 | 172 |
| 75 | 25 | 344 |
| 45 | 15 | 573 |
| 30 | 10 | 860 |
| 15 | 5 | 1721 |

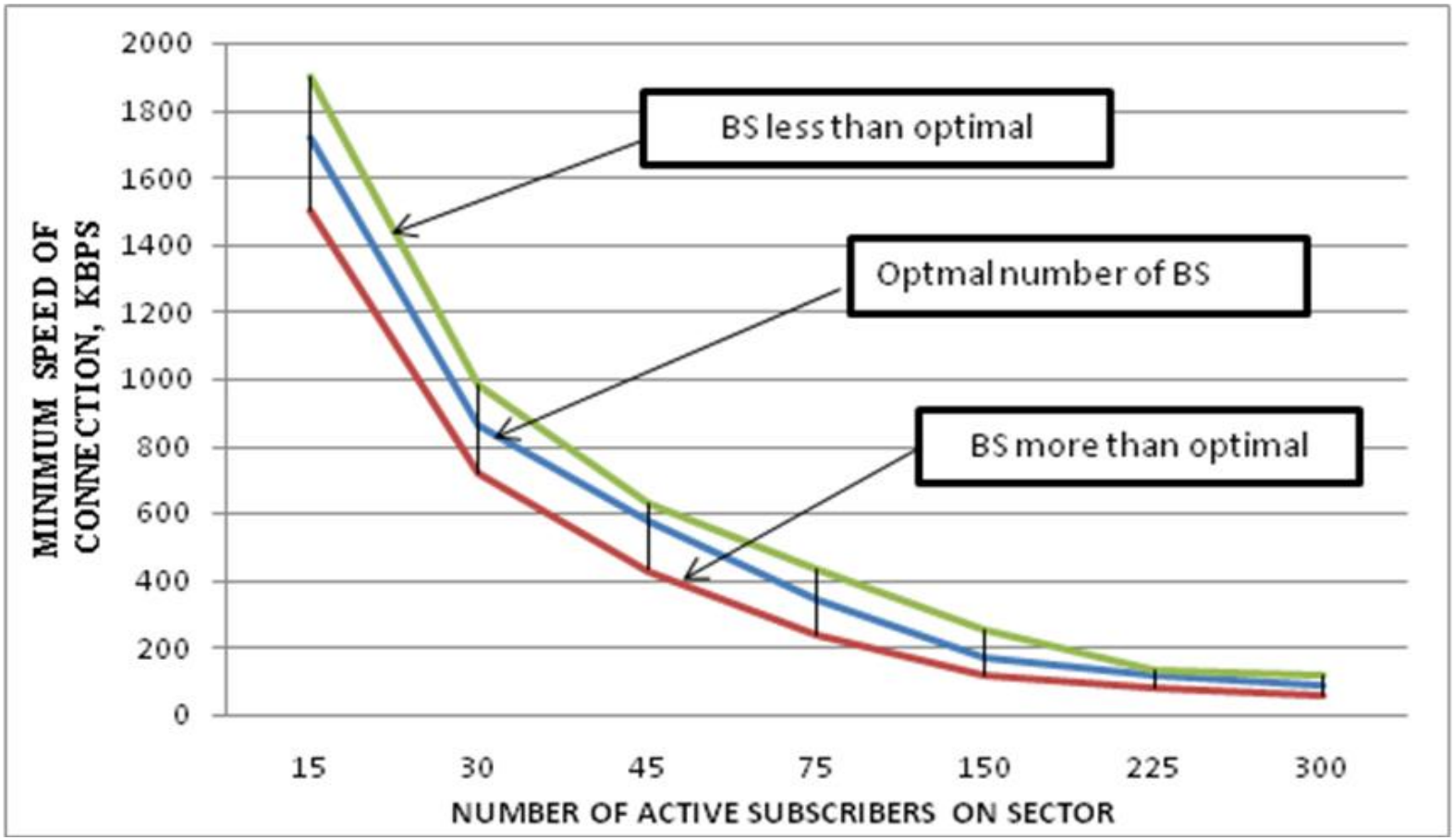



Fig. 3.2. Dependence of speed of connection of users on number of active subscribers on sector.

Delay time is more than normal. Normal delay time is about 3-5s. In our case green line give us estimated delay time about 9-12s.User senses delay of service.

Red line is assigned more than optimal number of BS. In this case calls packet service is not delayed, but decreasing of BS number give us cost enlarge of cellular network and as result price of telephone services.

### 3.3. Calculation of percent of time of disruption of communication

In the case under consideration the general time of disruption of communication on flight is caused by two reasons: an interference in a point of reception of the direct and reflected from layered not uniformity of the troposphere beams of $T_{int}$ ($V_{min}$); weakening of a signal because of rainfall, to be exact because of rains of Td ($V_{min}$). The component That ($V_{min}$) caused by a land relief can be not considered since antennas are installed on support rather highly and a gleam on all flights more than the minimum. Calculation of total percent of time of disruption of communication is spent on a formula:

$$T_{\Sigma}(V_{\min}) = T_{инт}(V_{\min}) + T_{Д}(V_{\min}),\% \quad (3.6)$$

The percent of time of disruption of communication because of interference is defined as:

$$T_{инт}(V_{\min}) = V_{\min}^2 * T(\Delta\xi)\%, \quad (3.7)$$

Where: $V_{min2} = 100{,}1 \cdot V_{min}$ – minimum admissible value of a multiplier of easing in relative units ($V_{min}$ – from table 4.9 in dB);

T (Δ ξ) – the probability of the interferential dying down caused by reflection expressed as a percentage with jump of dielectric permeability equal Δ ξ calculates from layered not uniformity of the troposphere on a formula:

$$T(\Delta\xi) = 4.1*10^{-4} * \xi * R^2 * \sqrt{f^3}, \quad (3.8)$$

Where: $\xi = 1$ – proportionality coefficient for overland areas;

R – between BS (flight length) km;

f = 36 GHz – the working frequency of MIK-RL stations.

The type of the dying down caused by dispersion of electromagnetic energy in a rain significantly is shown when the wavelength of the transferred fluctuations is commensurable with sizes of a rain drop. Such dying down is especially shown at frequencies over 8 GHz. Thus loss of downpours can lead to a dying down so deep that communication during heavy rain interrupts. Percent of time of the disruption of the communication caused by a dying down of this look.

Example of calculation of time of disruption of communication of one flight

We will consider flight No. 1:

On (3.9) we define:

$$T(\Delta\xi) = 4.1*10^{-4} * \xi * R^2 * \sqrt{f^3} = 4.1*10^{-4} *1*6^2 * \sqrt{36} = 0.089\% \quad (3.9)$$

Now, using $V_{min}$ values from formula 3.9. on (3.10.) we find:

For $r_{ош} = 10^{-3}$:

$$T_{инт}(V_{\min}) = V_{\min 2} * T(\Delta\xi) = 0.395*10^{-4} * 0.089 = 2.9*10^{-4}\% \quad (3.10)$$

Here $V_{min2} = 100{,}1 \cdot V_{min} = 100{,}1 *(-34{,}87) = 0{,}395 \cdot 10^{-4}$ (3.11)

The size of $T_d$ ($V_{min}$) is defined on the basis of dependence of a multiplier of weakening of V from intensity rainfall of Id and statistical distribution of this intensity:

$V(I_d) = -\gamma(I_d)$ of $\cdot K_r(I_d)$ of $\cdot R$, (3.12)

Where: $\gamma(I_d)$ – dependence of running easing on intensity of rainfall:

$\gamma(I_d) = \beta_д \cdot I_{дαд}$, (3.13)

here parameters $\alpha_д$ and $\beta_д$ – are functions of frequency:

$\alpha_д = 1{,}47 - 0{,}395 \cdot$ (3.14)

$\beta_д = -10^{-3} + 5{,}1 \cdot 10^{-5} \cdot f\, 2{,}45$, (3.15)

Kr (Id) – the coefficient considering spatial unevenness of loss of rainfall and depending on their intensity of Id and length of flight of R. Calculation of dependence of V (Id) on (3.13) – (3.14) is presented in formula 3.15. form.

Table 3.2.

Calculation of dependence of V (Id)

| $I_д$ , mm/hour | $Kr(I_д)$ | $\gamma(I_д)$ , Db/km | $V(I_д)$ |
|---|---|---|---|
| 30 | 0,95 | 7,8 | – 44,5 |
| 50 | 0,89 | 12,5 | – 66,7 |
| 70 | 0,82 | 17,9 | – 84,5 |
| 90 | 0,73 | 21,7 | – 95 |
| 150 | 0,6 | 35 | – 126 |

Now of the V (I) for minimum admissible value multiplier of weakening of $V_{min}$ = –34,87 dB (from table 4.9 for $r_{osh} = 10^{-3}$) we determine the most admissible intensity of rains of Imax of 53 mm/hour for this flight by the calculated dependence.

Further we determine $T_d$ ($V_{min}$) by the found intensity of rains = 0,015% for a midland of the territory of in some state. Now on (4.9) we define time of disruption of communication on this flight:

For $r_{osh} = 10^{-3}$:

$T_{\sum}(V_{min}) = T_{int}(V_{min}) + T_d(V_{min}) = 0{,}00004 + 0{,}015 = 0{,}01504\%$.

Results of calculation are presented in table 3.3.

Table 3.3.

Results of calculation

| №№ flight | Vmin, дБ | R, дБ | T(Δξ),% | Tint, % | Imax, mm/hour | Тд, % |
|---|---|---|---|---|---|---|
| 1-11 | - 34,87 | 6 | 0,089 | $2,9 * 10^{-5}$ | 53 | 0,015 |

## 3.4.SAFETY IN THE LTE NETWORKS

Safety in the LTE networks consists in several types:

- Protection of subscribers.
- Protection of the transferred messages.
- Enciphering of messages.
- Authentication and subscriber, and network.

Protection of the subscriber is that in the course of service hide him temporary identifiers. For closing of data in the LTE networks stream enciphering by an imposing method on open information of pseudorandom sequence (PSP) by means of the operator XOR is used (excluding or). In these networks the principle of tunneling of connections is applied to safety in a network. Encoding can subject S1 and X2 packages by means of IPsec ESP, and also encodings alarm messages of these interfaces are exposed. At the time of connection or activation of the subscriber equipment (UE) in networks, a network starts procedure of authentication and the agreement on keys of AKA (Authentication and Key Agreement). The purpose of this procedure is mutual authentication of the subscriber and a network and development of an intermediate key of KASME. Operation of the AKA mechanism occupies fractions of a second which are necessary for development of a key in the USIM application and for establishment of connection with the Center of registration (HSS). Thereof, for achievement of speed of data transmission of the LTE networks it is necessary to add function of

updating of key information without initialization of the AKA mechanism. For the solution of this problem in the LTE networks it is offered to use hierarchical key infrastructure.

Here too, as well as in networks 3G, the USIM appendix and the Center of authentication (AuC) carry out preliminary distribution of keys. When the AKA mechanism is initialized for implementation of bilateral authentication of the user and a network, the key of enciphering of CK and a key of the general protection which then are transferred from PO USIM in the Mobile equipment (ME) and from the Center of authentication in the Center of registration (HSS) are generated. ME and HSS, using key couple (CK; IK) and ID of the used network, develops KASME key.

Having established dependence of a key on an ID network, the Center of registration guarantees possibility of use of a key only with this network. Further KASME is transferred from the Center of registration to the structure of mobile management (MME) of the current network where it is used as a master key. On the basis of KASME the key of Knas-enc which is necessary for enciphering of data of the

NAS protocol between the mobile device (UE) and MME, and Knas-int necessary for protection of integrity is developed. When UE is connected to a network, MME generates a key of KeNB and transfers him to base stations. In turn, from a key of KeNB Kup-enc key used for enciphering of the user data of the U-Plane protocol, Krrc-enc key for the RRC protocol (Radio Resource Control - the protocol of interaction between Mobile devices and base stations) and Krrc-int key intended for protection of integrity is developed.

The algorithm of authentication and generation of a key is presented in fig. 4.1.

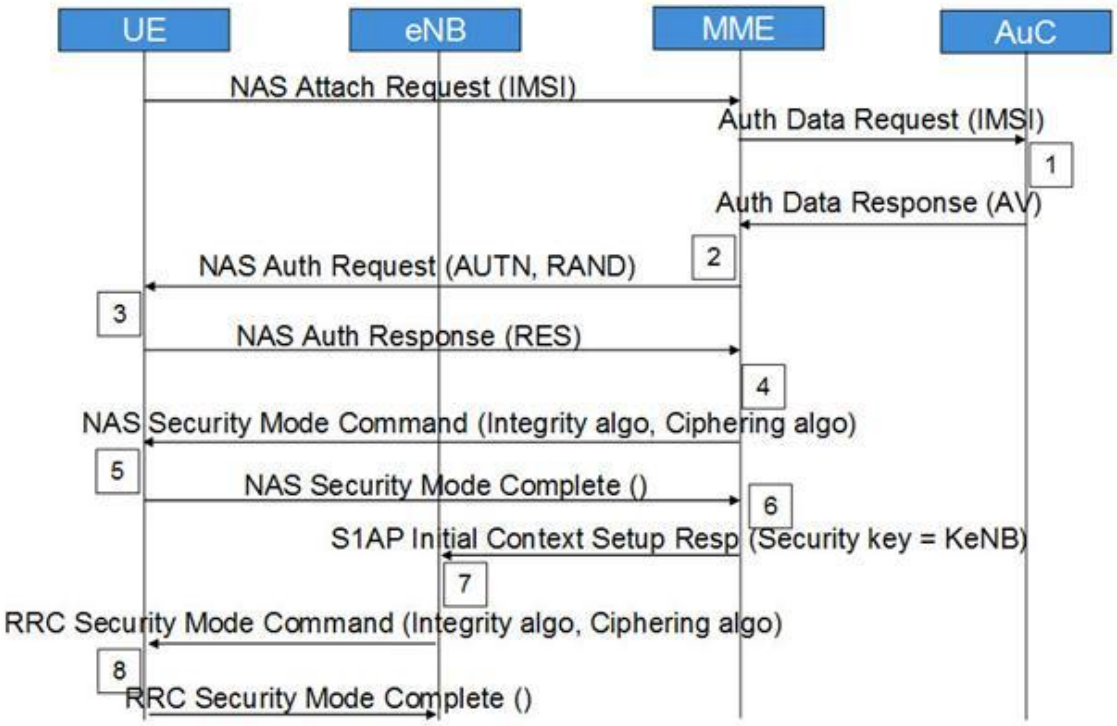



Fig.4.1. Chart of authentication and generation of a key

Here:

Step 1. Request for connection to a network from mobile station (UE). MME requests the authentication data relating to concrete IMSI, sending Authentication Data Request. AuC/HSS chooses PSK relating to concrete IMSI and calculates authentication data on PSK. AuC/HSS sends back AV with Authentication Data Response.

Step 2. MME receives IK, CK, XRES, RAND and AUTH from AV. MME sends AUTH and RAND by means of Authentication Request to UE.

Step 3. UE authenticates NW, checking the received AUTH. Then calculates IK, CK, RES, XMAC from the key of protection, AMF, (OP), AUTH and RAND. She sends RES with Authentication response.

Step 4. After receiving RES, MME compares it to XRES and if they coincide, authentication took place successfully; otherwise, MME sends failure of authentication (Authentication failure) to UE. MME dumps the NAS counter DL. Counts KASME, KeNB, Knas-int, Knas-enc. Sends NAS team of the mode of safety (algorithm of integrity, algorithm of enciphering, a NAS set of keys of ID,

function of safety of UE) with integrity protected, but not ciphered, using Knas-inc.

Step 5. After receiving NAS team of the mode of safety, UE calculates KASME, KeNB, Knas-int, Knas-enc. UE sends the NAS mode of safety is executed with integrity, protected and ciphered.

Step 6. After receiving NAS command of the mode of safety from UE, MME sends KeNB to eNB with S1AP initial installation of an initial context (a protection key).

Step 7. After receiving KeNB, eNB calculates Krrc-int, Krrc-enc, Kup-enc. Then it sends to RRC a protection key team with AS integrity of algorithm and AS the ciphering algorithm.

Step 8. After receiving RRC team of a key of protection of UE calculates Krrc-int, Krrc-enc, Kup-enc. UE sends to RRC the executed enciphering key to eNB.

After all described actions, all NAS and AS of the message will be reliably protected and ciphered, unlike the user data which will only be ciphered.

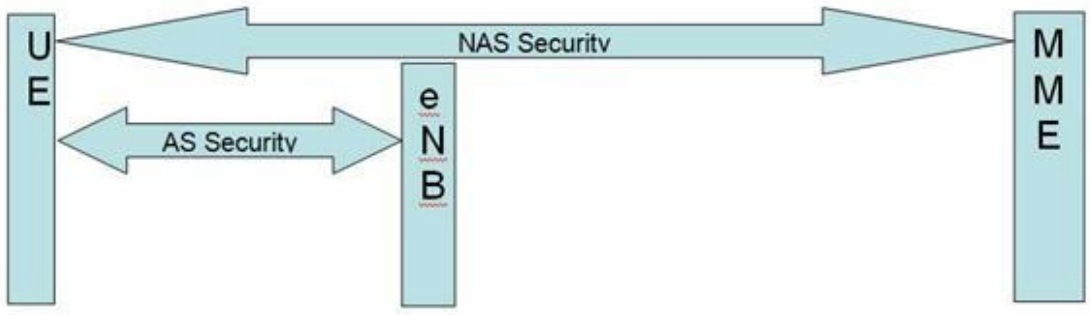



Fig. 4.2. Safety layers

The architecture of safety of LTE defines the mechanism of safety and for the NAS level and for the AS level. Safety of NAS (a layer without access):

It is executed for NAS of messages and belongs to the UE and MME area.

In this case it is necessary at transmission of messages of NAS between UE and MME – the integrity protected and ciphered with additional heading of safety of NAS. Safety of AS (a layer with access):

It is executed for RRC and the plane of the user data belonging to the UE and eNB area. The PDCP level on the parties of UE and eNB is responsible for enciphering and protection of integrity. RRC of the message are protected by integrity and ciphered, however data of U-Plane are only ciphered. For generation of vectors of authentication the cryptographic algorithm by means of the unidirectional functions is used (f1, f2, f3, f4, f5) when the direct result turns out by simple calculations, and the return result can't be received by a way back, that is there is no effective algorithm of receiving the return result. For this algorithm the casual 128 bit random number of RAND, a master key of K subscribers, also 128 bits and serial number of the SQN procedure (Sequence Number) is used. The SQN counter changes the value at each generation of a vector of authentication. The similar SQN counter works and in USIM. Such method allows generating every time a new vector of authentication, without repeating the previous already used authentication vector. Besides these three initial sizes: SQN, RAND and K in algorithm of f1 participates a field of management of authentication of Authentication Management Field (AMF), and in algorithms of f2 – f5 initial parameters – RAND and K, as is shown in fig. 4.1. At the exits of the corresponding functions receive Message Authentication Code (MAC) - 64 bits; XRES – expected Response, result of work of algorithm of authentication <32 – 128 bits>; the key of encoding of SK generated with use entering (K, RAND)-> f3-> CK; the key of integrity of IK generated with use entering (K, RAND)-> f4-> IK; and the intermediate key of Anonymity Key (AK) generated with the help (K, RAND)-> f5-> AK - 64 bits. At service of the subscriber the E-UTRAN network keys of CK and IK in open form don't transfer to a kernel of a network. In this case HSS generates KASME by means of algorithm of KDF (Key Derivation Function) for which initial parameters are CK and IK, and also the identifier of the serving network and SQNÅAK. The vector of

authentication contains RAND, XRES, AUTN and KASME on the basis of which there is a generation of keys of encoding and the integrity used in the corresponding algorithms.

When the mobile station receives from a network kernel three parameters (RAND, AUTN and KSIASME, where KSI – Key Set Identifier, the indicator of the established key which is unambiguously connected with KASME in mobile station). Then using RAND and AUTN, USIM on the basis of the algorithms of safety identical stored in HSS, makes calculation of XMAC, RES, CK and IK. Then in the answer of RES UE transfers the calculated RES which has to coincide with XRES received from HSS in MME. So the network authenticates the subscriber.

Having calculated XMAC, UE compares it to MAS received by it in AUTN. At successful authentication by the subscriber of a network (MAS = HMAS) UE reports about it in the answer of RES. If authentication of a network wasn't successful (MAS ≠ to HMAS), UE sends the answer of CAUSE where specifies the authentication failure reason to MME.

At a successful completion of the previous stage MME, eNB and UE make generation of the keys used for encoding and check of integrity of the received messages. In E-UTRAN there is a hierarchy of keys which is given in fig 4.2.

Vectors of authentication (fig. 4.3.): Keys of IK and CK are generated and in the center of authentication, and in USIM; The key of AK is generated only in the center of authentication;

The answer of XRES is generated only in the center of authentication, and RES is generated in USIM; The MAC code is generated only in the center of authentication, and the XMAC parameter corresponding to it is generated in USIM;

Fig. 4.3. Creation of vectors on the transferring party

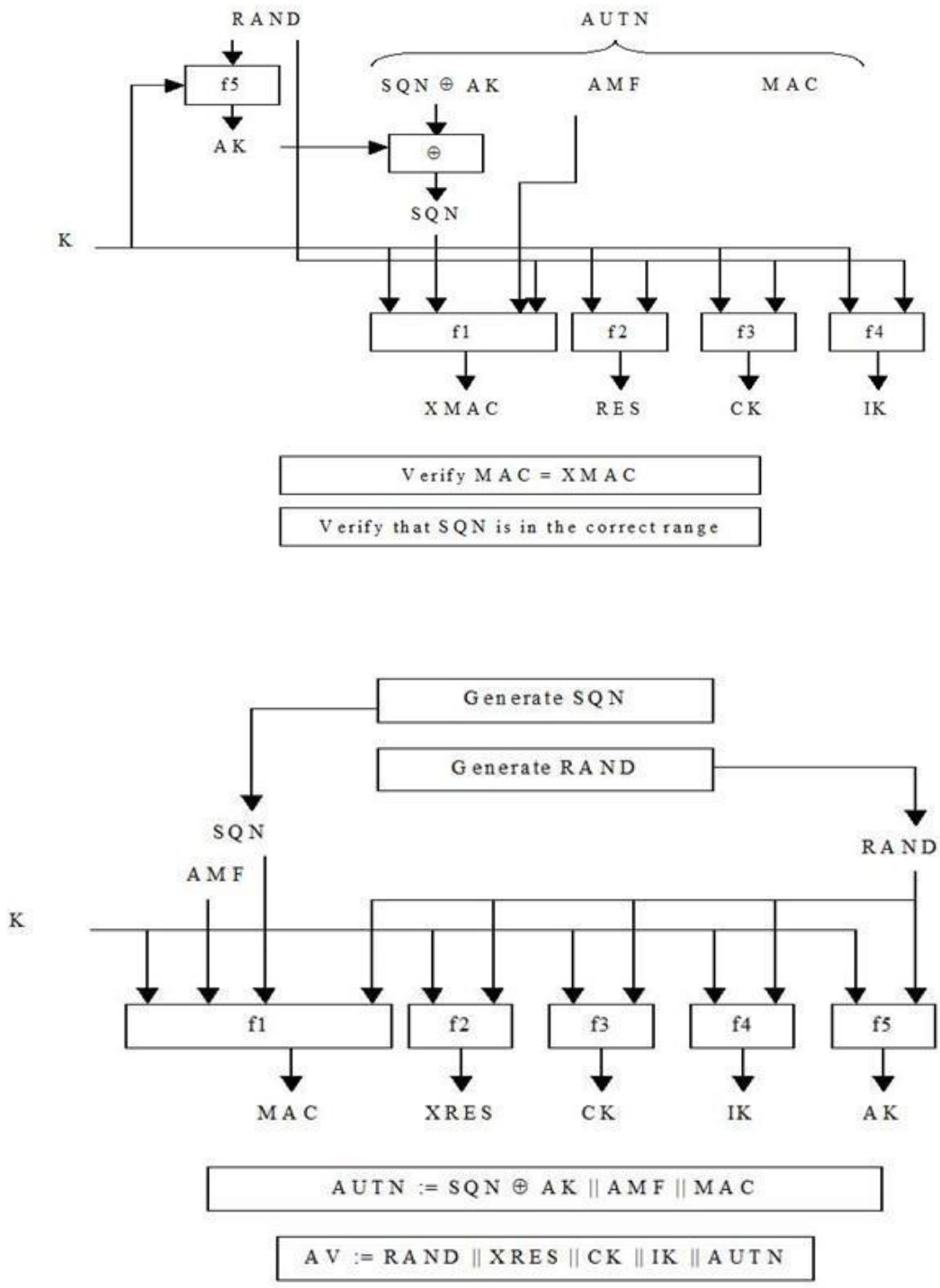



Fig. 4.4. Transformation of vectors on the reception party (in USIM)

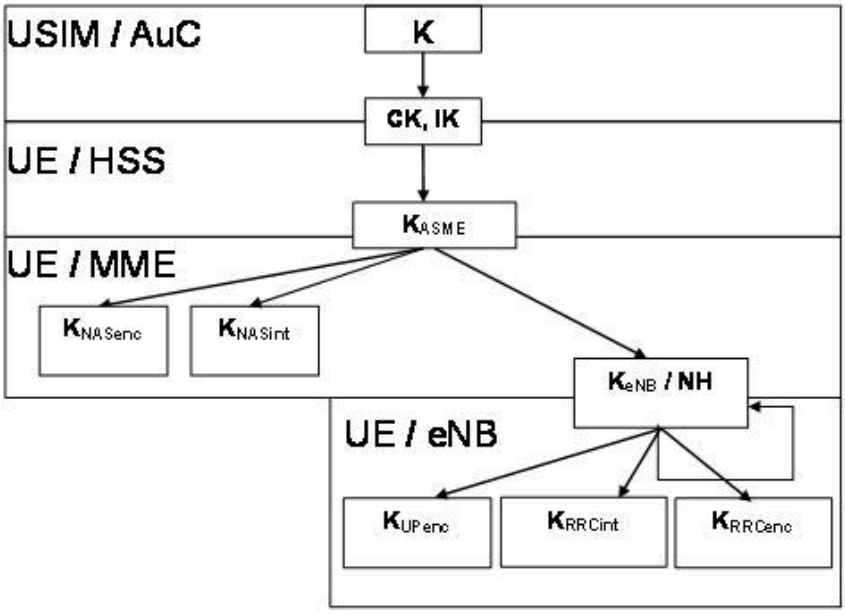



Fig. 4.5. Hierarchy of keys in E-UTRAN

Initial key for all chain is KASME (256 bits). By transfer in a radio channel protection is provided for an alarm traffic (Control Plane) and for the user packages (User Plane). Thus all messages of the alarm system divide into through alarm messages between UE and MME of the MM and SM protocols (NAS – Non Access Stratum) and alarm messages between RRC protocol eNB (AS – Access Stratum). For encoding and protection of integrity it is possible to use different basic algorithms:

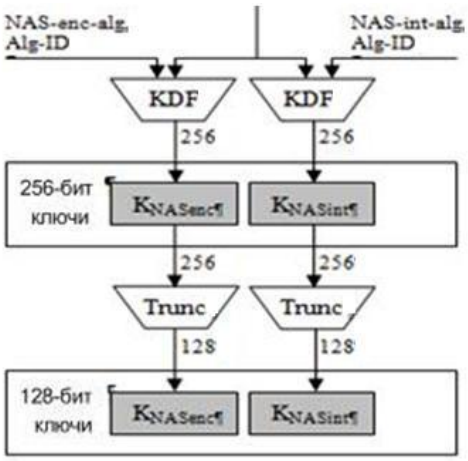



Fig. 4.6. Generation of keys of encoding and integrity for the NAS alarm system

Alarm messages of the RRC (AS) protocol also cipher and provide their integrity. Traffic packages only cipher. These operations make in the serving eNB and UE. The scheme of receiving keys of encoding and integrity (fig. 4.6) for AS and UP of a traffic differs from the previous case in that as initial parameter the secondary intermediate key of KeNB (256 bits) serves here. This key is generated, also using KDF where input parameters are: KASME, the counter of alarm messages of NAS up, former KeNB value, the identifier honeycombs and number of the frequency channel in the direction up. Therefore, at each periodic localization of UE there is a change of KeNB.

Also KeNB changes and at a hendover; thus in algorithm of generation of new KeNB it is possible to use the additional NH parameter (Next Hop), actually the counter of number of the base stations, on a chain serving the subscriber. All realized procedures of safety in the E-UTRAN network are shown in fig.

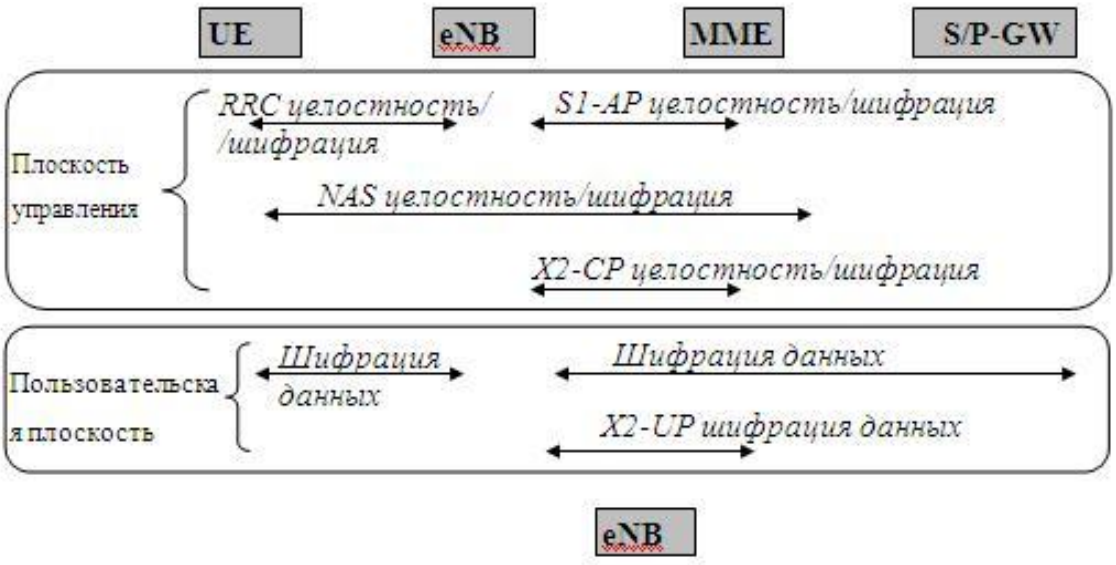



Fig. 4.7. The realized procedures of safety in the E-UTRAN network

The algorithm of encoding and decoding of messages is presented in fig.

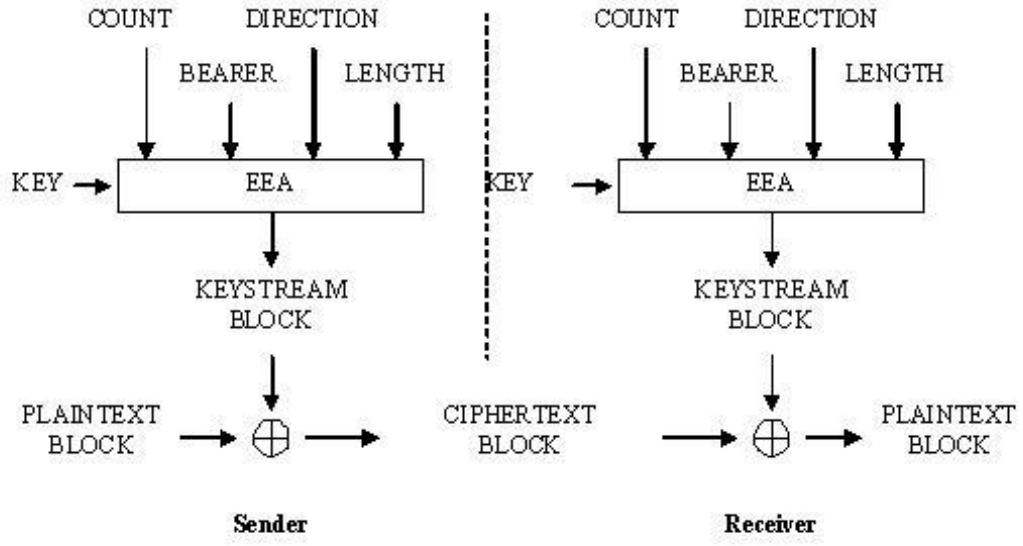



Fig.4.8. Algorithm of encoding in E-UTRAN

Initial parameters in this algorithm are the ciphering KEY key (128 bits), the counter of packages (blocks) of COUNT (32 bits), the identifier of the through BEARER channel (5 bits), a DIRECTION broadcast direction sign (1 bit) and length of ciphering LENGTH key. According to the chosen algorithm of encoding of EEA (EPS Encryption Algorithm) the ciphering number of KEYSTREAM BLOCK which by transfer put on the module two with the ciphered source text of the PLAINTEXT BLOCK block is developed. When decoding on the reception end repeatedly make the same operation.

Procedure of protection of integrity of the message consists in generation of "tail" of MAS (Message Authentication Code) (32 bits) attached to the transferred package. The algorithm of generation of MAS and check of integrity of the received package by comparison of HMAS with MAS (they have to coincide) is displayed in fig.4.9.

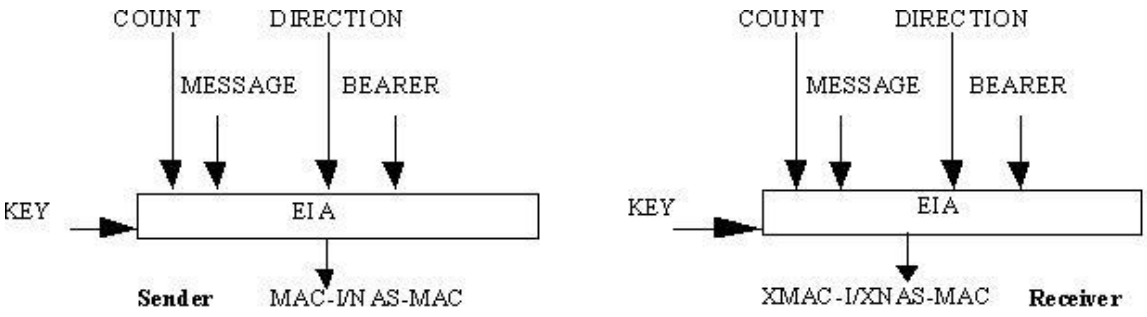



Fig. 4.9. Algorithm of check of integrity in E-UTRAN

In algorithm of EIA (EPS Integrity Algorithm) the key of integrity of KEY (128 bits), the counter of messages of COUNT (32 bits), the identifier of the through BEARER channel (5 bits), a DIRECTION broadcast direction sign (1 bit) and the message of MESSAGE is used.

**Summary**

Here we calculate also constructed the schedule for some number of active subscribers on sector when loading in several values to recognize minimum speed of connection . Because we should have determined the optimum speed and number of active subscribers in sector.

As we say earlier we find optimal speed and number of active subscribers in sector.We consist it at 3 parts and allocated with multi-colored lines that it was clear.

# 4. SAFETY ENGENEERING AND ECOLOGY

## 4.1. Rational organization of work place

The complexity of production processes and equipment changed the functions of the person in modern industry: increased responsibility of tasks; increased volume of information perceived by the working and the performance of the equipment. A person's work has become more difficult, increased load on the nervous system and increased physical load. In some cases, the man has become the least reliable link of the system «man-machine». There is a task of providing reliability and safety of persons at work. Solves this task ergonomics and engineering psychology.

Ergonomics (from the Greek ergon work and nomos - law) is the scientific discipline that studies the human in terms of its activities related to the use of machines. The goal of ergonomics - optimization of conditions of work in the system "man-machine". Ergonomics defines the requirements of the person to technology and to the conditions of its functioning. The ergonomics of the equipment is the most generalized index of properties and other characteristics of equipment.

The connection of the man with the environment and the parameters of the workplace. Working place, this is the area in which the committed work of the performer or group of performers. Jobs may be individual and collective, universal, specialized and special.

General requirements, which must be observed when designing jobs, the following:

• adequate working space for the person;

• optimum position of the body of the worker;

• sufficient physical, visual and auditory communication between man and machine;

• optimal allocation of working space in the room;

• the permissible level of action of factors of production conditions;

•the optimal placement of the information and the motor field;

• availability of means of protection from hazards.

Design should provide the zone of optimum and easy reach of the motor field of the workplace and the optimal area of the information field of the workplace. Angle of view in relation to the horizontal should be 30-40 degrees. The choice of working arrangements should take into account the efforts expended by the man, the magnitude of the movements, the need for movement, the pace of operations. The choice of working postures should take into account the physiology of man and parameters of working places determined by the choice of the position of the body at work (standing, sitting, a variable). Jobs for work «sitting» are organized in an easy job and middle severity, and the severe - working posture -"standing".

In the design of equipment and organization of a job it is necessary to foresee the possibility of regulating the individual elements, in order to ensure the optimum position of the operator.

The design of the equipment must ensure that it meets the anthropometric and bio mechanical characteristics of the individual on the basis of accounting change dynamics of the amount of heat when you move, the range of motion in joints.

For the account in the design of equipment anthropometric data should: • determine the contingent of people for whom is designed equipment;

• select a group of anthropometric characteristics;

• install the percentage of working, which must meet the equipment; • determine the boundaries of the interval size (efforts), which should be implemented in the hardware.

When designing the use anthropometric dimensions of the body, and take into account the differences in the sizes of the body of men and women, nationality, age, professional. To determine the boundaries of the intervals, which take account of the percentage of the population, the system is used pertseteley.

Design of the equipment should provide the ability to use at least for 90% of consumers.

To work in a position "sitting" are used by various operating seats. Distinguish workers seat for long and short term use. General requirements for the seat of long use of the following: the seat should ensure position, minimizing the statistical work of muscles; create conditions the possibility of changes in working postures; not to obstruct the activities of the systems of the body; to ensure the free movement relative to the working surface, have adjustable parameters; have the floor upholstery. For short-term use is recommended hard chairs and a different type of stools.

In the conditions of growing mechanization and automation of production processes is of special significance means of display of the information about the object of management. Widespread use of the received information model, that is organized according to certain rules information about the status of the object of control.

The information models of the following requirements:

• the content of the information model should adequately display the object of management;

• information model should provide the best information balance;

• the shape and composition of the information of the model must be consistent with the labor process and possibilities of man for the reception of the information.

Practice makes it possible to outline the sequence of the development of an information model: definition of the objectives of the system, the sequence of their decisions and sources of information; drawing up a list of control objects and their characteristics; the distribution of objects on the degree of importance; the distribution of functions between automation and man; the choice of coding of objects and drawing up of the overall composition models; determination of Executive actions of man.

In the process of constructing information model are determined by the location of the media in the workplace, are selected dimensions of marks and the layout of. Displaying means are placed in the field of view of an observer with the account of optimum corners and observation areas. Dimensions signs monitoring are determined taking into account maximum accuracy and speed of perception of the information, as well as the brightness of the character, magnitude contrast, the use of color. Optimum brightness are considered to be the value at which the maximum contrast sensitivity. The value of it will be greater, the smaller the size of the object of discrimination. Optimal area size contrast is 60-90%. In the work of the eyes is a place of a certain inertia, which requires taking into account the time of exposure of the optic signal and the time intervals for the sense of separate signals the following one after the other. In most cases, the exposure time of the signal should be no less than 50 MS. Each variety of indicators has its area of use: indicators backlit used for the display of high-quality information that requires an immediate response of the operator; gauges are used for the reading of the measured parameters; integral indicators for combining information immediately on several parameters.

The structure and dynamics of the controlled object are usually with the help of a chip. In some cases the scoreboard used to display information and perception of the team of operators.

In the design of the workplace should take into account the rules of the economy's movements: when using two hands of their motion should be simultaneous and balanced; movement should be smooth and rounded, rhythmic and customary for working. The design of the equipment shall take into account the rules relating to the speed and accuracy of workers ' struggles. For example, the most rapid movement to itself; in the horizontal plane of the hand speed more than in the vertical; the accuracy of movements better in a sitting position, than standing, etc. Controls, used in the workplace must comply with the General requirements of ergonomics: and direction of the management bodies must comply with the movement associated with him indicator; the compliance of the location

of the management bodies of the sequence of work of the operator; ease of use; the creation of the bodies of the Board of mechanical resistance and etc. In addition, for each type of bodies of pressure corresponds to a specific area of use and the special requirements of the size, form, effort, etc.

The automated workplace of the operator-Communicator (the operator in the control room) in the General case are used:

- means of mapping the information of individual use (imaging units, signaling devices, and so on);

- means of control and input of information (remote the display, keyboard control, separate controls, and so on);

- devices of communication and transmission of information (modems, telegraphic and telephone sets):

- the device documentation and storage of information (printing devices, magnetic recording and so on);

- auxiliary equipment (means of office equipment, the storage media, the device of local lighting).

At the automated working place should be provided with information and constructive compatibility used by technical means, of anthropometric and physiological characteristics of the person.

At optimization of the procedures of interaction between operators of telecommunications workers with technical means in the conditions of automation ergonomic factors act as the main determining the probability-time characteristics and the intensity of the work. These factors are sensitive to variations of individual properties of the operator.

Working the furniture should be comfortable for the execution of planned operations. The design of the working furniture: table, chairs is of great importance for the creation of healthy environments and highly productive work. Working the furniture is designed with consideration of anthropometric data of a human, technical, aesthetic and economic factors.

In the complete set of the working furniture of great importance is the design of the production of a chair, as it depends on the attitude of the employee and, therefore, energy consumption and the degree of its strain. Operating the seat must have the required dimensions, the relevant anthropometric data of the person and be flexible. The most comfortable chairs and seats with adjustable back tilt and height of seat. Changing the height of the seat from the floor and back angle, you can find the most appropriate labour process and the individual characteristics of the employee.

As a rule, all the surface of the written and desktops should be at the level of the elbow in the position of a person. When choosing the height of the table should be considered a man sits during work or stands.

The inconvenient of the table height reduces the efficiency of work and causes rapid fatigue. The lack of sufficient space for the knees and feet cause constant irritation of the employee. Minimum operating table height should be not less than 725 mm. As practice shows, for the working medium height the height of the desktop is accepted 800 mm. For the employee of another growth you can change the height of the working chair, or the position of the boards so that the distance from the object processing before the eyes of the working height is equal to approximately 450 mm.

Accommodation of the technical means and the chair of the operator in the working zone should provide easy access to the main functional nodes and units of equipment for conducting technical diagnostics, preventive inspection and repair; the ability to quickly occupy and to leave the work area; the exception of accidental actuation means of control and input of information; comfortable working posture and position of rest. In addition, the scheme of accommodation should meet the requirements of integrity, compactness and technical and aesthetic expressiveness of the working postures.

The display must be placed on a table or stand so that the distance of observation on the screen does not exceed 700 mm (optimal distance of 450 - 500 mm). Display screen height must be located so that the angle between the centre of

the screen and horizontal line of sight was 200. Horizontal viewing angle of the screen should not exceed 600. The remote display to be placed on a desktop or stand so that the height of the keypad in relation to sex was 650 - 720 mm. When placing the remote control on a standard desktop height of 750 mm it is necessary to use the seat with height adjustable seat (450 - 380 mm) and the footrests. Document (form) for entry operator data it is recommended to have at a distance of 450 - 500 mm from the eyes of the operator, predominantly on the left, with the angle between display screen and the document in the horizontal plane shall be 30 40 degrees. The tilt angle of the keyboard should be equal to 15 degrees.

Display screen, documents and keypad display should be located so that the difference of brightness surfaces, depending on their location relative to the source of light, not more than 1:10 (the recommended value 1:3). At nominal values of brightness of the image on the screen 50 - 100 CD/m2 illumination of the document should be 300 - 500 Lux.

Working place should be equipped in such a way that the movement of an employee would be the most efficient, least tedious.

The device documentation and other, rarely used by technical means, it is recommended to concentrate on the right from the operator in the zone of maximum reach and means of communication to the left, to free the right hand for the entries.

## 4.2. Emergencies

In theory safety emergencies - is a set of events, the result of the onset of which is characterized by one or more of the following signso

a) danger to life and health of a significant number of people;

b) the material violation of the ecological balance in the area of the emergency;

c) the failure of the life support systems and control, full or partial cessation of economic activities;

d) significant material and economic damage;

e) the need to involve large as the usually external to the area of emergency forces and means for the salvation of men and the elimination of consequences;

e) psychological discomfort for large groups of people.

It is characteristic that emergency arises outwardly suddenly, suddenly. Specification of definition of the emergency is achieved by introduction of quantitative measures of the dangers.

The classification of emergencies.

For reasons of emergencies are of natural, man-made, man-made, environmental, and social.

To the natural (natural) emergency situations are dangerous natural phenomena or processes that have extraordinary in nature and lead to a breach of everyday life more or less significant groups of the population, loss of life destruction of material values. These include earthquakes, floods, tsunamis, volcanic eruptions, mudflows, landslides, avalanches, hurricanes and Smer-Chi, massive forest and peat fires, snow and avalanches. The number of natural disasters are also droughts, long-term heavy rains, strong stable frosts, epidemics, epizootics, epidemics, mass distribution of pests of agriculture and forestry.

Natural disasters can happen: as a result of rapid movement of the substance earthquakes, landslides); in the release of within the earth's energy (volcanic activity earthquakes) at increasing the overall level of rivers lakes and seas floods tsunamis) under the influence of an unusually strong wind ahurricanes cyclones. Some natural disasters fires avalanches landslides, etc..may arise as a result of the actions of the people themselves but their consequences are always the result of the action of the forces of nature. For each natural disaster characterized by the presence of intrinsic in the affecting factors, adversely affecting human health.

Natural disasters are a tragedy of the entire state and especiallyo for those areas where they occur. As a result of natural disasters are affecting the economy of the country since the collapse of production of the enterprise the destruction of material values and most importantlyo there are losses among the peoplee killed their housing and property. In addition, natural disasters pose extremely adverse

conditions of life for the population, which may be the cause of outbreaks of infectious diseases. The number of people affected by natural disasters can be considerable and the nature of the lesions is very diverse. Most people suffer from floods (40% of the total damage), hurricanes (20%), earthquakes and droughts (15%). About 10% of the total damage is on the other types of disasters.

A number of Soviet and foreign experts, citing data on the losses in major disasters assume that in the future in connection with the growth and concentration of population similar in the force of the disaster will be accompanied by an increase in the number of casualties in the tens of times.

Man-made emergency situations is considered a sudden failure of machines, mechanisms and units during their operationи accompanied by serious violations of the production processc the explosions the formation of fire radioactive chemical or biological infections of large territories a group of damage destruction of people. To technogenic emergencies are accidents at industrial facilities constructione as well as on railм airo roado pipeline and water transport as a result of which the firesa the destruction of civil and industrial buildingsa there was a danger of radioactive contaminationя chemical and bacterial contaminationт there was the spreading of the oil products and aggressive poisonous liquid on the surface of earth and water and there are other consequences endangering human health and the environment.

The nature of the consequences of technogenic catastrophes depends on the type of accident, its scale and characteristics of the enterprise, where the crash occurred (on the means of transport and the circumstances in which the accident occurred.

Anthropogenic emergency situations are the consequence of the erroneous actions of the personnel. This class of emergency can occur at the same objects that and man-made emergency situations. The difference consists only in the fact that man-made emergency situations is not connected with the human factor directly.

The emergency ecological character may include: intensive degradation of the soil and its pollution by heavy metals (cadmium, lead, mercury, chromium, etc.) and

other harmful substances, polluting the atmosphere of harmful chemical substances noise electromagnetic fields acid rain the destruction of the ozone layer, etc.
To the social emergency relate the events taking place in the society robbery violence) ethnic conflicts accompanied by the use of force contradictions between the States with the use of weapons.

## Summary

This section covers matters of rational organization of work place , emergencies . Working the furniture should be comfortable for the execution of planned operations. The design of the working furniture: table, chairs is of great importance for the creation of healthy environments and highly productive work. Working the furniture is designed with consideration of anthropometric data of a human, technical, aesthetic and economic factors.

# CONCLUSION

Experts note that on the way of introduction to operation of networks 4G there is a number of obstacles. First, in the market not enough subscriber devices. Such phones would consume too much energy and can't work still long at accumulators (now similar problems are and at 3G-devices). Secondly, high-speed Internet access and video services will demand big by the size and better displays, than what are established in phones now. But the main problem nevertheless has essentially other character. The matter is that capital investments in expansion of networks of the fourth generation have to be much more solid, than in 2G and even in 3G. Meanwhile, investors including venture while are very cautious — they aren't sure of due economic return from 4G-projects. Besides, some producers suggest "to cross" 4G and wireless broadband networks. In different situations the user will have opportunity to choose the most suitable ways of connection.

Alternation of generations is expressed in cellular communication much more brightly, than, say, in the industry of personal computers or other similar equipment. In the mobile world everything is accurate: 1G (the first generation) — it is analog communication (NMT standard). 2G — generation of digital communication with switching of channels (GSM and CDMA standards). The third generation — 3G (UMTS standard) — provides along with switching of channels and a packet transmission of data. About mobile communication 3G now speak literally as about a progress symbol much. But before our eyes there is a surprising thing: forward already next generation of cellular communication called 4G escapes. If so goes further, networks 3G won't develop at full capacity — their place will take 4G. In my understanding the LTE technology gives chance will come nearer to high efficiency in mobile networks of new generation. Due to these it is possible to draw conclusions that the LTE technology will develop further and will advance thus other technologies one step bigger. 4G/LTE communication of the next generation and we have to improve it.

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