BROAD USER MODELS OF CHANNEL RESOURCES OF LTE TECHNOLOGY

Olimboy Olimov
Urgench branch of Tashkent University of Information
Technologies named after Muhammad al-Khwarizmi Urgench, Uzbekistan
olimovolimboy274@gmail.com

Azadov Izzat
Urgench branch of Tashkent University of Information
Technologies named after Muhammad al-Khwarizmi Urgench,Uzbekistan
azadovi@ubtuit.uz

Jumaboyeva Marhabo
Urgench branch of Tashkent University of Information
Technologies named after Muhammad al-Khwarizmi Urgench, Uzbekistan
jumaboyevamarhabo@gmail.com

Abstract

Long Term Evolution mobile communication technology channel resource allocation methods and standards, as well as Round Robin Scheduler, Max C/I Ratio, Best CQI scheduling, Proportional Fair Scheduling algorithm, each has its own function and determines the speed. In terms of the balanced distribution of the bandwidth of the communication channel, the Round Robin and Proportional Fair methods have the best performance and it is found that it is one of the effective methods to ensure the required speed. In Long-Term Evolution technology, transmission can be achieved by solving the distribution problem. As a result of the analysis, we found out the shortcomings of certain methods, as well as promising requirements for solving the problem of allocation of planning blocks between user stations. Using test environments, we modeled the Long-TermEvolution channel resources at two different frequencies in the frequency range below 6 GHz and above 2 GHz in Matlab environment and were able to analyze to see the signal-to-noise ratio level.

Keywords— LTE, HSPA, SDMA, Round Robin, GPP, OFDM.

Introduction

Mobile broadband is entering our lives in rapid succession. According to Ericsson's calculations, in 2011 the number of users of broadband communication services was 1.5 billion. And more than half of them are using the mobile option of communication. Also,Ericsson's according to the company, by 2015, the number of mobile broadband users will reach 3.8 billion, and 95 percent of them are expected to use HSPA(High Speed Packet data Access), CDMA (Code Division Multiple Access) and LTE networks.

Today, users of mobile systems services are:

- using web resources or sending e-mails using phones and laptops that support HSPA;
- using HSPA modems instead of DSL(Digital Subscriber Line) modems;

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• using 3G phones, they use a number of possibilities, such as sending large video and audio files.

The LTE standard, which is coming as the 8th release of the 3GPP project, should be a significant step for the development of the mobile communication system. According to the developers, users will clearly feel these benefits when using resource-intensive services and applications (interactive TV, user-generated video clips, complex games and professional services)[1].

Some of the key requirements for next-generation systems in the 3GPP project are listed below:

• the highest value of the data transmission speed in the "down" direction - not less than 100 Mbit/sec, and the response delay time in the radio network should not exceed 10ms;

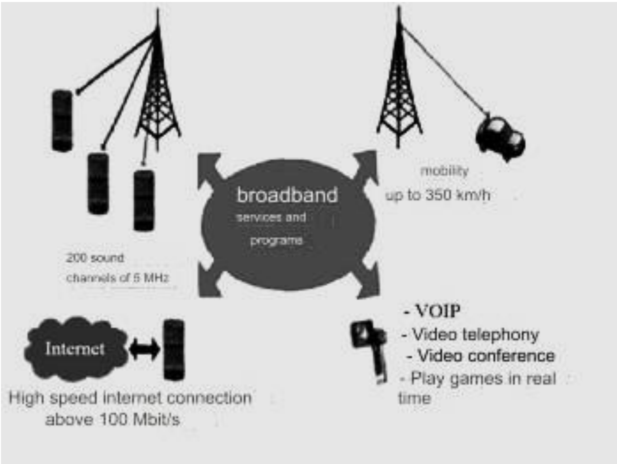

Fig.1. Broadband services and new applications available on LTE networks.

• ease of using different carrier frequency bands, that is, smooth transition from one carrier to another carrier frequency band and support of different carrier frequencies - in many existing and new frequency bands from 5MHz and lower frequency bands to 20MHz;

• support of duplex modes based on frequency (FDD) and time (TDD);

• new opportunities to increase subscribers' service to neighboring base stations and mutual "roaming" with existing mobile networks.

As a result of many years of research and development (ITTKI) carried out by the participants of the 3GPP project and other involved manufacturers, LTE technology has become a universal system that meets the requirements of 3GPP and exceeds them in some parameters.

The LTE standard provides for the use of various multiplexing technologies and modulation methods, in particular:

• for transmission in the "down" direction - orthogonal frequency multiplexing technology - OFDM and QPSK, 16-QAM and 64-QAM modulation methods;

• for transmission in the "up" direction - single-carrier frequency multiplexing technology - SC-FDMA and BPSK, QPSK, 8-PSK, 16-QAM - modulation methods are used [2].

The radio interface of E-UTRA technology is very flexible and can use different working channel widths from 1.4MGs to 20MGs (as opposed to UTRA's fixed 5MGs channels). Also, the spectral efficiency of E-UTRA technology has been increased by four times compared to UTRA. As a result of improving the network architecture and signaling methods, it was possible to reduce the response delay time in the "down" and "up" directions. "Multiple reception/multiple transmission" - as a result of using MIMO antenna technology, the number of subscribers per cell has been increased by 10 times in the LTE system compared to 3GPP systems based on W-CDMA technology.

As part of the SAE system architecture development program, a "flat architecture" of the network built on the basis of the IP protocol was proposed in the LTE standard. The purpose of the LTE/SAE architecture is to effectively support any IP services from the point of view of commercial use. This architecture is built and developed on the basis of the existing GSM/W-CDMA systems base networks, and the purpose of its construction is to further simplify the network operation, as well as to gradually and efficiently create the next generation networks. The LTE/SAE architecture significantly reduces the operational and capital costs involved in building and operating the network. The new "flat architecture" model requires increasing the throughput of only two types of network nodes (base stations and gateways) at traffic congestion points. In addition, it is observed that the level of automation in network configuration is increasing more and more. As a result, operators can very flexibly implement LTE technology, providing broadband and multimedia services, taking into account the networks they use, frequency spectrums and specific commercial characteristics[3].

Defined two-layer networks for the LTE system. This is the data transmission core network named EPC (Evolved Packet Core) and E-UTRAN (Evolved UMTS Terrestrial Radio Access Network) are new radio communication networks. The tasks performed by these networks and their structure are aimed at reducing the number of network elements, simplifying their functions, and more carefully booking. Most importantly, the LTE/SAE network provides interoperability and handover with other wired and wireless technologies, allowing operators and service providers to gradually implement seamless mobility services. The basic system supporting the operation of the EPC network was named EPS (Evolved Packet Subsystem).

LTE/SAE system architecture is built on several basic principles:

- use of common base point and gateways for connection with all technologies;
- using a more convenient architecture at the subscriber level - reducing the number of network levels (from four to two - base stations and gateways);
- all interfaces are built on the basis of the IP protocol;
- organization of separation of radio communication and switching functions as in W-CDMA/HSPA technologies;
- division of management and subscriber levels between the mobility management module and the gateway;
- interoperability with non-3GPP radio communication technologies using the IP protocol [4].

As you can see, the LTE standard has a number of high-level requirements in terms of functionality. Among them, orthogonal frequency multiplexing at the physical level - OFDM, multiple receive/multiple transmit antenna systems - MIMO and "intelligent" antennas applications of such technologies. Thus, the tasks before the LTE standard are quite serious and they mainly consist of: creating a simplified infrastructure and subscriber devices; in addition to the radio frequencies used in existing systems, convenient acquisition of new frequency bands; interoperability with other radio technologies belonging to the 3GPP and 3GPP-2 families.

PFS radio technology is used to implement various services, as well as work on the Internet, exchange PFS files, video communication, voice over IP (VoIP), network games, "live" video, "push-to-talk" and supports a number of services such as "push-to-view". Therefore, LTE base stations and subscriber devices must have a sufficiently high data transfer rate and a short response delay as the main criterion for functionality.

The maximum bandwidth for the LTE system is expected to be 20MGs for both transmission and reception. This gives the providers the opportunity to offer services to subscribers based on their capabilities, depending on the available radio frequency resources, and ensures that they expand their networks by gradually increasing the radio frequency resources.

In addition to the requirements shown in the table, the LTE standard has requirements such as reducing the overall cost and power consumption of the system, as well as ensuring the flexibility of the system and effective transition from UMTS systems. In this case, LTE technology should fully ensure flexibility with 3GPP networks, starting with "Release 6" (including HSDPA, HSUPA, HSPA+). Use of advanced types of "broadcast" and "multicast" services (broad coverage transmission to all or a large number of subscribers), different versions of IP protocols (IPv4 and IPv6), continuous quality of service - improved methods of QoS, as well as The number of options in the network architecture and the reduction of reservation functions are among the requirements of the LTE standard [5].

As mentioned above, structurally, LTE/SAE system architecture can be divided into two levels, as in previous generation mobile communication systems: radio network - RAN and base network - CN.

I. RRS Model of Channel Resources of LTE Technology

In LTE (Long-Term Evolution) technology, one of the effective ways to increase efficiency and improve the main indicators of the quality of service (QoS) is to use the principles of structural and functional self-organization. The purpose of LTE is to increase the capacity and speed of wireless data networks using new networks. The use of self-organization solutions allows to effectively respond to changes in the state and operating conditions of the wireless network, for example, failure or overload of network elements, changes in traffic entering the network, dynamics of changes in the signal-to-noise state and others[6].

A higher level of self-organization can be achieved by improving network protocols and mechanisms responsible for scheduling available network resources. Therefore, the principles of self-organization in LTE technology can be based on a radio resource management system (Radio Resource Management, RRM), that is, a scheduler responsible for resource planning for user stations (user equipment, UE). These types of resources primarily include time (time source) and frequency (frequency source). It should be noted that solving the RRM problem of radio resource allocation is primarily based on QoS requirements.

In LTE technology, as in HSDPA or WiMAX, the downlink resource planning mechanisms (DownLink) are not defined by the standard and leave the choice to base station equipment manufacturers (eNodeB).

Since multiple user stations share a single downlink channel in LTE technology, a frequency and time resource planning mechanism or method must be selected to ensure access to the data transmission environment of all UEs. The frequency and time scheduling mechanism, in turn, is used by the scheduler to emphasize the UE transmission rate[7].

The analysis showed that certain methods of allocation of frequency and time resources in LTE technology include the use of three mechanisms to grant access to the data transmission environment:

- proportional Fair Scheduling algorithm;
- cyclic algorithm (Round Robin Scheduler);
- maximum power ratio and noise level algorithm of the carrier (Max C/I Ratio, Best CQI scheduling) .

Frequency and time resource allocation methods were analyzed using the Round Robin Scheduler algorithm. The use of the Round Robin Scheduler algorithm involves the equal distribution of frequency-time resources for each UE .

The development of a mathematical model of frequency and time resource planning of the downstream communication channel of LTE technology should be aimed at meeting the following requirements:

- direction to efficient use of frequency and time resources;
- considering UE transmission speed and quality of service requirements;
- focus on the mainly dynamic nature of solving the problem of time frequency distribution;
- focus on maximizing overall network performance and improving other QoS indicators;
- taking into account the technological features of the network (mode of operation, channel width, number and configuration of resource blocks);
- taking into account the territorial distance of stations (determines the choice of modulation and coding scheme (modulation and coding scheme, MCS) for UE signal transmission)[8] .

The signal received from the receiving sources is split into waves after the meeting with many obstacles of the receiver, a part of it reaches the receiver. Each wave from the receiver forms a signal propagation path.

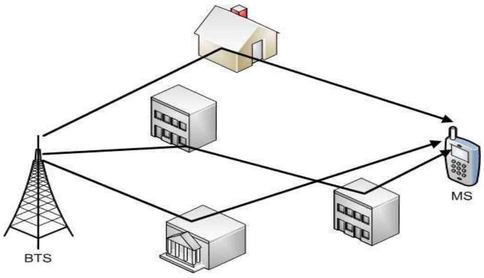

Fig. 2. Characteristics of the LTE radio wave.

In a dense urban building environment, due to many obstacles such as buildings, trees, cars, etc., it is very common for the antennas of the situation (MS) and the antenna of the base station (BTS) to be directly. In this case, the only way to reach the receiver signal is to reflect the waves. However, as mentioned above, a signal that has been reflected several times now means that special complexity also means that objects are not always stable and the situation can change over time. In this regard, a problem arises - one of the most important problems in the wireless communication system. At the receiving end, several antennas carry the signal from the radio. In addition, the antennas on the receiving side are also defined by multiple spatial separations, to ensure the reception of separated reception. The number of received signals corresponds to the number of receivers, their number of antennas and transmission paths. In addition, each of the receivers receives a signal from all antennas. Each of these forces is separated from the signal of the road sign signal to which it responds. It is equipped with each signal for any specific signal or delayed, in a phase shift. Depending on the principle of operation of the system (laid in space, explosion, antenna rate selection (SPARC), etc.), it can be selected or transmitted for a short time by another antenna [9].

A model for increasing the transmission rate of channel resources in LTE networks

An important means of increasing the speed of physical data transmission in wireless networks is to expand the width of spectral channels. Multiphoning (MURDM) is carried out with maximum performance by using a wider channel separated by orthogonal frequency division of data transmission. OFDM is a digital modality that has proven itself very well as an investment in wireless data transmission in WiMax / WiFi networks. The channel bandwidth expansion method is cost-effective and fairly feasible with moderate increases in digital signal processing (DSP). With proper use, you can double the transmission frequency of Wi-Fi 802.11 from a 40 MHz channel to 40 MHz, you can provide more than the strengths of the currently used channels. LTE architecture is a very powerful and cost-effective approach to increase the bandwidth and physical transmission rate [10]-[11].

Downlink during transmission m - state of SBs during transmission in k-th frame within at most one UE;

$$\sum_{n-1}^{N} x_{k,m}^{n} \leq 1 \ (k = (\lambda = \left|\overrightarrow{0, K-1}\right|;\ m = \left|\overrightarrow{0, M-1}\right|. \quad (1)$$

The condition for UE scheduling blocks to allocate only the downlink communication channel:

$$\frac{\sum_{m-0}^{M-1}\sum_{n-1}^{N} x_{k,m}^{n}}{M} \leq \eta\lambda,\kappa \ (\kappa = \left|\overrightarrow{0, K-1}\right|, \qquad (2)$$

The downlink transmission rate with MCS used is the condition for determining the number of SBs that the n-th UE needs:

$$\sum_{m=\frac{M}{2}-3}^{\frac{M}{2}+2} R_{SB}^{0} x_{0,m}^{n} + \sum_{m=\frac{M}{2}-3}^{\frac{M}{2}+2} R_{SB}^{5} x_{5,m}^{n} + \sum_{m=0}^{\frac{M}{2}-4} R_{SB}^{0-9} x_{0,m}^{n} + \sum_{m=\frac{M}{2}+3}^{M-1} R_{SB}^{0-9} x_{0,m}^{n} + \sum_{m=0}^{\frac{M}{2}-4} R_{SB}^{0-9} x_{5,m}^{n} + \sum_{m=\frac{M}{2}+3}^{M-1} R_{SB}^{0-9} x_{5,m}^{n} + \sum_{m=0}^{M-1}\sum_{k=0}^{4} R_{SB}^{0-9} h_{l,k} x_{k,m}^{n} \geq R_{mp}^{n}, \quad (3)$$

$n = \overline{1, N}$, $l -$ The frame configuration expression used in - uses the following variables:

$$R_{SB}^{5} = \frac{\left(\left(N_{symb}^{RB} N_{SF}^{RB} - N_{PDCCH} - N_{PSS,SSS}\right)K_S - N_{pilot} N_{SF}^{RB}\right) R_C^{n,m} k_b^{n,m}}{KT_{SF}}, \quad (4)$$

The condition for combining RB into RGB dimensions that satisfy the width of the used frequency channel:

$$x_{k,m}^{n} \ \frac{1}{p} \sum_{z=\left\lfloor\frac{m}{p}\right\rfloor p}^{\left(\left\lfloor\frac{m}{p}\right\rfloor+1\right)p-1} x_{k,z}^{n} \qquad (n| = ;\ \kappa = \overrightarrow{0, K-1};$$

$$\mu=0, \left[\overrightarrow{\frac{M}{p}} \quad p-1\right), \qquad (5)$$

Simulation results in Matlab showed that the downlink measurement range did not change during the overall performance using certain methods, ie:[12]

- It was 0.9622 Mbps for Round Robin method
- For the Proportional Fair method – 1.2377
- Mbit/s, for Max C/I Ratio method – 1.4192 Mbit/s.

Performance of common downlink using the proposed model R $^{n,}_{mp6}$ = 0:0,15 Mbit/s. The Max C/I Ratio method with the maximum value corresponding to Mbps was 1.4192 Mbps. R $^{n,}_{mp6}$ = 0,15 : 0,26 Mbit/s total bandwidth decreased by 3% to 1.3641 Mbit / s. Shows the simulation results showing the dynamics of the change in the downlink bandwidth balancing level between UEs. Fixed bandwidth balancing according to level expression[13]-[14].

$$F_i = 1- \left(\frac{{}^{max}{}_{n}R_n^i - {}^{max}{}_{n}R_n^i}{\sum_{n=1}^{N} R_n^i}\right), \quad (6)$$

Ηερε P $^{i}_{n}$ – baud rate, selected ν– ΥΕ το ι- measurement interval $n = \overline{1, N}$,

III. Program Code

```
clear all; clf

sel_ant=2; % Number of antennas to choose from sel_method=0; % 0/1 for ascending/descending order selection.[15]
NT=4; NR=4; % Number of receiving/transmitting antennas      I=eye(NR,NR);
sq2=sqrt(2);

SNRdBs = [0:10];  MaxIter=1000;

for i_SNR=1:length(SNRdBs)

  SNRdB = SNRdBs(i_SNR);

  SNR_sel_ant = 10^(SNRdB/10)/sel_ant;

  rand('seed',1); randn('seed',1);  cum = 0;

  for i=1:MaxIter

    if sel_method==0

      sel_ant_indices=[];  rem_ant_indices=[1:NT];

     else

      sel_ant_indices=[1:NT];  del_ant_indices=[];

    end

    H = (randn(NR,NT)+j*randn(NR,NT))/sq2;

    if  sel_method==0  % incremental order selection method   for current_sel_ant_number=1:sel_ant
```

```
            clear log_SH;
            for n=1:length(rem_ant_indices)
                Hn = H(:,[sel_ant_indices rem_ant_indices(n)]);
                log_SH(n) = log2(real(det(I+SNR_sel_ant*Hn*Hn')));
            end
            maximum_capacity = max(log_SH);
            selected = find(log_SH==maximum_capacity);
            sel_ant_index = rem_ant_indices(selected);
            rem_ant_indices = [rem_ant_indices(1:selected-1) rem_ant_indices(selected+1:end)];
            sel_ant_indices = [sel_ant_indices sel_ant_index];
        end
      else % descending order selection method for current_del_ant_number=1:NT-sel_ant
            clear log_SH;
            for n=1:length(sel_ant_indices)
                Hn = H(:,[sel_ant_indices(1:n-1) sel_ant_indices(n+1:end)]);
                log_SH(n) = log2(real(det(I+SNR_sel_ant*Hn*Hn')));
            end
            maximum_capacity = max(log_SH);
            selected = find(log_SH==maximum_capacity);
            sel_ant_indices = [sel_ant_indices(1:selected-1) sel_ant_indices(selected+1:end)];
        end
      end
      cum = cum + maximum_capacity;
   end
   sel_capacity(i_SNR) = cum/MaxIter;
end
plot(SNRdBs,sel_capacity,'-ko', 'LineWidth',2); hold on;
xlabel('SNR[dB]'), ylabel('bps/Hz'), grid on;
title('LTE transmission speed in networks ')
```

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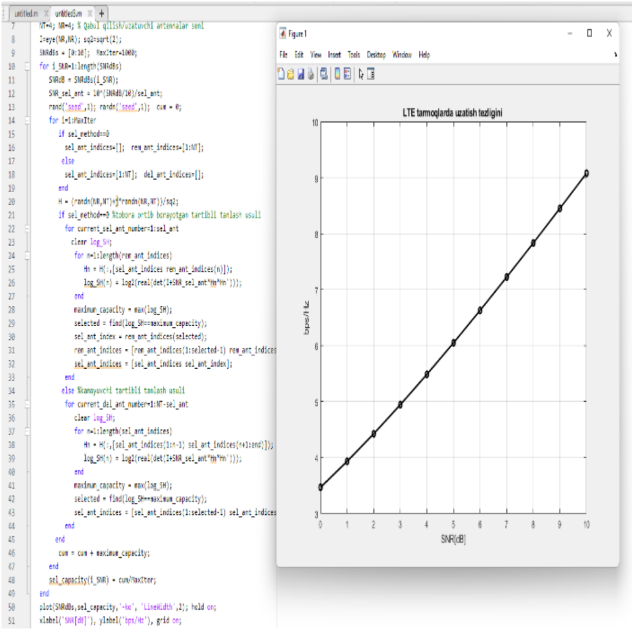

Fig. 3. The process of working with the transmission model.

IV. Conclusion

This article found that LTE is one of the main tasks of working with a wireless network. The use of LTE technology is the task of ensuring the required quality. Methods for determining the required transmission rate in the downlink of service network stations, including the need for user separation, were compared. From the point of view of the balanced distribution of the bandwidth of the communication channel, it was shown that the Round Robin and Proportional Fair methods have the best performance when the transmission rate requirements of the user stations are low.

Under conditions of high transmission rate requirements, the most balanced distribution of the bandwidth of the downstream communication channel is ensured by the proposed model. He also found that one of the effective ways to ensure the required transmission speed in LTE technology can be achieved by solving the distribution problem through downlink block scheduling. As a result of the analysis, we have identified the shortcomings of certain methods, as well as prospective requirements for solving the problem of allocation of planning blocks between user stations. This will allow us to achieve higher data rates, network capacity and spectral efficiency in the future. The results in our paper are mainly.

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