A Simulation Framework for the Realization of Handover Procedure for LTE Technology

Aydan Haka
Faculty of Computing and Automation at Technical University of Varna
st. Studentska 1, Varna 3000
Bulgaria
aydin.mehmed@tu-varna.bg

ABSTRACT: *LTE is a widely used 4G technology defined by 3GPP, capable of realizing Broadband Wireless Access services. The benefits of LTE technology are that it provides same time voice, data and video services on many networks. It uses the handover procedures to ensure uninterrupted delivery of the services in time. We now consider a simulation framework for the realization of handover procedure for LTE technology and provide importance to packets.*

Keywords: 4G, LTE, Horizontal Handover, QoS

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1. Introduction

In [1] the European Commission presents coordinated designation and authorization of the 700 MHz band for wireless broadband by 2020 and coordinated designation of the sub-700 MHz band. According to this decision this frequency bands will be used for terrestrial systems capable of providing wireless broadband communications services and for deployment of 5G technologies.

LTE is a widely used 4G technology defined by 3GPP, capable of realizing Broadband Wireless Access services. LTE supports high spectrum efficiency low latency scalable bandwidth from 1.4 MHz to 20 MHz, using MIMO technology, OFDM technique for downlink and SC-FDMA for uplink, and allows the user to access the service in a state of moving both in one cell or between cells (Handover) without any termination of communication. According to [2], there are two basic Handover technologies: Hard Handover – also called break-before-make; Soft Handover – also called make-before-break.

Furthermore, Handover procedure is divided into two categories:

- Horizontal handover – automatic switching between access points in one technology;

- Vertical handover - automatic switching from one technology to another at the point where the service is delivered.

The realization of Handover procedure depends on eNodeB's Reference Signal Receive Power (RSRP) values measured from UE [3, 4]. As shown in [5] the Horizontal handover at LTE is realized through the X2 interface of the eNodeB. The X2 is a point-to-point interface, and it can be established between the serving eNodeB and its neighbors. In case the X2 interface is not configured or the connection is blocked, the Handover procedure can be implemented via MME using S1 interface.

To keep mobile users satisfy, carrying out a Handover requires providing good QoS. This can be achieved by studying the delay value during Handover and prioritizing the different types of network streams.

2. Related Works

There are many developments using Handover mechanisms on LTE cellular networks that offer different solutions to improve QoS parameters of the serving network.

In [6], authors propose an approach that enhances the capability of LTE-femtocell networks when dealing with downlink variable bit rate video transmission and supporting efficient mobility management through an optimized handover policy. This is realized as making a pre-allocation of radio resources, based on the knowledge of future required video traffic of connected users. The results show that Handover period is increased. However, the QoS for variable bit rate video traffic increases.

In [7] is proposed a pre-scheduling mechanism for real-time video delivery over LTE. Proposed mechanism dynamically adjusts the data rates of transmission for providing a high QoS for real-time video before new connection establishment. The results show higher throughputs compared to the EXP/PF scheme.

Research [8] focuses on the mobility management and Handover issues between different cells - macro, micro and femtocells. There is proposed algorithm which improves the performance of femtocell in terms of decreased number of Handover, which improves the QoS.

Research [9] focuses on the analysis of specific type of LTE traffic, the video streaming in frequency division duplex (FDD) mode in Handover process on LTE network. The results show that the QoS for the high speed UEs, which generates video stream, is not increased significantly.

Unlike the solutions considered the proposed simulation framework do not focus on only one type of traffic. It operates with all the types of traffic which LTE supports. It can be used to investigate QoS based on LTE standard and proposed traffic prioritization mechanism, and how it affects to different UEs. Moreover, the presented simulator generates the transmission matrix of allocated resources for every eNodeB for one frame. Based on this transmission matrix it can be research the delay, throughput and packet delivery ratio values.

3. LTE Simulation Model

The main concept of cellular networks is the division of services into small areas called cells. Each cell has its own coverage area and operates with different parameters. Each of them contains an eNodeB, which serves all users in the range, and ensures UE mobility between cells.

This study will focus on analyzing QoS for mobile users performing the Handover between neighboring eNodeB’s within LTE cellular network.

According to [10] the Figure 1 shows distribution of built eNodeB’s from different PLMN in suburban area of Varna, Bulgaria.

In this figure eNodeB’s are built up along the highway in one line, and UE’s move in two directions – from West to East, and from East to West. Represented placement of eNodeB’s was used for simulation topology as shown in Figure 2.

In the beginning every eNodeB has different number of connected UE’s. They can be static or mobile, but this research focuses on mobile users. According to topology UE’s can move in one of two directions (i.e., West to East or East to West). Every UE moves with different speed in one of the directions, and when reaches the end of serving cell initiates Handover. After that they

Figure 1. Distribution of eNodeB's on suburban area of Varna, Bulgaria

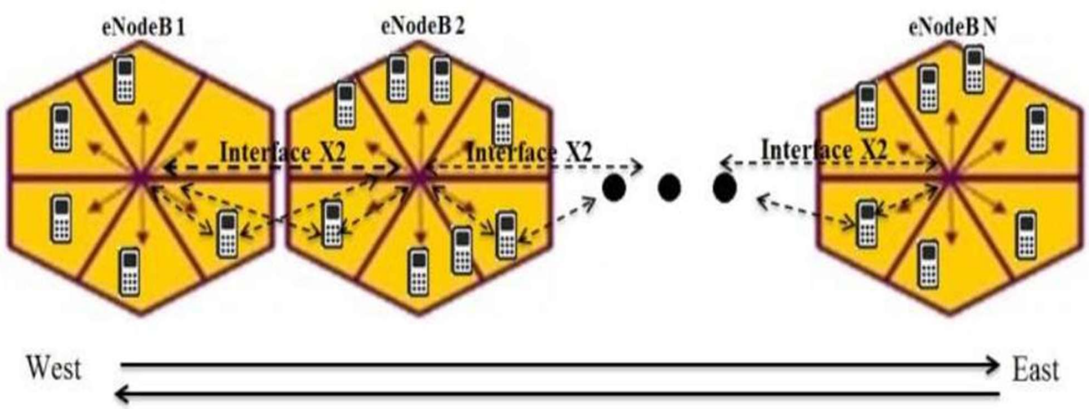


Figure 2. Handover topology used for simulation

connect to the next eNodeB in moving direction. Stages when UE performs the Handover process on the LTE network are as in Figure 3.

The scheduler of every eNodeB performs proposed prioritization mechanism. According to this mechanism faster mobile users are with greater priority from slower users, because faster ones will reach end of cell first. So, faster UEs receive more resource unlike the others.

After the Handover is completed the number of UEs is changed dynamically for every eNodeB. Unchanged is just the number of static users, if available. The scheduler of eNodeB then prioritizes users and redistributes resources according to priority.

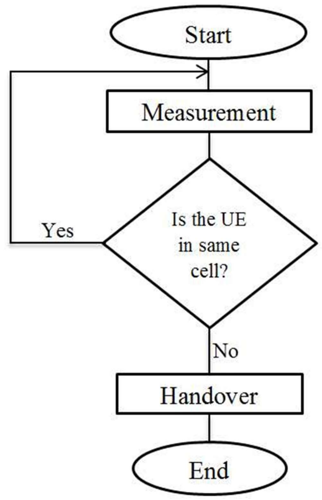


Figure 3. Handover process diagram

4. Proposed Algorithm for Prioritization of UEs in LTE

This simulation framework uses the same prioritization, presented from authors [11]. According to the priority the scheduler of eNodeB arranges UEs, where the order of priority is as: first, the users are ordered by payed priority – value from 0 to 7 where greater value indicates greater priority, second criteria is distance to eNodeB – users which are closer to eNodeB has greater priority, next criteria is speed of UE, if the user is mobile, where the high speed users has greater priority, in the end the users are prioritized according different type of service from required traffic flow.

5. Simulation Framework for Realization of Horizontal Handover in LTE

The simulation framework presented in this paper is improved version of simulator shown in [11]. Improvements consist in the

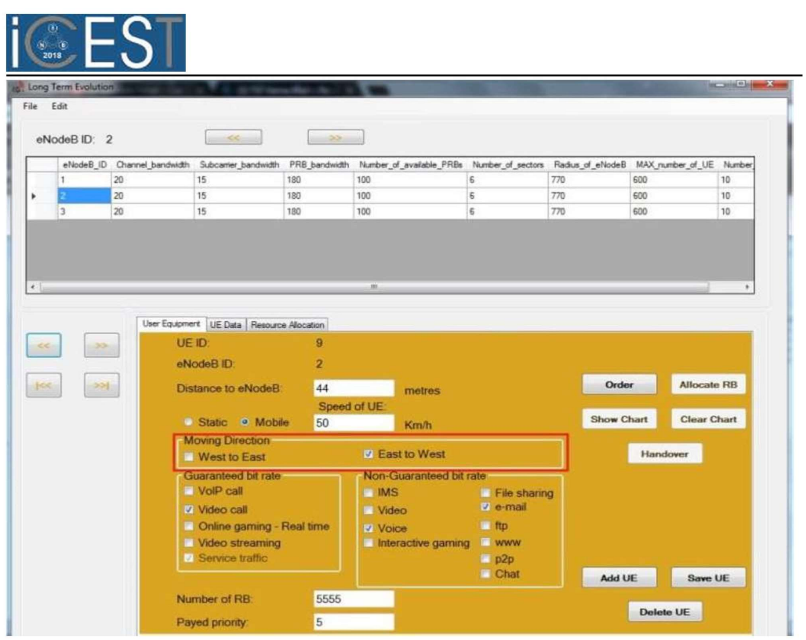


Figure 4. Data of UE connected to eNodeB

fact that for mobile UEs a direction of movement can be selected in the range of the eNodeB, which allows implementation of mechanism for realization of Handover. Before the Handover is realized, it is checked at what speed and what direction the subscriber moves. After that, is calculated the distance that the UE will travel within five minutes in meters. The calculated value is added to distance to eNodeB given to the UE. After that, if the distance to eNodeB is greater than the radius of the serving eNodeB, the Handover to the target eNodeB is realized in to the movement direction. For the mobile UEs for which the value of distance to eNodeB is not greater than radius of cell, the Handover is not occurs, and they stay at the range of the serving eNodeB. The Handover is realized by the standard, and the context of the UE is transmitted to the next eNodeB. After the Handover is completed, the scheduler of eNodeB then prioritizes users by proposed mechanism, and redistributes resources according to priority. The Figure 4 shows the new fields for selecting moving direction of UE.

Figure 5 shows the base station information database and the related UEs. In the database for UE was added the fields “West_to_East” and “East_to_West”, and they show the selected moving direction of UE, if in the field is written “Checked”. This figure shows connected UEs to eNodeB 2 before realization of Handover.

eNodeB ID: 2

eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority	Service_traffic
33	Fals...	100	Unchecked	Checked	5555	5	Checked
33	Fals...	70	Unchecked	Checked	5555	5	Checked
33	Fals...	50	Checked	Unchecked	5555	5	Checked
33	Fals...	50	Unchecked	Checked	5555	5	Checked
33	Fals...	30	Unchecked	Checked	5555	5	Checked
33	Fals...	10	Checked	Unchecked	5555	5	Checked
33	Fals...	10	Unchecked	Checked	5555	5	Checked
33	Fals...	5	Checked	Unchecked	5555	5	Checked
33	Fals...	5	Checked	Unchecked	5555	5	Checked
33	Fals...	5	Unchecked	Checked	5555	5	Checked

Figure 5. Database with information of eNodeB 2 and related UEs

According to the speed of UE and the selected movement direction the high speed UEs, after the realization of Handover will connect to eNodeB 1 or eNodeB 3 in the first iteration. The low-speed users are still connected to serving cell (i. e. eNodeB 2) as shown in Fig. 6, after realization of first Handover iteration. For eNodeB 1 and eNodeB 2 in the beginning there no connected UEs.

eNodeB ID: 2

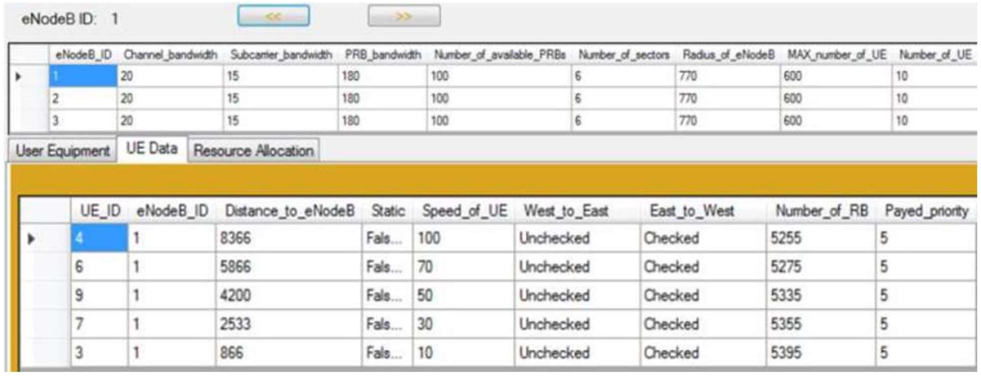
eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

UE_ID	eNodeB_ID	Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority
8	2	450	Fals...	5	Checked	Unchecked	5415	5
1	2	450	Fals...	5	Checked	Unchecked	5435	5
5	2	450	Fals...	5	Unchecked	Checked	5455	5

Figure 6. UE data after realizing of the Handover on eNodeB 2

After the first iteration of Handover is complete, to eNodeB 1 are connected UEs with ID 4, 6, 9, 7 and 3 as shown in Figure 7, and to eNodeB 3 are connected UEs with ID 2 and 10 as shown in Figure 8.

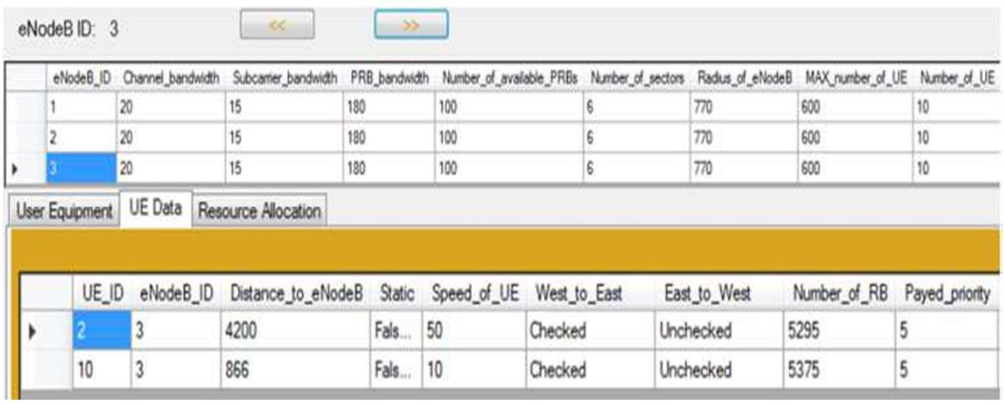

eNodeB ID: 1

eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

UE_ID	eNodeB_ID	Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority
4	1	8366	Fals...	100	Unchecked	Checked	5255	5
6	1	5866	Fals...	70	Unchecked	Checked	5275	5
9	1	4200	Fals...	50	Unchecked	Checked	5335	5
7	1	2533	Fals...	30	Unchecked	Checked	5355	5
3	1	866	Fals...	10	Unchecked	Checked	5395	5

Figure 7. Realized handover to eNodeB 1 in first iteration


eNodeB ID: 3

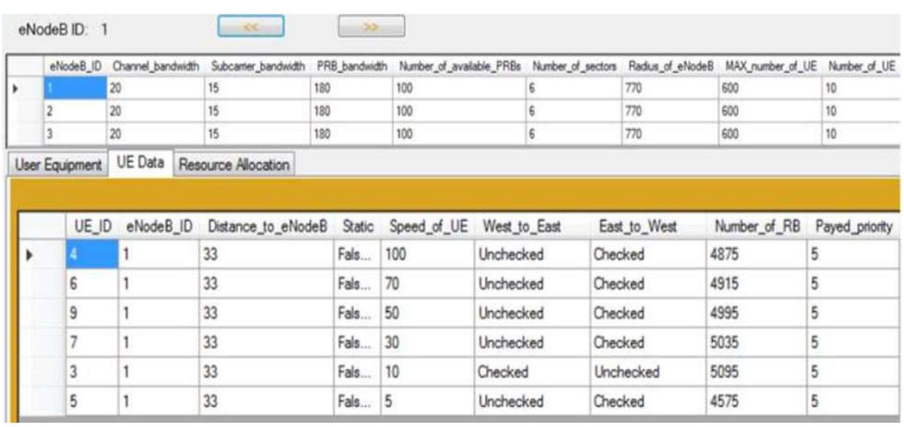
eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

UE_ID	eNodeB_ID	Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority
2	3	4200	Fals...	50	Checked	Unchecked	5295	5
10	3	866	Fals...	10	Checked	Unchecked	5375	5

Figure 8. Realized handover to eNodeB 3 in first iteration

After the second Handover iteration the low speed UEs will connect to eNodeB 3 UEs with ID 8 and 1, and to eNodeB 1 - UE with ID 5. Figure 9 and Fig. 10 shows realized handover for users in second iteration respectively for eNodeB 1 and eNodeB 3. After second iteration there no UEs connected to eNodeB 2.

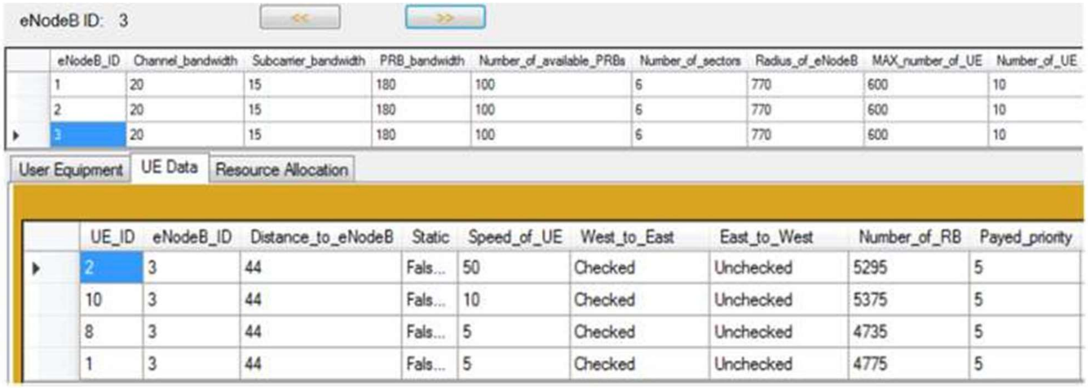

eNodeB ID: 1

eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

UE_ID	eNodeB_ID	Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority
4	1	33	Fals...	100	Unchecked	Checked	4875	5
6	1	33	Fals...	70	Unchecked	Checked	4915	5
9	1	33	Fals...	50	Unchecked	Checked	4995	5
7	1	33	Fals...	30	Unchecked	Checked	5035	5
3	1	33	Fals...	10	Checked	Unchecked	5095	5
5	1	33	Fals...	5	Unchecked	Checked	4575	5

Figure 9. Realized handover to eNodeB 1 in second iteration



eNodeB ID: 3

eNodeB_ID	Channel_bandwidth	Subcarrier_bandwidth	PRB_bandwidth	Number_of_available_PRBs	Number_of_sectors	Radius_of_eNodeB	MAX_number_of_UE	Number_of_UE
1	20	15	180	100	6	770	600	10
2	20	15	180	100	6	770	600	10
3	20	15	180	100	6	770	600	10

User Equipment | UE Data | Resource Allocation

UE_ID	eNodeB_ID	Distance_to_eNodeB	Static	Speed_of_UE	West_to_East	East_to_West	Number_of_RB	Payed_priority
2	3	44	Fals...	50	Checked	Unchecked	5295	5
10	3	44	Fals...	10	Checked	Unchecked	5375	5
8	3	44	Fals...	5	Checked	Unchecked	4735	5
1	3	44	Fals...	5	Checked	Unchecked	4775	5

Figure 10. Realized handover to eNodeB 3 in second iteration

6. Tests and Discussion

In this study, four tests with different number of UEs were carried out, which moves at different speeds. During the tests, users are moving from serving to the next eNodeB by performing a Handover procedure. After the Handover is completed, it is determined the number of realized and unrealized Handover procedures and the delay values. The delay values are calculated with the equation (1):

$$Delay = \frac{Total\ time\ for\ deliver\ a\ frame}{Total\ RB\ Sent}$$

Figure 11 shows the number of realized and unrealized Handover procedures. The Handover occurs when UE goes to the edge of serving cell and the received signal is low. Then UE search for stronger signal and connect to next eNodeB.

According to the simulator the realization of Handover depends on UE location (i.e. distance to eNodeB) and movement speed. Because of this, mostly high speed UEs realizes more Handovers unlike the low speed UEs. As shown in Figure 11, the number of realized handovers increases with increasing the number of high speed UEs unlike the number of unrealized, which depends on number of low speed UEs.

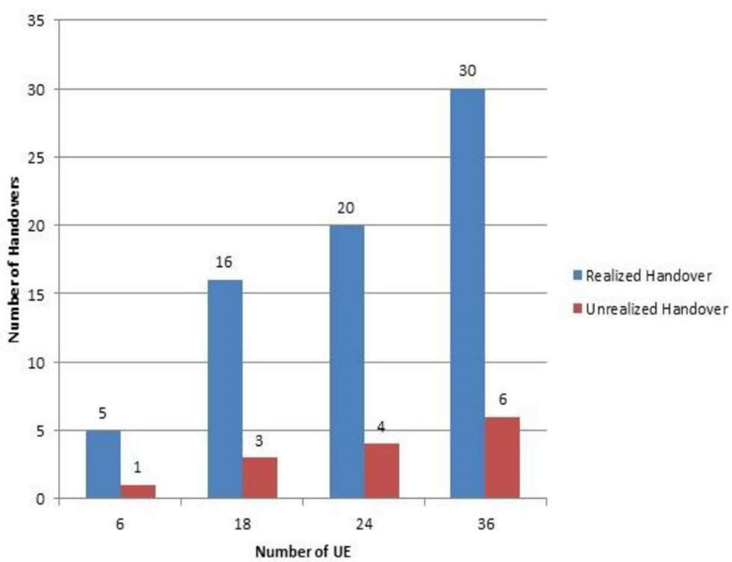


Figure 11. Realized and Unrealized Handover procedures

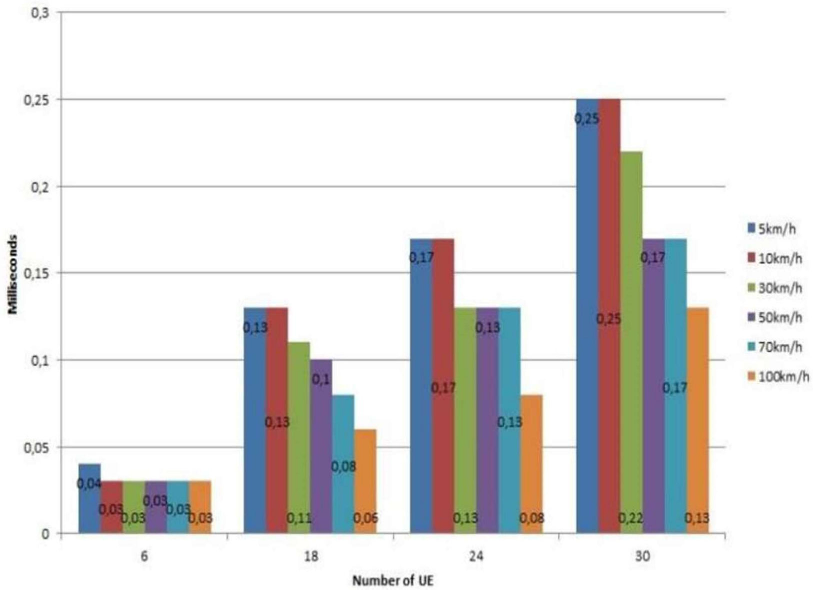


Figure 12. Delay values with different number of UEs

As the number of UEs increases, the number of Handover procedures increases, which gain the requirements of QoS. When a Handover is performed, improvement of the QoS may be achieved with decreasing the delay value for high speed UEs. This is performed from the scheduler of eNodeB and the prioritization mechanism on it. According to the prioritization mechanism the high speed UEs gain more resource blocks, and their requests are executed first. These UEs have greater priority, because they moves with high speed, and they may reach first the end of the cell, and will perform the Handover.

According to Figure 12 it can be seen that the applied prioritization improves the QoS for high speed users, because unlike the other UEs, the high speed UEs has lower delay value. Although the delay values increase with increasing the number of UEs, they stay lowest for high speed UEs. The values for delay are calculated as average value from realized tests for resource allocation in one frame.

8. Conclusion

In this paper is proposed simulation framework for realization of horizontal Handover in LTE network. The framework performs an algorithm for realization of UE mobility between neighboring cells, according to the proposed prioritization mechanism improves QoS for high speed UEs. There are presented number of realized and unrealized Handovers and delay value for resource allocation by users. It was always assured a minimum delay value for allocated resources for high speed users realized Handover.

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