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Journal of Engineering Science and Technology
Vol. 15, No. 2 (2020) 805 - 819

COMPENSATION THE NOISY CHANNEL OF 802.16E SYSTEM IN DOWNLINK USING CoMP TECHNIQUE

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Abstract

In general, a high-noise channel is one of the most serious problems facing systems. It is resulting in exhaustion of system resources with minimal performance and addressing the problem of limited data transmission. 802.16e system is one of the systems experiencing this problem. The signal strength of the user is affected at the edge of the cell more than the rest of the users for several reasons, including distance from the base station and the interference of neighbouring cells and similar cells (co-channels). In this research, it is suggested to use the Coordinated Multipoint (CoMP) technique in the downlink to reduce the effect of noise (which is represented by interference) and to increase the signal strength of the participants in the cell edge in particular, as well as the participants within the cell in general. The results that collected using OPNET modeller are explained that the CoMP algorithm offered to support the system by decreasing the lost bytes. For instance, at 2MB file size, the CoMP is reduced the lost bytes about 63.5% as compared without CoMP. As a consequent, the CoMP algorithm will support the resources of 802.16e system as a term of traffic without adding any physical tools at user station or base stations.

Keywords: CoMP, FTP, Large file, Noisy, Random distribution.

1. Introduction

Recently, the world has seen a steady increase in the various applications and games that require high data rate in the uplink and downlink transmissions. This definitely needs to have a high signal-to-noise ratio so you can use the suitable modulating and coding types that provide high data rate requirements. The poor signal to noise ratio is the main reason for the consumption of system resources and the effect is more pronounced at the edge of the cell.

The user at the edge of the cell suffers from the weak signal as a result of the distance from the base station or the result of interference with adjacent cells or even with similar cells (co-channels) [1]. Furthermore, increasing the transmitted power is useful to increment the signal strength but also increases the interference by other base stations, which negatively effects on the amount of signal to noise ratio for all users in cell edge. On the other hand, each sector of the base station handles users separately within the sector, and the increased transmitted power in the cell makes the other users for other sectors see it as intra-site interference within the same cell [2].

Generally, the data rate depends on the magnitude of signal to noise ratio where this ratio determines two aspects: the type of modulation scheme (QPSK, 16QAM, and 64QAM), while the second objective is the encoding rate, which explained the information bits with respect to the overall bits (information plus extra bits for the detection or/and correction). If the strength of the signal to noise ratio is high, this will lead to employing the high level of modulation and encoding such as 64QAM modulation in the case of 802.16e system.

Consequently, it is possible to sending 5 bits/burst for the sub-carrier. It is clear that the exhaustion of the resources would rise about five times at low value of signal to noise ratio [3]. The signal strength is controlled by the base station but the noise level is out of control within the coverage area. Therefore, the main objective remains to improve the signal to noise ratio. On the other side, techniques can be used to contribute this goal. The CoMP operation is one of these techniques that improving the signal to noise ratio not in the middle of the cell but in the whole cell, especially at the edge of the cell that is experiencing greater noise [4].

The CoMP technique coordinates and cooperates among base stations to help the subscriber to increase and improve the weak signal [5]. CoMP is well known to have been introduced by the third-generation partnership project (3GPP) standard for long term evolution (LTE) technology. The specific points and details of the CoMP process have been identified, such as scenarios and architecture with respect to LTE technology.

CoMP is generally divided into uplink and downlink transmissions. In downlink transmission, it works with two modes: Joint Processing (JP) and Coordinated scheduling/Coordinated beamforming (CS/CB) [6]. While in the case of the 802.16e standard, the general specifics of the CoMP process in this standard are not clear in the same way as LTE [7]. Although the 802.16e standard does not frame CoMP technique, it allows professionals and researchers in this field to develop this process for the 802.16e standard.

This paper addresses some aspects, including simulation modelling of the 802.16e system, as well as the noisy channel effect by reducing the interference of

802.16e using CoMP. Another aspect deals with the effect of file transfer increment on throughput of sending or receiving. On the other hand, the paper is offered two main scenarios. First of them calculates the metrics in the case of the basic capability of the system while the second dealt with the CoMP algorithm.

The organization of the article sections is divided into six parts: The section (1) represents the introduction and related works, Section 2 describes an overview of 802.16e System and CoMP technique in downlink beside file transfer service. Section 3 discusses the paper method. Section 4 includes assumptions of 802.16e modelling. Simulation and discussion the results presented in Section 5. Finally, the conclusions are shown in Section 6.

In general, many researches have clarified the 802.16e system in terms of its specifications, features and weaknesses, and they introduced many ways to improve its performance. Some of these researches are reviewed as follows. A comprehensive modelling of 802.16e system offered to use VoIP application in the system of 802.16e using some scenarios in the downlink direction as well as an overview of several design choices where the metric was packet drop rate per user [8].

Aguilar et al. [9] used several types of algorithms such as effective exponential SNR mapping (EESM) for the dynamic channel and evaluation of effective SNR mapping algorithms in 802.16e system as well as to apply the adaptive modulation and coding depending on the principle of OFDM system.

Li and Park [10] propose a type 2 power-saving classes setting algorithm for multiple mobile stations for real-time connections in 802.16e system. This algorithm is to optimize the total power saving of the mobile stations and ensure the packet delay of each connection. More energy savings are achieved by the proposed algorithm compared to the state-of-the-artalgorithm. In other words, the CoMP technique was used in the LTE system to address vulnerabilities and improve system performance. Several research papers discussed this technique from several aspects and this is some of them.

Jang and Wend [11] proposed two techniques: CoMP and dynamic frequency reuse (DMFR), which is appropriate to LTE-A macro-cell or femtocell networks. DMFR is able to improve data transmission in both cell edge and cell sectors by interference management and CoMP techniques using several scenarios. DMFR and Fractional Frequency Reuse (FFR) are also compared through throughput of user and spectrum efficiency and results show that DMFR is better.

Cui et al. [12] using joint transmission, which is a type of CoMP technique to achieve performance improvement by allowing full management among several cells, changing unwanted interference into suitable signal power. Also, an analytical model for a typical joint transmission CoMP technique is presented to achieve adaptive modulation. This model consists of three transmission points.

Kwak et al. [13] used the joint transmission CoMP, they proved that the system performance is degraded when the user velocity increases for Gaussian broadcast channel. Yusoff and Hashim [14] presented an analytical model for CoMP technique. This model includes some types of power consumption and the use of CoMP technique to improve performance by saving power and energy efficiency.

In addition, some suggestions on reducing power consumption for the most consumed part. Saleh et al. [15] obtained the optimal scheduling between joint transmissions (JT) and coordinated scheduling (CS) in CoMP technique for LTE-A networks through introducing an optimization framework to find the peak max-min throughput and the best scheduling. The optimization problem is solved using an optimization tool. They are shown that in best scheduling, the fraction time of JT is lower than that of CS.

Neyja et al. [16] focused on CoMP technique by illustrating some of the topologies and applying two types of shared and dedicated frequency spectrum in cellular systems. The Remote Radio Head (RRH) and heterogeneous network scenarios are enabled to optimize for user throughput and user spectral efficiency. The simplest way to improve cellular network performance is to enhance signal strength using JT downlink CoMP scheme.

The average throughput of the cell is improved with shared spectrum type. In other words, dedicated spectrum type increases the throughput of cell edge. Muqaibel and Jadallah [17] dealt with different types of clusters for ideal and practical CoMP networks.

In addition to discussing the impact of cluster size on the Signal to Noise Ratio (SNR) for practical and ideal networks. The SNR is enhanced for small clusters compared to large clusters size. The results showed that real CoMP enhances SNR to remarkable values as in the ideal CoMP networks.

The main aim of this research is to compensate the effect of noisy channel on the resources of 802.16e system in case of transferring files using the multi-point collaboration technique in the downlink stream. Previously, most of techniques, which are used to improve the performance of 802.16e system as a term of system resources are hardware tools such as relay stations and techniques of antenna systems.

The contribution of this work is the mixing between the CoMP technique and 802.16e system where the CoMP operation depends on the processing approach rather than hardware support to reduce the cost of enhancing the system.

2. Overview of 802.16e System and CoMP Technique

2.1. 802.16e system

The IEEE introduced 802.16e standard, which supports mobility of users, see Table 1. It provides 30-40 Mbps data rates. It supports two modes of operation point-to-multipoint and mesh mode.

In the first mode, many users equipment's are associated with the base station where the downlink channel represents the access channel from the base station to the user equipment.

The main advantage of this system is submitting the flexibility in the number subcarriers that is used to appropriate the available bandwidth with active smart antenna techniques where the number of subcarriers depends on scalable orthogonal frequency division multiple accesses (SOFDMA) [7].

The technique of SOFDMA is effectively supporting the spectral efficiency. Furthermore, the communication may cover a distance up to 30 miles [18].

Table 1. Properties of 802.16e system.

Parameter	Description
Spectrum	< 6 GHz
Maximum data rate	Up to 15 Mbps (5 MHz channel)
Alignment	Both LOS and NLOS
Coverage range	Up to 5 km
Channel bandwidth	Flexible from 1.25 up to 20 MHz
Modulation	QPSK, 16-QAM, and 64-QAM
Mobility	100/h

2.2. Concept of CoMP

Coordinatedof multipoint is an algorithm that done using software method. It aims to create coordination and cooperation among the base stations to push the nominal system to enhance its data rate. The primary elements of CoMP are the equipment's of users and base stations as shown in Fig. 1.

This figure illustrates the style of implementation the algorithm. Firstly, the algorithm builds coordination among base stations. Then, it checks all signal states for users of the system. Following this step, the algorithm has the capability to allocate the users of poor signal in order to enhance the weak signal to offer higher data rate. The architecture of CoMP divides into two types: centralized coordination and decentralized coordination [19].

This classification is based on the type of cooperation and coordination between base stations wherein the centralized coordination, the base station covers the whole cell without interior sectors. In this case, a central control organizes the cooperation among base stations. On the other side, the decentralized kind has another way to implement the cooperation where the cooperation is built using the sectors of the nominal cell.

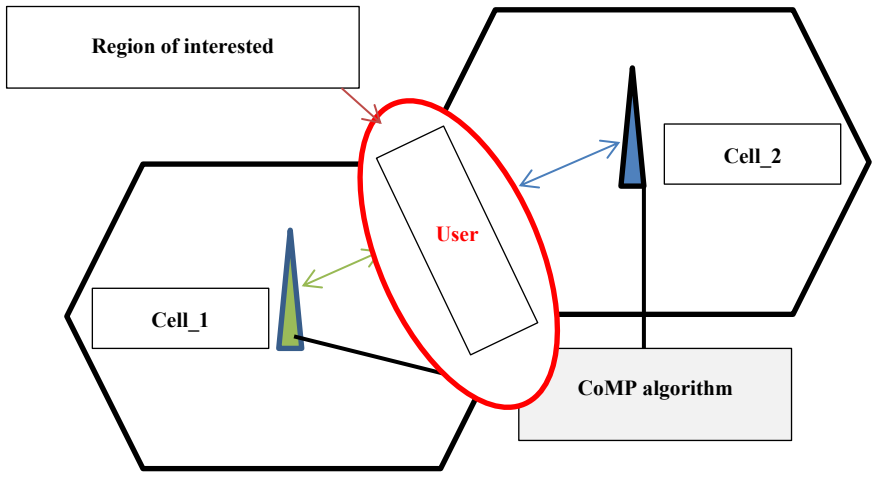

Fig. 1. CoMP operation.

2.3. Service of file transfer

The service of file transfer depends on the protocol of file transfer (FTP). The main purpose of this protocol is transferring files between users and the server, which submits this service.

There are two kinds of operations in this protocol: upload operation (the direction of the file from a user to the server) and download operation (the direction of the file from the server to a user).

Depending on the terminology of the protocol, (put operation) means the uploaded procedure while (get operation) representing the downloading procedure.

In general, the class of bits in this protocol is divided into two types: information bits and control bits [20]. It is worth to mention that the size of information bits is variable.

On the other side the size of control bits is fixed (512 bytes). Consequently, the size of control bits is very small with respect to information bits especially in case of large size of files.

3. Methods

This research depends on the following steps to employ the CoMP technique as shown in Fig. 2. Firstly, the initial assumptions of the system are determined and located in an appropriate way. All sectors of the cells are declared to the users.

Then, the users are distributed randomly on the cells. It is assumed that all users are fixed in order to facilitate dealing with them. This phase includes allocating the initial values to users and base stations such as bandwidth, frequency, types of duplexing, and other factors.

After allocation each user to the nominal sector in the nominal cell (the case of system steady-state), then the level of the signal power is determined, and hence, the appropriate modulation plus coding rate scheme are assigned and the intra-site sectors of the cell are standby to cooperation and coordination among them.

It is worth to mention that 802.16e system supports three types of modulations (QPSK, 16QAM, and 64QAM) and deals with coding rate ratio 1/2 up to 5/6.

The sectors of each cell check the level of the signal, which qualifies to the nominal scheme of modulation and coding rate in the downlink for a user, which is registered in this cell, if the level of user signal qualifies to use the robust modulation then the sectors of the cell coordination and cooperation together to raise the robust scheme to higher scheme (QPSK1/2 to QPSK3/4 and QPSK3/4 to 16QAM1/2 only).

The method avoids enhancing the scheme of 16QAM to 64QAM. This is related to increase the power of transmitting. Consequently, it is expected to deal with a new problem, the interference.

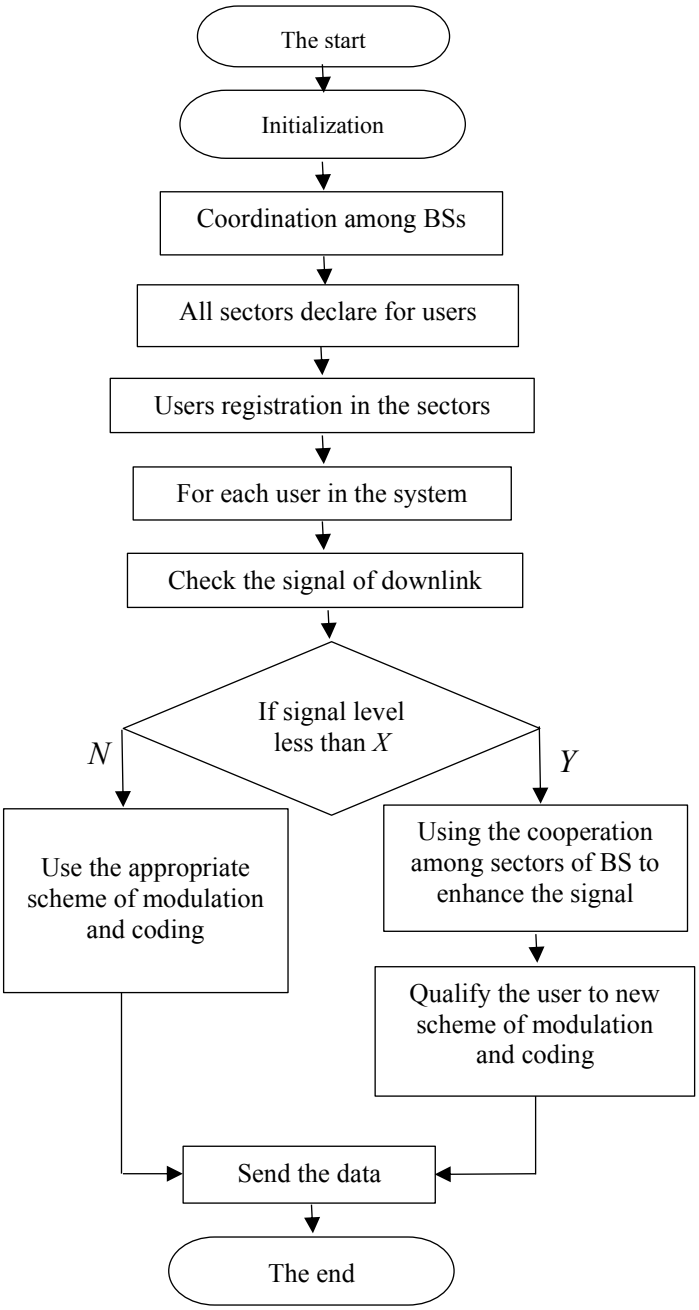

Fig. 2. Flow chart of the method.

4. Model Assumptions and Scenarios

The basic components of paper modelling are explained in Fig. 3. It consists of three cells; each cell is covered by one base station, which covers the sectors of the cell. All base stations are connected to IP cloud, which connects to the server to submit the services for the users of the system.

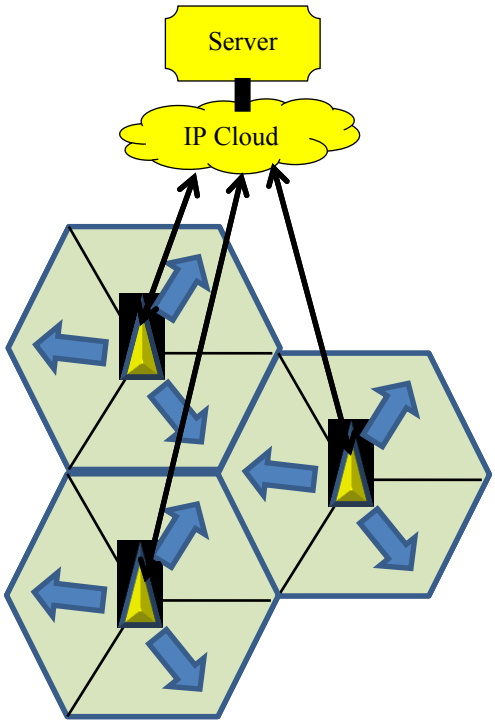

Fig. 3. General model of three cells configuration.

This paper aims to represent the effect of noisy channel on the users of the system as shown in Table 2, which illustrates the distribution of users number with respect to the scheme of modulation plus coding ratio on the sectors (S1, S2 and S3) of the system cells before and after employing the CoMP technique. The effect of noisy channel on the users' schemes leads the system to focus on two schemes: QPSK1/2 and QPSK3/4.

Forexample, the amount 8 in S2 for BS1 represents the number of users in Section 2, which are used modulation and coding QPSK1/2, while the number 15 shows the number of users in Section 3 for BS3, which are used same modulation and coding.

It is noted that most of the users suffer the weak signal (robust scheme of modulation: QPSK). It is worth to mention that the effect of CoMP technique confines to scheme of QPSK modulation only where the CoMP contributes to qualifying this scheme to a higher level of modulation and coding scheme (QPSK1/2 to QPSK3/4 and QPSK3/4 to 16QAM1/2).

The other assumptions of the model are illustrated in Table 3. The model of this work is built using OPNET modeller version 14.5. On the other hand, the running of the model falls in two scenarios, the first one runs this model without employing the effect of CoMP while the second collects the results after it takes the effect of CoMP into consideration.

Table 2. Distribution of users' number.

Basic distribution of users' number									
Scheme	**BS1**			**BS2**			**BS3**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
QPSK1/2	10	12	9	15	8	13	14	10	15
QPSK3/4	10	8	11	7	12	12	8	13	9
16QAM1/2	2	3	4	2	3	0	2	0	1
16QAM3/4	3	2	1	1	2	0	1	2	0
Distribution of users' number AFTER CoMP									
Scheme	**BS1**			**BS2**			**BS3**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
QPSK1/2	0	0	0	0	0	0	0	0	0
QPSK3/4	10	12	9	15	8	13	14	10	15
16QAM1/2	12	11	15	9	15	12	10	13	10
16QAM3/4	3	2	1	1	2	0	1	2	0

Table 3. Assumptions of model.

Parameter	**Value**
CoMP type	Intra-site
Direction enhancement	DOWNLINK
Profile type	OFDMA
Frame duration	10 m s
Symbol duration	102.86 µs
No. of subcarriers	2048
Duplexing technique	TDD
Bandwidth	20 MHz
Simulation time	60 min
No. of cells	3
No. BSs	3
No. of BS sectors	3
Users no.	225
Users/sector	30
Distribution of users	Randomly
Application	File transfer
File size (BYTES/SEC)	1M up to 5M

5. Results and Discussion

The model which is shown in Fig. 3 is implemented after applying the simulation parameters given in Table 3. To indicate the state of the channel without using any enhancement technology in addition to the detection of the channel's susceptibility to the maximum transmission data rate has been changed in file size from one up to five Mbytes per second as well as the amount of loss is calculated. Figure 4

shows sent and received traffic with varying file size at normal system case, which represents the basic case of the 802.16e system (no CoMP). It contains a large number of users with a low level of modulation and coding such as QPSK1/2 and QPSK3/4 as indicated in Table 2.

The second scenario adopts CoMP technique to enhance the 802.16e system, where the CoMP technique increases the strength of poor signal which will lead to increase the level of modulation and coding rate scheme especially for users at the edges of the cells by reducing the interference and increasing the amount of signal to noise ratio and spectrum efficiency.

In this case, the level of modulation and coding rate could be increased to QPSK3/4 or 16QAM1/2 depending on the initial scheme (QPSK1/2 or QPSK3/4).

Figure 4 also shows that increment of the file size up to 5M bytes will cause lost bytes, there is a difference between sent and received traffic. Hence, the resources of the system could not overcome the transferring of large file size and the effect of hard circumstances of the channel.

Figure 5 shows the relationship between sent traffic and received traffic with the increment of file size after employing CoMP technique. It is worth to mention that effect of applying CoMP gradually begins to compensate the effect of noisy channel and reduces lost traffic as compared to the case of without CoMP for the same amount of data.

Further, in case of comparing Figs. 4 and 5; the results show two visions. First of them is related to ratio of lost bytes, this ratio is decreased with CoMP technique as compared to without CoMP.

Hence, CoMP technique improves traffic slightly due to the coordination among the base stations. On the other sidethe coordination consumes more bandwidth. Furthermore, the noisy channel, could not enable CoMP technology to offer great improvement related to traffic.

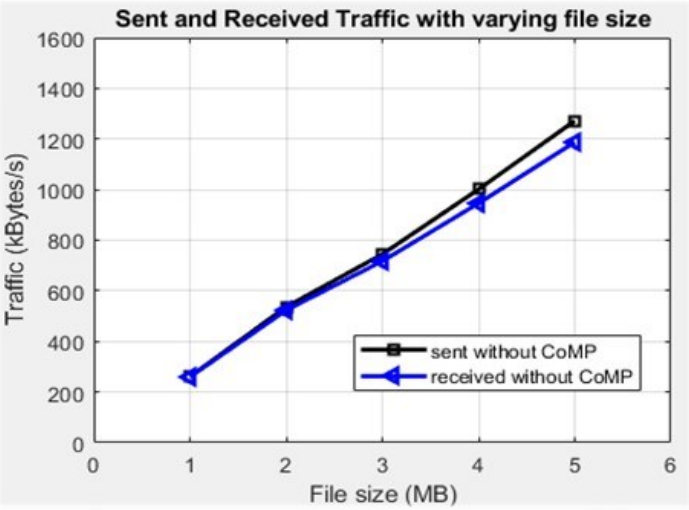

Fig. 4. Traffic of sent and received vs. file size without CoMP technique.

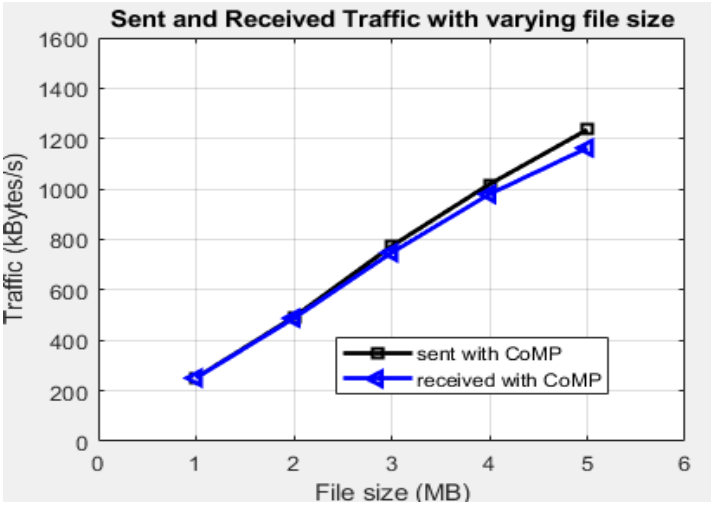

Fig. 5. Traffic vs. file size with CoMP technique.

In the downlink, CoMP technology reduces the traffic losses by reducing the impact of the noisy channel, and these losses are reduction the improvement on the received traffic. The improvement is uneven according to the size of the file due to the assumptions that are represented by the random location of the users and as shown in Fig. 6. Random location of users leads to random use of the type of modulation and coding and these results submit uneven improvement. For instance, when the file size is 4MB and 5MB the improvement amount is 29% and 14%, respectively.

The relationship between instantaneous sent traffic and simulation time for two different of file sizes is shown in Fig. 6. The case of steady state is achieved after 1000 s. Figure 7 also illustrates effect of employing CoMP technology in case of sent traffic.

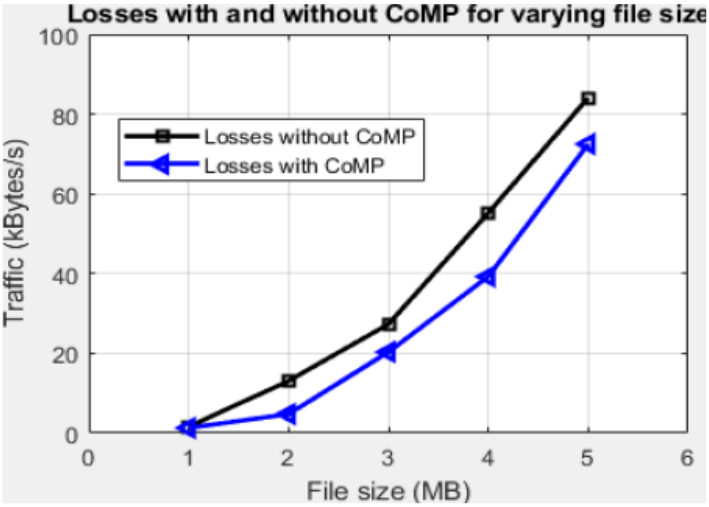

Fig. 6. Traffic losses vs. file size with and without CoMP technique.

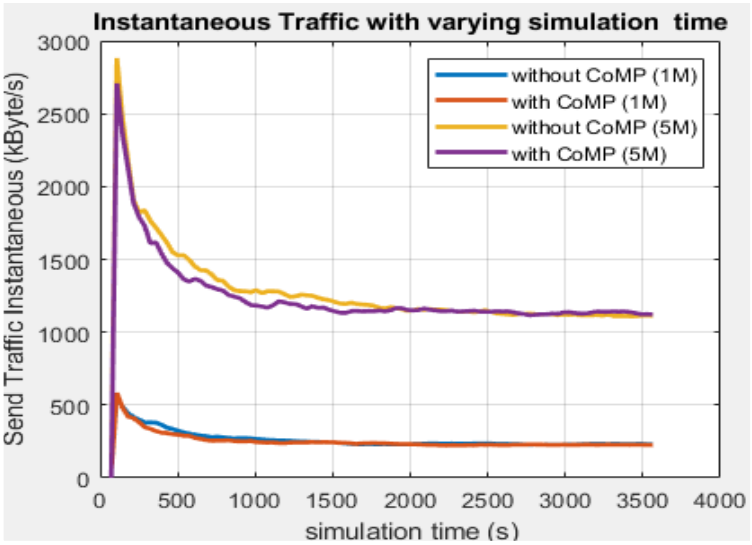

Fig. 7. Instantaneous of sent traffic vs. simulation time with and without CoMP technique.

Figure 8 demonstrates instantaneous values of received traffic with simulation time in case of with and without CoMP technique for different sizes of files. Obviously, the amount of traffic increases when the file size increases in the basic state of the 802.16e system and also after employing CoMP technique. The traffic rate for two cases of file size 1MB and 5MB are 259579.9 b/s and 1187293 b/s, respectively for the normal state of the 802.16e system. While in case of employing CoMP the traffic rate are 250471.7 b/s and 1163093b/s respectively.

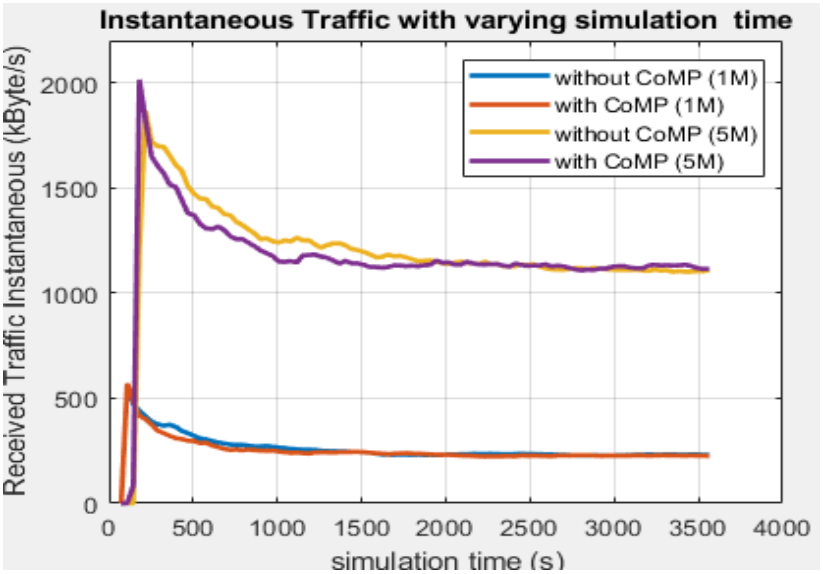

Fig. 8. Instantaneous of received traffic vs. simulation time with and without CoMP technique.

6. Conclusions

As mentioned before, this research dealt with coordinated of multipoint algorithm with the system of 802.16e in order to compensate the noisy channel, which is represented by robust modulation scheme for users (QPSK) in cases of large file sizes (up to 5 Mbyte) for downlink stream. The performance metrics of the paper were sent traffic, received traffic, and lost bytes.

- In the case of the users pulls the files from the server only (without uploading), the results indicated that the CoMP offered an improvement by reducing the ratio of losing the data (the difference between the sent and received traffic) for all cases of files sizes. For instance, the lost bytes are decreased by 13.7% as compared without CoMP in case of file size equal to 5MB per user.
- Whilst in case of 2MB, the improvement of CoMP to reduce the lost bytes were about 63.5% as compared without CoMP.
- It is noted that the improvement, which is offered by CoMP is nonlinear due to the random distribution of users.
- The future work will deal with antenna techniques to enhance the throughput of the system by qualify the users' scheme of modulation as a term of CoMP technique.

Nomenclatures

3GPP	Third Generation Partnership Project
CB	Coordinated Beamforming
CoMP	Coordinated of Multipoint
CS	Coordinated Scheduling
DMFR	CoMP and Dynamic Frequency Reuse
EESM	Effective Exponential SNR Mapping
FFR	Fractional Frequency Reuse
FTP	File Transfer Protocol
JP	Joint Processing
JT	Joint Transmission
LTE	Long Term Evolution
LTE-A	Long Term Evolution-Advanced
OFDM	Orthogonal Frequency Division Multiplexing
RRH	Remote Radio Head
SNR	Signal to Noise Ratio
SOFDMA	Scalable Orthogonal Frequency Division Multiple Access
UE	User Equipment

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