Resource Efficient Algorithm for D2D Communications Between Adjacent and Co-channel Cells of LTE Networks

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Abstract. Device-to-device (D2D) communication has been a hot topic recently because of its potential advantages such as high data rates, spectrum-efficient, and energy-efficient. D2D communication has the advantage of maximum spectral usage, provides higher throughput. The idea in this paper is to design an algorithm for resource efficient D2D communications in adjacent and Co-channel cell of LTE networks. One of the methods used is cell splitting to make different adjacent and Co-channel cell, hence increasing cell capacity and offloading the base station. In this research work, we evaluate how to improve the Quality of service for the User Equipment by designing an algorithm of resource efficient for D2D communication within adjacent and Co-channel cells. As a result, different cells can reuse the same frequency resources in the LTE cellular network. The simulated results show that the proposed algorithm can largely improve the system capacity compared with other existing algorithm.

Keywords: LTE · D2D communications · Adjacent cell · Co-channel cell

1 Introduction

Recently, D2D communication is the topic for most of researchers in this field suggesting the possible means by which wireless communications can be enhanced. D2D communication is the way how two devices can communicate with or without base station (BS) to efficiently facilitate more high data rate services among nearby users and devices. In paper [1] different multiple access techniques which are used to allow many mobile subscribers to share finite amount of radio spectrum simultaneously has been introduced. There are several advantages of this kind of communication compared to traditional cellular network such as higher throughput, efficient spectral usage, extended network coverage improved energy efficiency, delays and fairness hence system capacity is improved [2]. In this type of communication, the user equipment sends the request to base station and then sends it to the receiver. The base station (BS) works as the middle point for both the sender and receiver to communicate [3]. Our focus in this paper is to design a resource efficient algorithm for D2D communication within adjacent and co-channel cells in LTE networks, so that the network provides better QoS

V. Odumuyiwa et al. (Eds.): AFRICOMM 2017, LNICST 250, pp. 192–203, 2018.
https://doi.org/10.1007/978-3-319-98827-6_17

without overloading the network [4]. The rest of the paper is organized as follows: Sect. 2 focuses on the D2D communication based on the adjacent and co-channel cells in LTE networks. Section 3 describes the related works. Section 4 describes the proposed D2D algorithm design. Section 5, we show the analysis of simulation results and Sect. 6 describes conclusion and further works.

2 D2D Communication Based on Adjacent and Co-channel Cells in LTE Networks

D2D communication is the way how two devices can communicate with or without base station (BS) to efficiently facilitate more high data rate services among nearby users and devices. As illustrated in the Fig. 1, two adjacent cells (cell1 and cell2) where UE1 discover UE2 while they are located on two different cells. As explained in Sect. 1, you find that UEs are connected on base station for each cell, those base station was connected through the gateway. It is from that connection of base station where those two devices UE1 and UE2 are connected. If there are more UEs within those adjacent cells, the method of cell splitting and frequency reuse are applied for adjacent and co-channel cells in order to provide better QoS, better utilization of spectrum and avoiding of interference within the system.

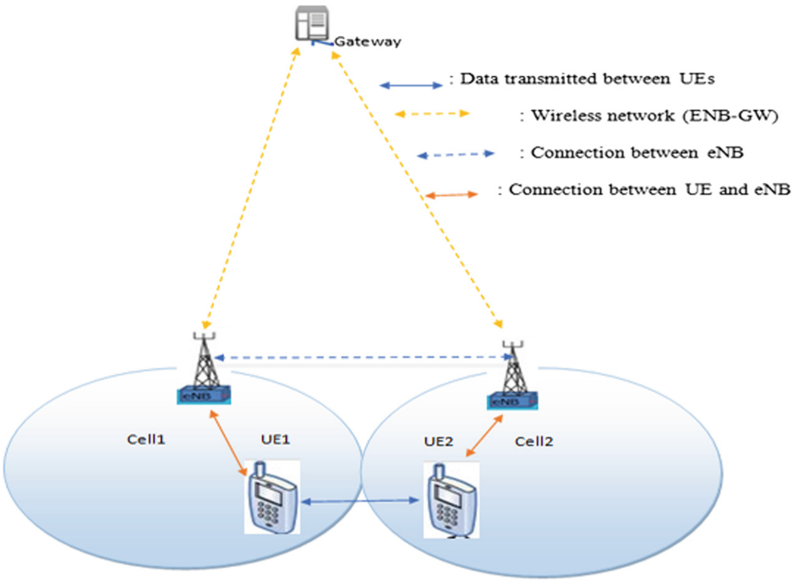

Fig. 1. Proposed system model of D2D communication within two adjacent cells in LTE network.

According to the Fig. 2, there is a complete network between different adjacent and co-channel cells, for example on the cluster 1, packets are transmitted between cell 7 and cell1.in addition, the packet are transmitted from cells located on two different cluster like for example on cell 2 within cluster 2 and cell 6 within the cluster one. The aim of this paper is to design and analyze a resource efficient algorithm for D2D communication within different adjacent and co-channel cells of a LTE network.

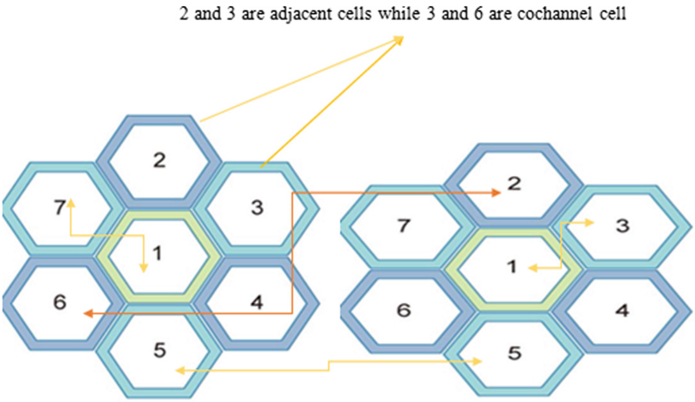

Fig. 2. Proposed system model of D2D communication within different adjacent and cochannel cells in LTE Network.

3 Related Works

Although a lot of work has been done on this topic but, most of them did not consider the system capacity of adjacent and co-channel cells as an issue. Reusing the resources of more than one cellular user were proposed in [5] but they do not indicate the way it will increase the system capacity. Three sharing modes are mentioned in [6] as non-orthogonal, orthogonal and cellular sharing modes but it focuses on optimization of power and energy. The spectrum reuse protocol where D2D users are only allowed to communicate with each other during the uplink (UL) frame of the network. This is due to the fact that during UL only the base station (BS) is exposed to interference by the D2D users but focuses on the spectrum sharing by analyzing and identifying the interference problem of the primary cellular network caused by the D2D transmitter during the UL and DL phases separately [7]. The system model in [8] contains the inner part and the outer part, where the inner part consists of the traditional UEs which communicate through BS whereas the outer part consists of the D2D UEs which have at least one neighbor within a targeted distance. The author in [9] assumes that the large number of resources in inner part is taken as infinite and Poisson point distribution is considered in this case for cellular UEs. The author in [10] assumes that the finite number of sources in outer part of the cell for D2D UEs and the corresponding model in this case is the Engset distribution and the number of sources in the inner part is distributed into small cell with a reuse factor of seven so that the number of resources is reduced and consider Engset distribution for both parts by applying the method of sharing available resource where each part uses dedicated resource but the author does not show how their model shall enhance the system capacity since this can accommodate more users. But in this paper our focus was for adjacent and co-channel cells where system capacity and throughput should have been considered to ensure better QoS. In this model, two adjacent cells are split into multiple small adjacent and cochannel cells, and an algorithm of resource efficient for D2D communication was designed to enhance the system performance. Also, based on Shannon's equation for capacity calculation, several formulas was used to design an algorithm of resource efficient for D2D communication within adjacent and cochannel cell in LTE network which helped to provide increased capacity for better performance and to increase the quality of service to the cellular users.

4 Proposed D2D Algorithm Design

In this paper, the concept is to analyze and design an algorithm of how two or more different devices located on two different adjacent cells or cochannel cells should be communicated. Two adjacent cells are split into multiple small adjacent and cochannel cell such that different UEs or Devices located on that two adjacent and cochannel cell are communicated. Due to that method of cell splitting and designed algorithm, the packet from the device located on one cell are transmitted to another device located on the other cell while those devices are located on two different cell which are adjacent or cochannel. A scenario is designed as follows, in each cell, there is a base station (Enode-B) to serve UEs located on that cell and for another cell there is a base station to serve the UEs located on that cell and those two base station was discovered one-another by the Gateway, if base station of one cell discover base station of another cell through the gateway, the device of one cell can discover another device of the other cell while those cell are adjacent or cochannel as it is illustrated on the Fig. 1.

4.1 Flowchart Representation of the Proposed Algorithm

In this paper, three parameters such as data, noise and error rate were proposed to test and it has been achieved because packets are transmitted successfully into different adjacent and co-channel cell. Noise is minimised and the error rate is very low. The following diagram indicate the flow of packets transmitted from different adjacent and co-channel cells. The overall algorithm is shown in the flowchart of system in Fig. 3. The flowchart representation for both adjacent and cochannel cell algorithm is shown in Fig. 3. As it is shown on the flowcharts below, we find the flow of how the packets were transmitted between different adjacent and cochannel cells in LTE network based on the proposed algorithms three parameters such as Data rate, Noise and Error rate was evaluated and it was achieved successfully as it is shown on the following algorithm. The proposed algorithm below help to set different devices within adjacent and co-channel cells in LTE network and help to check how transmission of packet are transmitted through different cells. The algorithm helps to minimize noise and error rate in order to provide good QoS.

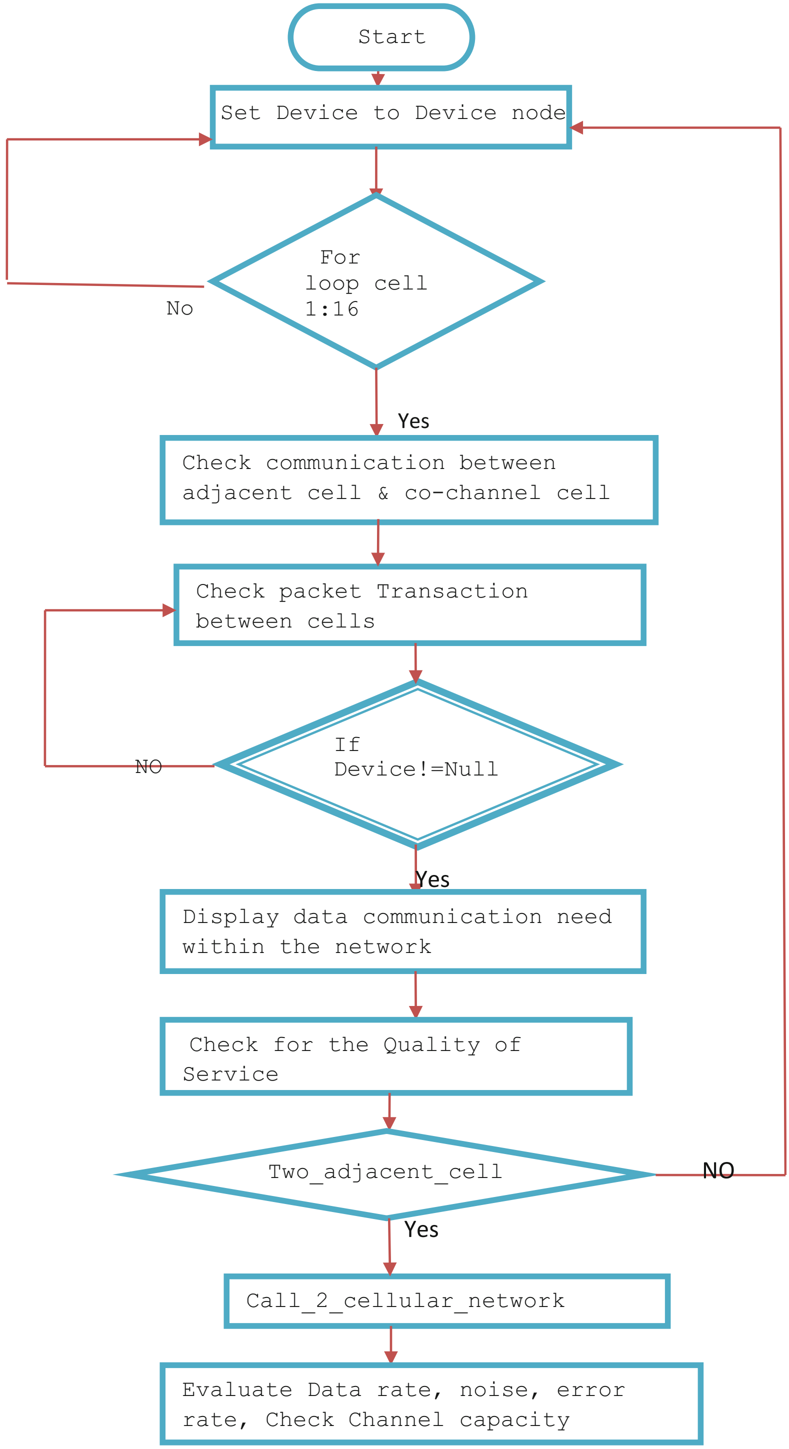

Fig. 3. Proposed flowchart of the system

4.2 Proposed Algorithm

```
1: Set Device to device cell
2: For loop cell 1:16
3: Check communication between adjacent cell & co-channel cell.
4: Check paket Transmission between nodes.
5: if (d1: Device! =null)
      {
   Print" data communication need within the network"
       }
6: check for the QoS;
7: Validating the network networkgrid.
8: if (two_adjacent_cell)
       {
   Cellular network= Call_2_cellular_network
             }
9: Evaluated Data rate, noise, error rate and Check Channel capacity
```

5 Simulation Results and Analysis

For evaluating the performance of the proposed algorithm, we simulated and showed the results in ns-2 where two adjacent cells split into multiple adjacent and cochannel cells to make LTE network. The cells are randomly deployed in a circular area. The number of cells varies from 8 to 17. The initial energy of normal node is 32 J. Table 1 summarizes the simulation parameters and their default values.

Table 1. Simulation parameters

Parameter	Value
Number of cells	17
Initial energy *E*0	32 J
Simulation time	2.00 ms
Channel type	Wireless channel
Network interface type	Physical
Bandwidth	100 Mbits/s
Delay	10.00 ms
Scenario size	240 m × 240 m

Figure 4 below shows how LTE network made by different cell was created, as you have seen on the interface bellow you find that two adjacent cell split into multiple cell which are adjacent and co-channel cell, in each cell there is a base station and the gateway to interconnect those two base station in order to facilitate communication between two UEs located on different cell. According to the Fig. 6 below, LTE network is divided into 15 adjacent and co-channel cells where two clusters, two base stations and one gateway is formed. For those two clusters there is 7 small cells for the first cluster and 6 small cell for the second cluster. Base station (E-NodeB) is located in each cell to serve the UEs located on that cell. Those two base station are located on two different cell and it is connected each other throughput gateway. Device from one cell discover another device for another cell if those two base stations was discovered each other through gateway and by D2D discovery mechanism. Figure 5 shows haw data transmission was transmitted for adjacent and cochannel cells.

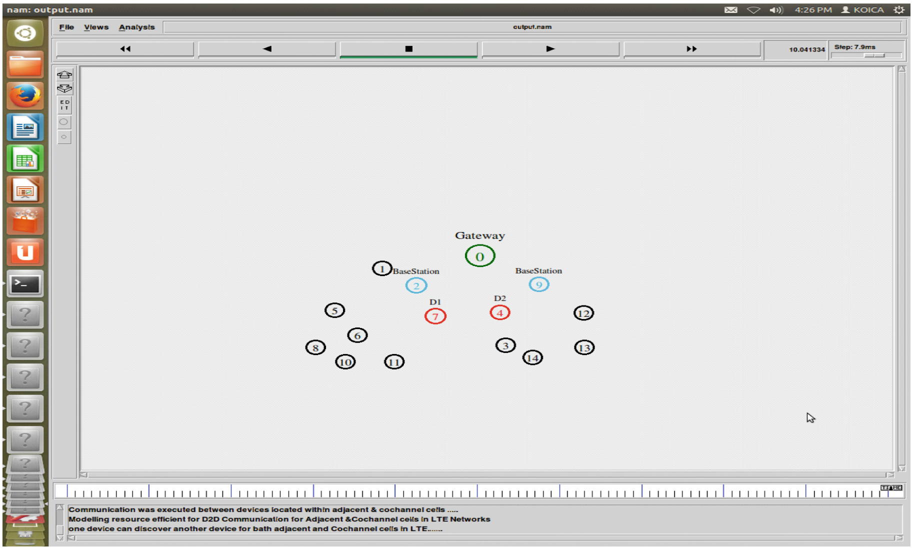

Fig. 4. LTE Network with cell splitting into multiple adjacent and co-channel cell

As it is shown on the Fig. 5 above, you find that packets are transmitted between devices located on adjacent and cochannel cells. As you have seen, cell 7 contain device D1 and it is located on the first cluster while cell 4 in the form of circle contain device D2. The data was transmitted from D1 to D2 while they located on two adjacent cells but it is possible because each device is connected to base station and if those two base stations were interconnected through gateway they will be the process of D2D discovery mechanism and those devices interconnect each other. As explained before, you find in Fig. 6, that there is a direct link between D1 and D2 while they are located on two different cells which are adjacent or cochannel. You find that the packets were transmitted from D1 to D2 while D1 is located on cell 7 and D2 on cell 4. This is due to the interconnection between those two base stations through the gateway.

According to the Fig. 6, the throughput is defined as total number of bits per second used by the user equipment excluding the number of bits per second used for control overhead. The throughput is calculated for both adjacent and co-channel cellular network. Here results are shown in form of lines, where red line shows the throughput of the adjacent and co-channel cell with D2D link in the proposed algorithm and green line shows the throughput of D2D communication in the existing algorithm. As you have seen for the proposed algorithm the throughput was increased much compared to the existing algorithm. As it is illustrated on the Fig. 10, the transmission of the packet is very high for the red line result while for the green line is low, thus the system

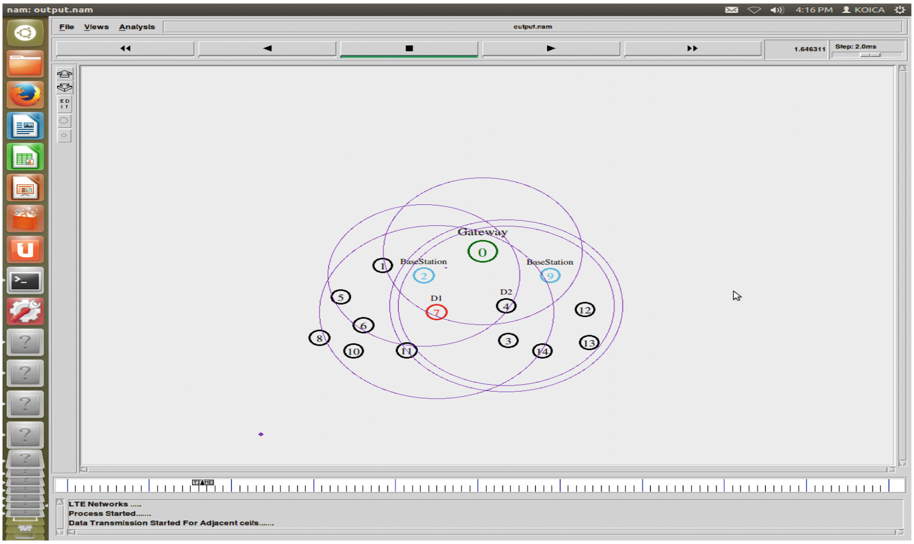

Fig. 5. Packets transmission from D1 to D2

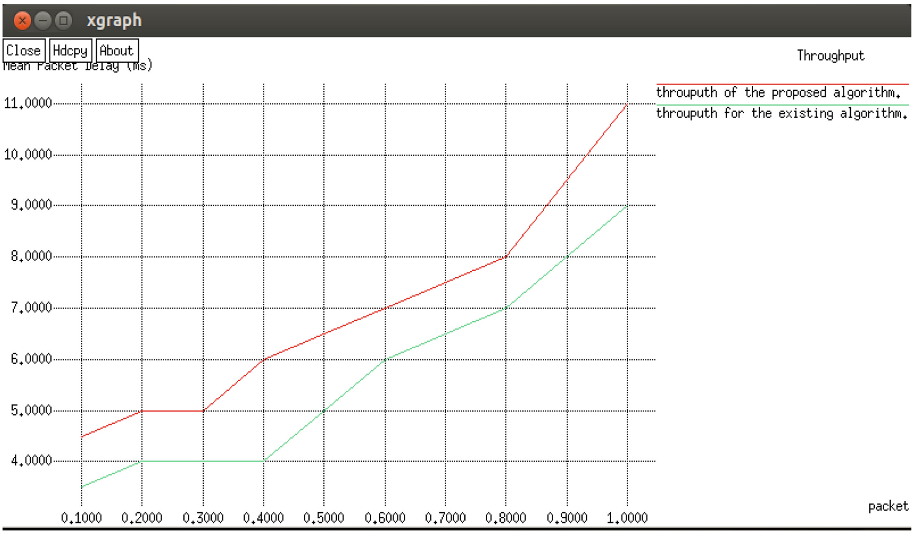

Fig. 6. Network throughput (Color figure online)

capacity is increased because different UEs located on adjacent and co-channel cell was communicated by D2D discovery mechanism in case base station was finished to set connection between them. For example for 0.30000 s the bit/s transmitted was still constant as it shown on green line while for red line was increased, hence the proposed algorithm gives better QoS than existing algorithm.

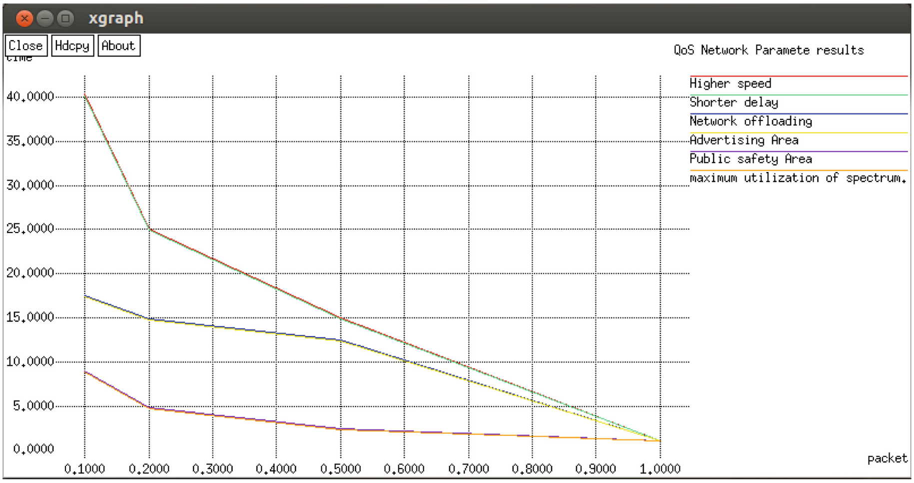

Fig. 7. Different QoS parameters result analysis

As it is shown on the Fig. 7 above, you find that different QoS parameters for both adjacent and cochannel cell was analyzed such as: High speed, shorter delay, network offloading, public safety and utilization of the spectrum was analyzed and the result on different lines indicated on the interface above shows that the proposed algorithm gives a good performance of those parameters because the packet was transmitted within shorter delay, a very high speed and it helps to have a good utilization of the spectrum. Thus, QoS was increased.

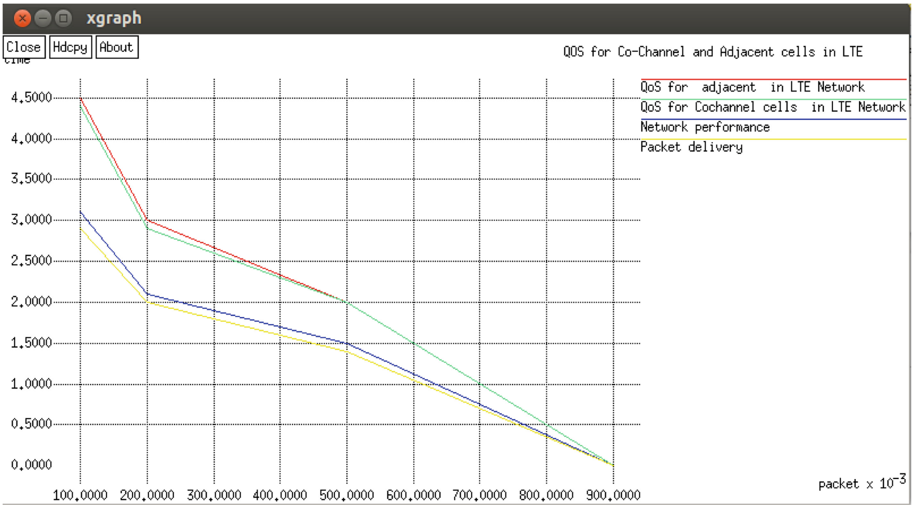

Fig. 8. Performance of the system and packets delivery

According to the Fig. 8 above, the result shows the performance of the system and the packets delivered within a time for both adjacent and cochannel cell. As it is indicated on the interface above, you find that many packets were transmitted within a short time. In addition, due to the good performance of the system, the more packets to be transmitted increased, the more time takes decreased. Thus, the proposed algorithm provides better quality of service than the existing algorithm.

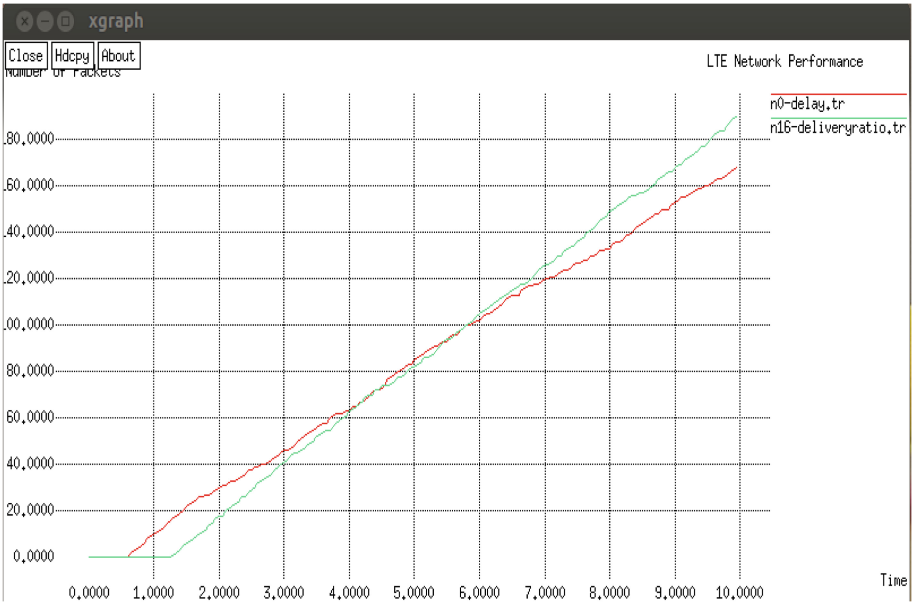

Fig. 9. Packets delayed vs packets delivery (Color figure online)

According to the Fig. 9 above, the results shows how the packets was delayed for the existing algorithm and delivered for the new algorithm within a time. As you have seen red line indicate the packet delayed result for the existing algorithm and green line shows the packet delivery for the proposed algorithm. The result on the green line indicates that more packets transmit on very high level within a time for the proposed algorithm while for the existing algorithm packets were delayed to be transmitted. Thus, the new algorithm provides better quality of service than the existing algorithm.

According to the Fig. 10 the result indicates on red line and green line that the more we have very high density of users, the more the system capacity also was increased because the proposed algorithm enhance the system capacity for both users located on adjacent and cochannel cells in LTE network and the more users was served, the more the quality of service was achieved and the problem of overloading the system will be resolved.

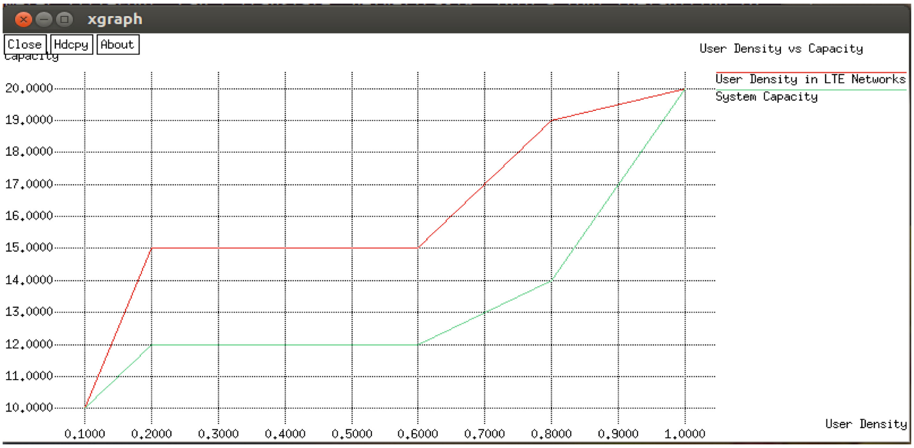

Fig. 10. User density vs. capacity (Color figure online)

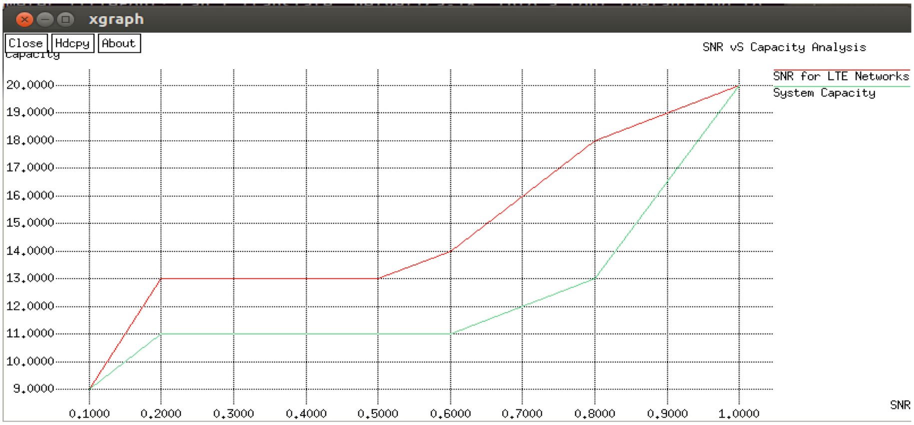

Fig. 11. SNR vs. capacity (Color figure online)

As it is indicated on the Fig. 11 the result of the new algorithm shows that the capacity increase as the target SNR increases as it is indicated by red and green lines of the Fig. 11 above. However, when D2D communication is used together with LTE more control overhead is required since the base station needs to make sure that all signaling information has been transmitted. In addition to that the discovery mechanism also requires some percentage. Once the capacity increase, thus QoS is achieved and many users was served by D2D link for both UEs located on adjacent and co-channel cells.

6 Conclusion and Further Works

In this paper, an algorithm was designed for how two or more different devices located on two different adjacent cells or co-channel cells should communicate between each other. Only one scenario of LTE cellular network, where two adjacent cell split into multiple small cells is tested. It is from those small cells where small adjacent and cochannel cells will be created. A resource efficient algorithm has been designed within the scenario. This algorithm improves the QoS in the adjacent and co-channel cells of the cellular network by increasing the capacity. We carried out analysis focusing on how the system capacity will be increased. The simulation results of the proposed algorithm shows that the QoS is achieved and the overloading problem of the system was resolved. In addition, the resource reuse is also the key for capacity enhancement in the way that reusing resources offloads BS between adjacent and co-channel cells and then other UEs can be served hence better QoS is achieved. In this paper several existing algorithms were evaluated and considered but our proposed algorithm works better than the existing approaches.

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