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Analysis of Mobility Impacts on LTE Network for Video Streaming Services using Distributed Antenna System

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ABSTRACT

LTE (Long Term Evolution) is a Broadband Wireless Access (BWA) technology that allows high speed and a wide range of access. LTE is designed to meet the needs for Quality of Service (QoS), i.e. the ability to download up to 300 Mbps and upload up to 75 Mbps. This study investigated the impacts of user mobility on the LTE network for video streaming services. The approach employed in this study included multi-user with Distributed Antenna System (DAS) and various variations of user mobility speed. Observations were made on the condition of the user moving from one cell to another so that the handover occurred. The throughput value will increase by 33% and 47% when the user's distances are respectively 1250 m and 2000 m from eNode B. In addition, the delay value will reduce by 66.32% and 67.58% when the user's distances are respectively 1250 m and 2000 m from eNode B. Moreover, the PDR value will increase by 48.74% and 55.45% when the user's distances are respectively 1250 m and 2000 m from eNode B. The use of a distributed antenna system (DAS) model on LTE network has resulted in improved quality of performance when the user streams a video.

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1. Introduction

The mobile broadband technology is currently evolving due to the increasing users' need for not only voice communication services, but also data and multimedia services such as video calls, video conference, and video streaming. The increasing need for data services is driven by the users' increasing mobility with data services that can support their dynamic activities. The emergence of smartphone and tablet technology is supported by various data features, especially for video services to trigger the increased data traffic on broadband networks. The growth of data traffic due to video services has led the telecommunication providers to expand the opportunity into their businesses by providing a fast and reliable wireless network that meets the QoS standards. The users' increased need for varied services and a large number of users in one Base Station as well as the need for providing HD video streaming and multimedia services with QoS assurance make the performance of wireless network communication systems using 2G and 3G technologies not optimal.

LTE (Long Term Evolution) is a high speed and wide range Broadband Wireless Access (BWA) technology. LTE is designed to satisfy the needs for Quality of Service (QoS), i.e. the ability to download up to 300 Mbps and upload up to 75 Mbps. Many studies have been conducted on the LTE network performance. N. Feamster and H. Balakrishnan discusses video quality and compares the upload video codecs and their impacts on packet loss which causes errors in the transmission [1]. A. Talukdar, M. Cudak, and A. Ghosh suggest that video quality with 3 downlinks can affect the LTE Air Interface for video [2]. Guo 'Enzo, Lin' James, and Zhang 'Yang suggest that the values of jitter, end-to-end delay, LTE delay, Throughput, and MOS parameters decrease during internet browsing [3]. Alessandro Vizzarri who investigates the effect of voice codecs on the performance of end-to-end LTE network (VoLTE) found that VoLTE for voice services is strongly influenced by the values of MOS, end-to-delay, voice transmission and reception traffic, voice packet delay variation, and LTE downlink/uplink delay [4].

This study investigated the impact of user mobility on the LTE network for video streaming services. The scenario used in this study was multi-user using a distributed antenna system model with various variants of the user mobility speed. The test parameters included throughput, delay, and PDR.

In terms of the condition of propagation and topology, assumptions used in this study differed from previous studies. This study was conducted on the condition of users moving from one cell to another cell thus creating a handover by simulating it using Network Simulator 3.

2. Design and Methodology

The LTE architecture consists of three main components: EU (User Equipment), E-UTRAN (Evolved UMTS Terrestrial Radio Access Network), and EPC (Evolved Packet Core) [5]. Figure 1 illustrates an LTE network architecture.

The technical specifications released by 3GPP for LTE technology are shown in Table 1. One of the 3GPP-based LTE performance requirements is the mobility supports up to 500 km/h and the low speed ranging from 0 km/h to 15 km/h.

2.1. Video streaming service

Streaming video service is a process of continuously transmitting data broadcasted through the internet networks to be displayed by a streaming application on the client devices [6].

2.2. Distributed Antenna System

The distributed antenna system model consists of a central base station that will connect to several Remote Radio Heads (RRH) distributed throughout the cell area. The base station controlling the RRH can be placed together with the RRH or in a separate location. The base station can be connected to the RRH through various types of transmission media but mostly connected with a fiber optic cable [7]. The topologies that can be used in the distributed antenna system (DAS) model include ring topology, star topology, and bus topology [8]. The remote antenna from each RRH of the DAS model will connect to the base station base. The remote connection of this antenna will make it easier for the base station to control the RRH so that this model will allow the expansion of cell coverage or user capacity. In the DAS model, the QoS obtained by the user can also be better once the distance from the user to the nearest RRH is shorter compared to the distance from the antenna base station with the fixed user coverage and capacity [9]. Figure 1 illustrates the Distributed Antenna System (DAS) model.

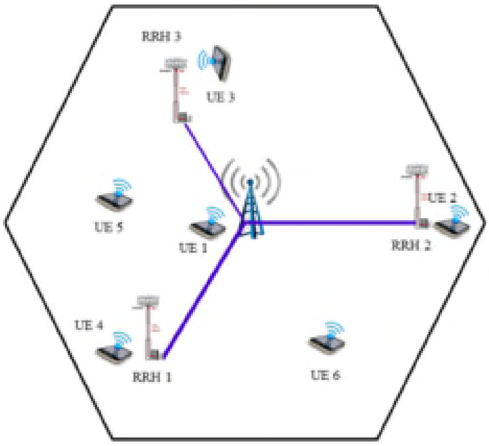

Figure 1 Distributed Antenna System (DAS) Model [8]

2.3. QoS Parameters for LTE

2.3.1 Throughput

A network throughput is defined as the average success rate of message delivery through a communication channel. Throughput has units of bits per second or data packets per time slot [10].

Throughput =File Size/Transmission Time (bps)

2.3.2 PDR

Packet Delivery Ratio (PDR) is the ratio between the number of packets successfully received at destination and the total packets sent from a source [11].

$$PDR=(\sum \text{packets delivered}/\sum \text{Packets sent})*100$$

2.3.3 Delay

Delay is defined as the time taken for packet delivery from source to destination. The equation for calculating the average delay, where n is the total packets, is presented as follows [10].

$$\text{Average delay} = (\text{Packet Arrival} - \text{Packet Start})/n$$

3. Results

3.1. System design

The performance of LTE network in this study was analyzed using the Network Simulator (NS3). The LTE network topology simulation model is illustrated in Figure 2. The modeling employed four eNode B LTE with n as the number of User Equipment (EU). Each eNode B was mapped using a core radio access network. The network was analyzed based on the user's mobility and distance from eNode B on the network when the user used video streaming services. For the first time streaming video, the user was initialized to be at a certain distance from eNode B with an initial speed of 5 km/hour. At the time the user mobilized, the user's speed changed. Changes in the user's speed will, in turn, bring changes to the network's mobility model. Meanwhile, the area coverage depends on the propagation model used so that the performance of the streaming video kites depends on the number of users and their mobility speeds.

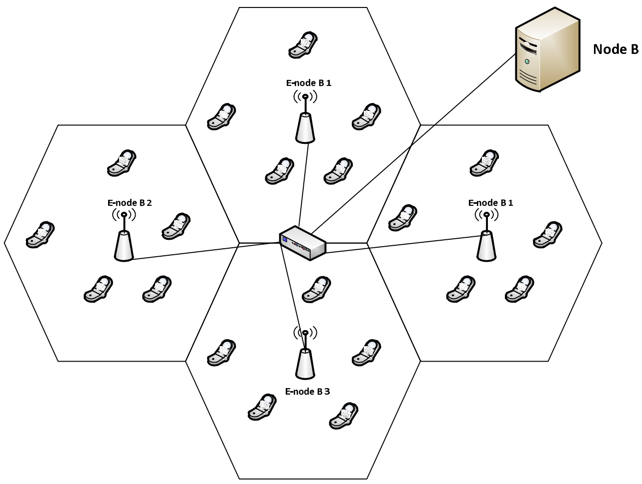

Figure 2 Simulation With Four eNode B LTE

The parameters applied to the simulation as shown in Figure 2 can be seen in Table 1.

Table 1 Parameter Simulation

Parameter	Value
Simulation time (s)	100
Simulation area (m)	1250 x 1250
Transport protocol	UDP
Packet size (byte)	512
Data rate (Mbps)	1

In this study, the observation scenario for the mobility impact on LTE network employed simulation parameters as listed in Table 1 by taking into account the output simulation parameters of throughput, delay, and PDR. Figure 3 illustrates model simulation using the NS3 software.

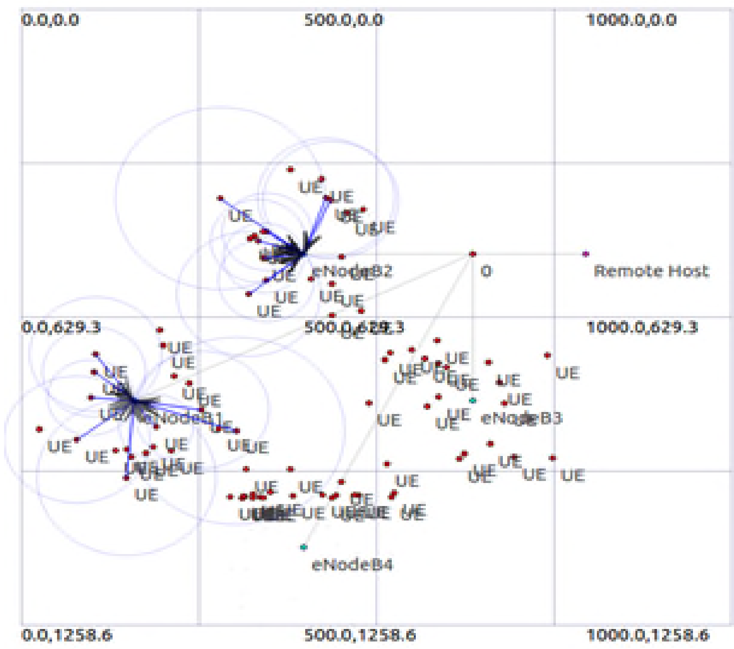

Figure 3 Model Simulation NS3 Software

3.2. Simulation results

The simulation using NS3 generated throughput, delay and PDR values for 20 users in the cell.

3.2.1 Throughput

Based on the simulation results as illustrated in Figure 4, the scenario of increasing speeds generates an average throughput value at 1250 m from eNode B on LTE network whereby the value of throughput with DAS is higher than that without DAS. The values of LTE network throughput with DAS for video streaming at the speeds of 5 km/h, 10 km/h, and 20 km/h are 1.006 Mbps, 0.482 Mbps, and 0.214 Mbps, respectively. The use of Distributed Antenna System (DAS) has increased the average throughput value by 33% compared to that without DAS.

Figure 5 shows that when a user moves away from the serving eNode B with a scenario of the same speed variation and a distance of 2000 m from eNode B, the throughput value on LTE network with DAS is still higher than that without DAS. The LTE network with DAS generates a throughput value of 0.128 Mbps at 20 km/h speed, while the network without DAS at the same speed generates a throughput value of 0.016 Mbps. The use of DAS has increased the average throughput value by 47% compared to that without DAS.

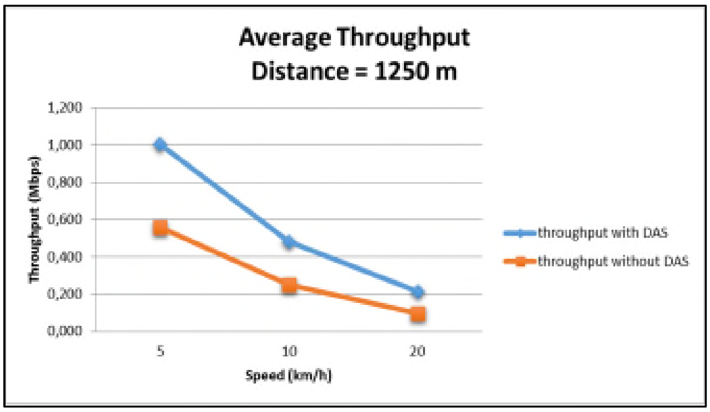

Figure 4 Throughput Values with Speed Scenario (Distance =1250 m)

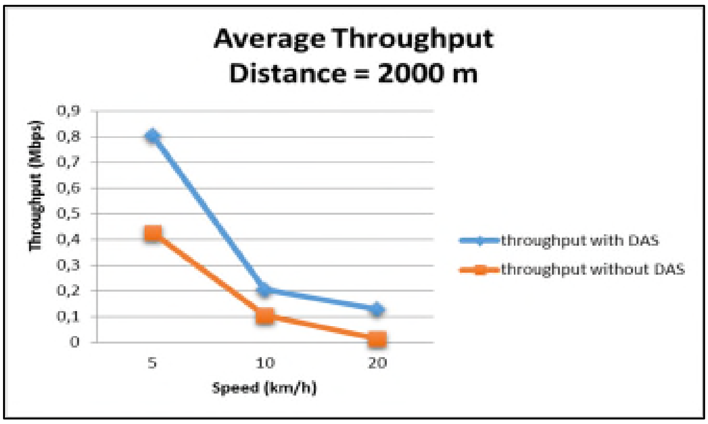

Figure 5 Throughput Values with Speed Scenario (Distance = 2000 m)

Figure 6 shows that the throughput value on LTE network with Distributed Antenna System (DAS) is highly dependent on distance. The more the user moves away from the serving eNode B, the more the throughput value decreases, with an average decrease of 25.46%. Meanwhile, the more the user's speed during mobility increases, the more the throughput value decreases.

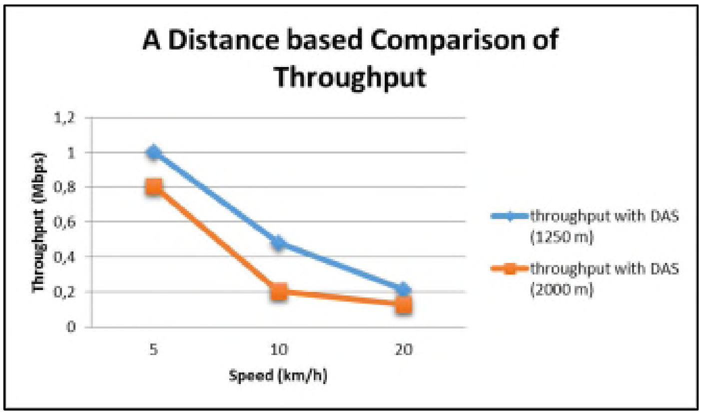

Figure 6 Distance-Based Throughput Comparison

3.2.2 Delay

Figure 7 shows that the delay value is highly influenced by speed and distance. At a distance of 1250 m from eNode B, the value of delay for LTE network with DAS is smaller than that without DAS. The lowest delay value is 0.0132 s at 5 km/h speed on LTE network with DAS. The delay value will decrease by 66.32%.

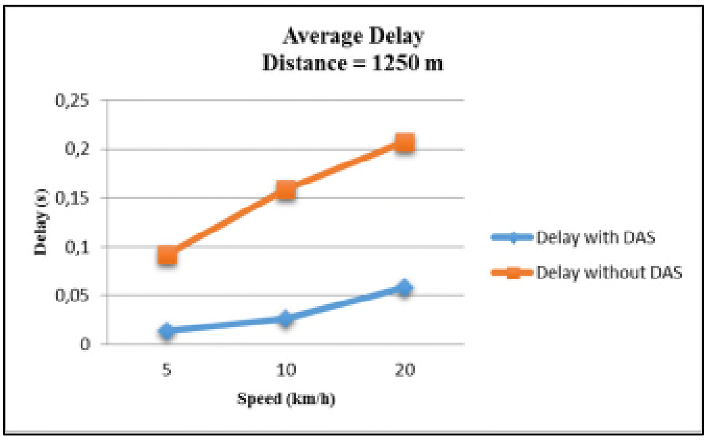

Figure 7 Delay Values with Speed Scenario (Distance =1250 m)

Figure 8 shows that when a user moves away from the serving eNode B at a distance of 2000 m from eNode B, the delay value gets higher. The delay value on LTE network with DAS is lower than that on LTE network without DAS. At the time the user is 2000 m from eNode B, it will generate the lowest delay value of 0.0183 s on LTE network with DAS. The delay value will decrease by 67.58%.

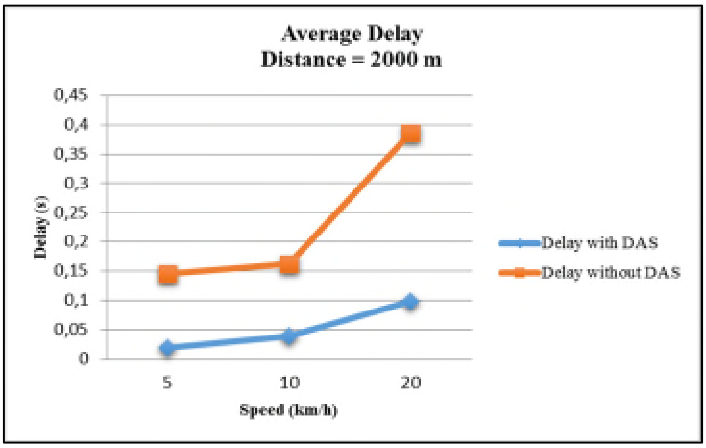

Figure 8 Delay values with speed scenario (distance = 2000 m)

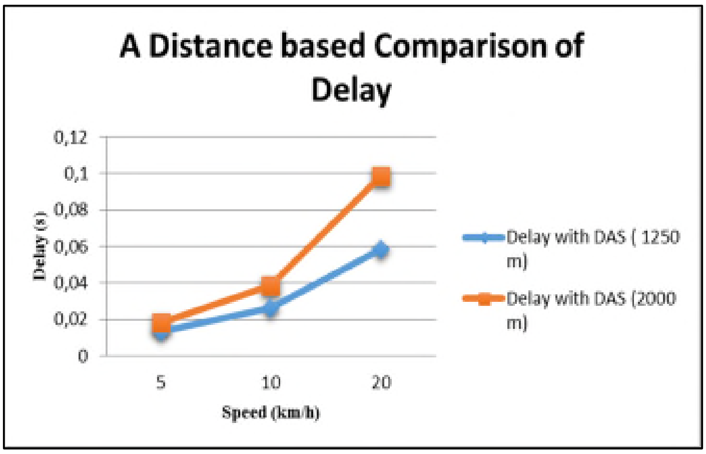

Figure 9 Distance-Based Delay Comparison

Figure 9 shows that the delay value is strongly influenced by distance. At the time the user moves away from eNode B when playing a streaming video, the delay value will get higher. The average value of delay has increased by 20.15% in which the further distance of the user from the serving eNode B, the higher the delay value will be.

3.2.3 Packet Delivery Ratio (PDR)

The PDR value represents the number of packets received by the user. The number of users highly affects the PDR value. Figure 10 shows a comparison of the packet delivery ratio (PDR) value to the speed variation when the user is 1250 m from eNode B. The PDR value will be lower as the user's speed increases. The figure also shows that when the LTE network is using DAS, the PDR value generated during the simulation period will be higher than LTE network without DAS. On the LTE network with DAS, the highest PDR value is obtained when the user has a speed of 5 km/h, which is equal to 99%. Meanwhile Figure 12 shows that the highest PDR value (80.32%) is generated by LTE network with DAS, i.e. when the user has a speed of 5 km/h at a distance of 2000 m from the serving eNode B. The PDR value will increase by 48.74% when the user's distance is 1250 m and increase by 55.45% when the distance is 2000 m from eNode B.

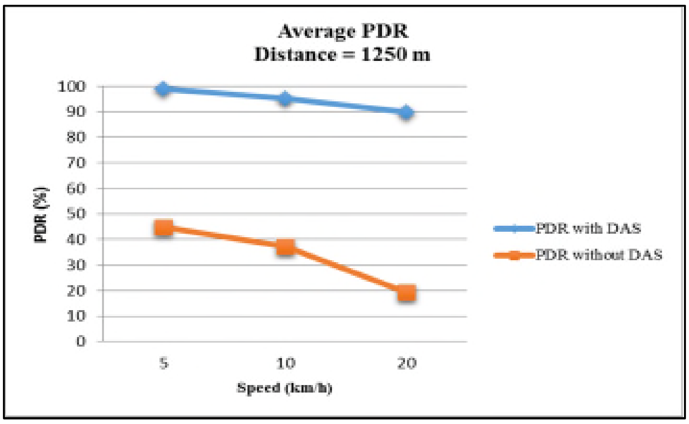

Figure 10 PDR values with speed scenario (distance =1250 m)

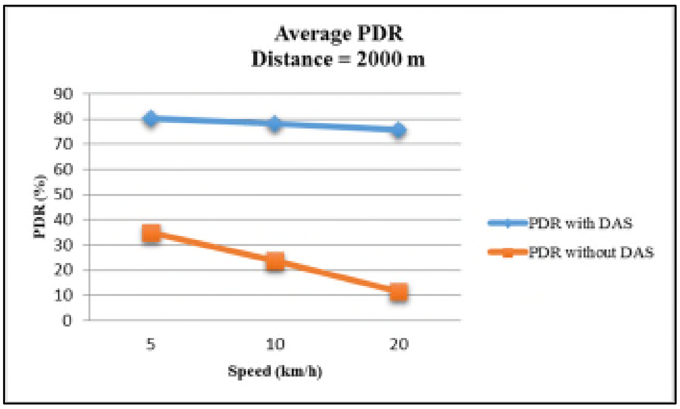

Figure 11 PDR Values with Speed Scenario (Distance =2000 m)

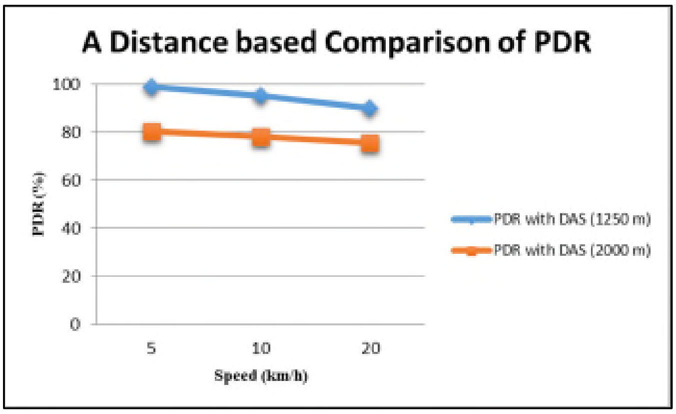

Figure 12 A Distance Based Comparison of PDR

Figure 12 shows that the PDR value averagely decreases by 9.61%. This indicates that the further the distance of the user from the serving eNode B and the more the user's speed increases, the more the PDR value decreases.

4. Conclusion

The LTE network scenario with Distributed Antenna System (DAS) model has resulted in improved quality of performance when the user plays a video streaming in comparison to the scenario without DAS. The values of throughput, delay, and PDR generated in the scenario with DAS highly depend on the user's speed and distance from the serving eNode B. The throughput value will increase by 33% and 47% when the user's distances are respectively 1250 m and 2000 m from eNode B. In addition, the delay value will reduce by 66.32% and 67.58% when the user's distances are respectively 1250 m and 2000 m from eNode B. Moreover, the PDR value will increase by 48.74% and 55.45% when the user's distances are respectively 1250 m and 2000 m from eNode B.

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