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A DISTRIBUTED MODEL TO COMPARE THE QoS PERFORMANCE FOR LTE AND WiMAX NETWORK DELAY

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Abstract

Worldwide Interoperability for Microwave Access (WiMAX) and Long-Term Evolution (LTE) provides a solution to increasing demands for broadband wireless applications which facilitates high-rate voice services at low cost and good flexibility over IP-based networks. With the development of high-speed mobile broadband access technology, the Long Term Evolution which is developed by 3rd Generation Partnership Project (3GPP) and WiMAX, standardized by the Institute of Electrical and Electronics Engineers (IEEE) both designed to provide high data rate wireless network connection for cell phones, laptops, and other electronic devices. The IEEE 802.16 Standard introduces several advantages; one of them is support for Quality of Services (QoS) at the Media Access Control (MAC) level. However, the existing delay for both LTEs and WiMAX Network does not provide sufficient QoS. In this paper a distributed Client-Server model was developed to compare the QoS with respect to delay in WiMAX and LTE Network in order to enhance the services that are provided to the end users. The model was simulated in the OPNET modeler (16.0) with Multiple Access Points (APs), Base Stations (BSs) as well as mobile devices, Subscribers Stations (SSs), and some server BSs that were selected based on Nearest Neighborhood Algorithm and Orthogonal Frequency Division Multiplexing (OFDM) techniques. The results obtained from this proposed model showed significant performance in network Delay for LTEs Network over WiMAX Network.

Keywords— WiMAX, LTE, QoS, Delay and OPNET Modeler 16.0

INTRODUCTION

WiMAX networks provide high data rates, last mile wireless access, point to multipoint communication, large frequency range and quality of services for various types of applications. WiMAX is an access technology, which provides wireless data transmission in various ways ranging from point-to-point links to mobile cellular access (Kasim 2012). It is based on IEEE 802.16 standard, which provides wireless broadband access as an alternative to the cable and Digital Subscriber Loop (DSL) WiMAX provides basic IP connectivity to the users using mobile broadband data access (Saidu et al. 2015). OFDM mitigates noise, multipath, and interference effects, which are the primary challenges of wireless communication (MinakshiHalder 2015). Based on the research from (MinakshiHalder 2015) the 2005 WiMAX revision provided bit rates as much as 40 Mbit/s while using the 2011 update as much as 1 Gbit/s for fixed stations. It is a part of the "Fourth Generation" (4G) wireless-communication technology offering a metropolitan network with a signal coverage radius of approximately 50 km (30 miles) (Srivisshudhanan 2015). A WiMAX network consists of a Base Station and a number of Subscriber Stations. Typical Base Stations are backhauled to the core network while Subscriber Stations are used as access points for end users (Naqvi et al. 2012). On the other hand, Long Term Evolution (LTE), a mobile telecommunication technology standardized by 3GPP, is the biggest jump on the evolution path from 3G UMTS and CDMA2000 towards 4G, with ambitious requirements for data rates, capacity and latencies (Dhake et al. 2015). An advanced version of LTE, LTE-Advanced based on 3GPP UMTS Rel 10 in 2011, is also a 4G recognized mobile technology (Dhake et al. 2015).

The two technologies, WiMAX and LTE, competed with each other starting their pre-4G versions and continued with their 4G versions while having much in common. It looks like that finally WiMAX gave up the competition and selected to harmonize and integrate with LTE in its future harmonized WiMAX advanced standard supporting multiple access technologies (Masum & Babu 2011).

QoS in WiMAX inherited from the standard and also from an end-to-end network view (Hamid 2013). Providing QoS between two end-points in broadband wireless networks like WiMAX requires connecting many links with intermediate components like routers, switches, etc. Since WiMAX is envisioned to provide end-to-end IP services and will likely be deployed using an IP core network, IP QoS and its interaction with the wireless link layer are what is most relevant to WiMAX network performance. There are more components and functionalities in an end-to-end network providing QoS than the air interface QoS features discussed above, such as policy control and charging (PCC) functions in the QoS provisioning general flow of QoS in LTE (Karada et al. 2013).

The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds (Latré et al. 2006). Delay may differ slightly depending on the location of the specific pair of communicating nodes. Although users only care about the total delay of the network, the average delay is divided into several parts; the processing delay – the time Base Station takes to process the packet header, the queuing delay – the time the packet spends in routing queue, the transmission delay – the time it takes to push the packet's bits onto the link and propagation delay – the time for a signal to reach its destination (Singh 2010).

Due to the bottleneck and the competition among different kinds of traffic flow on the network, packets of voice streaming may experience dropping in the scheduling buffer. In this paper a new Distributed Client-Server model to improve the QoS performance of LTE and WiMAX network with respect to Delay will be developed to improve the services that are provided to the end users. The model will be simulated in the OPNET modeler (16.0) with Multiple Access Points (APs), Base Stations (BSs) as well as mobile devices, Subscribers Stations (SSs), and some server BSs that were selected based on Nearest Neighborhood Algorithm and Orthogonal Frequency Division Multiplexing (OFDM) techniques.

Background of the Research

In recent years, there has been rapid growth in various wireless networks along with the demand for wireless data services and multimedia applications. To provide better service, to meet this growing demand research has been done in the field of QoS in WiMAX and LTE networks. Earlier studies have already established that IEEE 802.16 is not providing sufficient QoS for WiMAX networks. The work of (Kiran et al. 2013) consider the scenario of WiMAXnetworks, QoSS performance improvementinr multimedia communications supporting the integration of IEEE 802.11 and IEEE 802.16. However, their results show less QoS improvement using Frequency Division Multiplexing (FDM) techniques for delay and throughput parameters as FDM provides low data rate. (Jha & Dalal 2010) proposed a model for the WiMAX network based on OFDM technology and point-to-point connection using unicast transmission. Their proposed model is considered a heterogeneous traffic pattern with a wide variety of service demands in terms of data rate and QoS performance. The method used in their approach seeks an optimal solution by tackling the problems of BS positioning and resource allocation simultaneously, but network congestion is the major drawback of this model as all BSs depend on the central server, hence, increased network delay (Jha & Dalal 2010). Also a rapid growth has been noticed in various wireless technologies in recent years. This has resulted in an increase in demand for wireless data services and multimedia application such as VoIP, streaming audio and video (Jha et al. 2011).

Methodology

The approach is based on the software point of view to the QoS with respect to delay in WiMAX and LTE Network in order to enhance the services that are provided to the end users base on the algorithm implementation. The model will maintain the same physical infrastructure; hence no extra cost will be required for installing new hardware and equipment over the existing infrastructure.

1) *Algorithm 1: Process for Client –Server BS Selection*

This algorithm is designed to select the client and server BSs among the set of BSs for network information distribution. In the Nearest Neighborhood Algorithm, each BS from the set of BSs registered with the central server for obtaining network information is a potential candidate for server BS. The calculation of distance between the BSs occurs at each BS to determine the nearest BSs from the central server. The nearest BSs with network information are selected to provide the network information to the closest client BS in need. If there is any BS with network information closer to the client BS than any previously selected nearest Neighbor set, it deletes the furthest server BS from the Nearest Neighbor set. If two or more BSs have the same distance and are in the final Nearest Neighbor set, then the server randomly chooses the server BSs as described in Figure 1.

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Algorithm 1:
 1. START
 2. Each BS BSi from set of Base Stations BS= {BS1, BS2, BS3, ..., BSn}
    Register with the central server
 3. Let P= {P1, P2, P3,..., Pm} ⊆BS be the set of m Base Stations
    (Candidates for Server) and m<n
 4. Input Q, the client Base Station, which doesn't have network information
 5.    Set K such that 1 ≤ K ≤ n
 6.    Set i = 1
 7.    DO
 8.         Compute distance from Q to Pi
 9.         IF(i ≤ K) THEN
10.         Include Pi in the set of Nearest Neighbor Base Stations
11.         ELSE
12.            IF (Pi is closer to Q than any other previous Nearest
                   Neighbor Base Station) THEN DELETE farthest Base
                          Station P in the set Nearest Neighbor
13.           END IF
14.            Include Pi in the set of Nearest neighbor Base Stations
15.         END IF
16.        increment i
17.    UNTIL (K Nearest Neighbor BSs with network information is found)
18.      IF (two or more BSs have the same distance and are in final Nearest
            Neighbor set) THEN Select Server at random from BSs
19.      ELSE
20.         Select the single value as Server from the set
21.      END IF
22. END
```

Fig. 1. Client-Server BSs Selection Process

2) *Algorithm 2: Central Server – Server BS' Communication*

The algorithm for communications between the central server and the selected server BS for obtaining network information is presented in Figure 2. This algorithm is required for communications between the central server and the server BSs in getting network information from the central server by the server BS. At the initial stage of communication, the selected server BS acts as a client BS. The central server sends an advertised existence message through (ADV_EXT_MSG) broadcast message, the server BSs send a network information request (NW_INFO_REQ) to the central server. Then the central server sends an authentication request through (AUTH_REQ) message, in which the server BS sends an authentication reply containing authentication information through (AUTH_REPLY) message, and then the central server processes the authentication. If the authentication is verified then the central server sends the network information to the server BS; otherwise the request is denied.

Algorithm 2:

1. START
2. Inputs: Central Server S, Server BS C_i from Algorithm1
3. S has network information
4. Server BS Ci received NW_INFO_REQ from Client BS
5. Each Server BS C_i sends NW_INFO_REQ to S
6. S sends AUTH_REQ to validate Server Ci from which it received Request
7. Server BS Ci sends AUTH_REPLY containing authentication information
8. IF (authentication is verified)
9. S sends a NW_ INFO to Server BS Ci
10. ELSE
11. S sends a message that Server Ci is not authenticated
12. END IF
13. END.

Fig. 2. Central Server and Server BSs Communication Process Flow Chart

3) *Algorithm 3: Client BS –Server BS' Communication*

In Figure 4 (the algorithm 3), the process of client and server BS communication for obtaining the network information is described. Using this algorithm, the client BSs will communicate with the selected server BS to get the network information through the following processes. The server BS sends an existence message through (ADV_EXT_MSG) broadcast message to the client BSs. Then client BSs send the network information request through (NW_INF_REQ) message, upon which the server BS sends an authentication request through (AUTH_REQ) message to validate client BS. The client BS sends an authentication reply using (AUTH_REPLY) message containing the authentication information. The server BS then processes the authentication. If the authentication is verified, the server BS sends the network information to the client BS, if otherwise, the request is denied as shown in Figure 5.

Algorithm 3:

1. START
2. Take input (Server Base Station M, Client Base Station Si) from Algorithm 1
3. M has network information
4. M advertises its existence through SERVER_ADV message
5. Each Client BS Si when receives SERVER_ADV message
6. IF Si does not have the network information received earlier
7. Send NW_INF_REQ message to Server BS M
8. ELSE
9. Provide the information to the SS
10. END IF
11. Server BS M sends AUTH_REQ to validate client BS Si from which it received the request
12. Client BS Si sends AUTH_REPLY containing authentication information
13. IF (authentication information verified)
14. Server M sends NW_INF to Client BS Si
15. ELSE
16. Server BS M sends message that node Si is not authenticated
17. END IF
18. END

Fig. 3. Client BS and Server BSs Communication Process Flow Chart

4) Algorithm 4: Subscriber Station – Clint Base Station Communication

A Subscriber Station (SS) need the network information to communicate with the Base Station (BS). The algorithm 4 shows communications between BS and SSs for obtaining this network information, where a SS sends a network information request through NW_INFO_REQ message to the client BS. The client BS sends an authentication request to SS for security; the SS sends an authentication reply using (AUTH_REPLY) message to client BS, that will be processed and, if verified, the network information is sent to the SS; otherwise, the request is denied as presented in Figure 4.

Algorithm 4:

1. START
2. Take input (Client BS *S*, SSs *Ci*) from Algorithm 1
3. *S* has network information
4. Each SS *Ci* when sends NW_INFO_REQ to *S*
5. *S* Sends AUTH_REQ to validate SS *Ci* from which it received Request
6. Client *Ci* sends AUTH_REP containing authentication information
7. IF (authentication is verified)
8. *S* sends NW_ INFO to SS *Ci*
9. ELSE
10. *S* sends the message that *Ci* is not authenticated
11. END IF
12. END.

Fig. 4. SS and Client BS Communication Process Flow Chart

Simulation Setup and Configurations

To simulate and analyze the Distributed Client-Server there is need of the fully simulated and accurate software beforehand. Therefore, as many nodes and sub-nodes, with their correct attributes, should be incorporated into the system model. Thus, for the sake of accuracy accompanied by an almost complete WiMAX system model simulated OPNET modeler 16.0 was researched to be one of the best candidates.

a. Existing Centralized Model

In this model, all BSs communicate directly with the central server to obtain network information. All BSs send network information requests to a central server, and the central server sends an authentication request to the BSs. The BSs send an authentication reply containing the authentication information to a central server. The central server then processes the authentication if the authentication is verified; the central server sends the network information to the BS otherwise the network information will be denied. The centralized model uses Frequency Division Multiplexing (FDM) techniques in transmitting network from a central server to BSs.

b. New Distributed Client–Server Model

To achieve the aims and objectives of this research, a new Distributed Client-Server model was introduced to improve the QoS performance in fixed WiMAX using delay. The new

Distributed Client-Server model exploits the characteristics of point-to-multipoint connections with multicast information dissemination using OFDM transmission techniques in fixed WiMAX network. Furthermore, the Distributed Client-Server model uses Orthogonal Frequency Division Multiplexing techniques to transmit network information from a central server to BSs.

c. *OPNET Simulation Setup Parameters*

Simulation setup parameters for the existing Centralized and new Distributed Client–Server models are described in Table 1. Each simulation began at 0 min and ran for 360 minutes. The existing Centralized model used Frequency Division Multiplexing (FDM) techniques and the proposed Distributed Client–Server model used Orthogonal Frequency Division Multiplexing (OFDM) techniques for transmission.

TABLE I. *OPNET simulation setup parameters*

Scenarios	No. of BSs	No. of SSs	No. of Server BSs		Techniques used	
			Centralized Model	*Distributed Model*	*Centralized Model*	*Distributed Model*
1	5	50	0	2	FDM	OFDM
2	7	70	0	3	FDM	OFDM

d. *Scenarios for Existing Centralized Model*

The following network scenarios were deployed in the OPNET Modeler (16.0) simulations to evaluate network throughput, delay and application response time parameters. Two different scenarios were designed for the Centralized model in a WiMAX network as described in the following sections.

1) Scenario 1

Scenario two (2) of the existing Centralized model comprises five (5) WiMAX BSs simulated with fifty (50) SSs, ten (10) SSs around each BS without any server BS. All other parameters configuration remained the same as in scenario 1, as shown in Figure 8. All BSs were connected to the IP backbone (Internet) using point-to-point protocol (ppp) without any server BS. Basic parameters associated with WiMAX configuration attributes, applications' configurations, application profiles, tasks' definitions, QoS attribute Definition, BSs and SSs for the model were configured as shown in Figure 5.

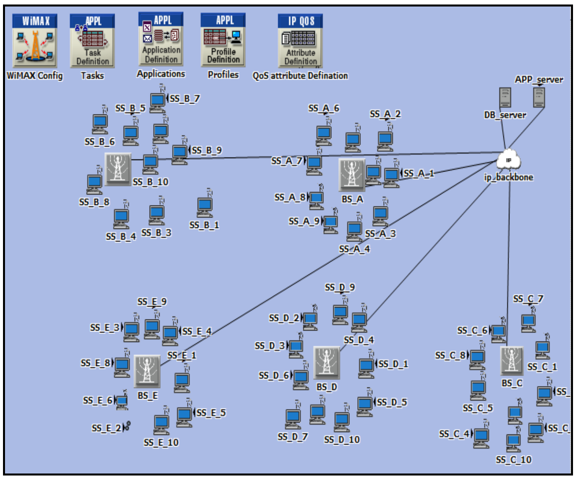

Fig. 5. Scenario 1 for the Existing Centralized Model

2) Scenario 2

In scenario two (2) of the existing Centralized models, seven (7) WiMAX BSs were simulated with one-hundred (70) SSs where ten (0) SSs around each BS in the subnet without any server BSs. All other parameter configurations remained the same as in scenario.

e. Scenarios for Distributed Client-Server Model

This section describes two (2) simulation scenarios for the Distributed Client–Server model in a fixed WiMAX network. The simulation of QoS parameters with respect to delay were evaluated in the OPNET modeler 16.0. The nearest BSs with network information are selected to provide the network information to the closest client BS. If there is any BS with network information closer to the client BS than any previously selected nearest Neighbor BS then the furthest server BS from the Nearest Neighbor BS set will be deleted. If two or more BSs have the same distance and are in the final Nearest Neighbor BS set, then the central server randomly chooses the server BSs at the MAC layer using the designed Nearest Neighborhood Algorithm.

1) Scenario 1

In scenario one (1) of the proposed Distributed Client-Server model five (5) WiMAX BSs were simulated with fifty (50) SSs having ten (10) SSs around each BS. BSs (A) and (D) are server BSs selected by the designed Nearest Neighborhood Algorithm, while the remaining BSs designated as clients BSs. All other parameters configuration remained the same as in scenario 1 for the proposed model as described in Figure 6.

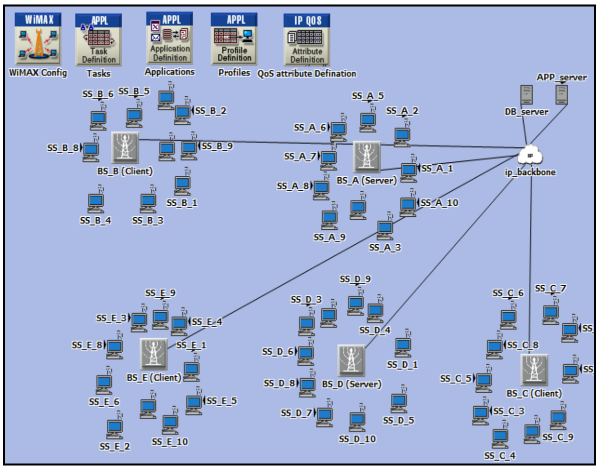

Fig. 6. Scenario 1 for the Distributed Client–Server Model

2) Scenario 2

Seven (7) WiMAX BSs with seventy Subscriber's Stations (70) were simulated in scenario three (3) of the Distributed Client-Server model with ten (10) SSs around each BS. The BS (A), BS (C) and BS (D) were chosen as servers BSs by the Nearest Neighborhood Algorithm with the remaining BSs as designated clients BSs. All other parameters configuration remained as configured in scenario1.

II. *Results and Discussion*

This chapter presents the results achieved based on the various scenarios of topologies performed in the OPNET modeler 16.0 network simulation software. The results obtained from the simulation are also analyzed. A comparison between the existing Centralized model and the proposed Distributed Client-Server model was also discussed.

1) Scenario 1 Simulation Results for Delay Comparison

The Scenario1 of the Distributed Client-Server model for both LTE and WiMAX network was simulated and the delay result is presented in Figure 7.

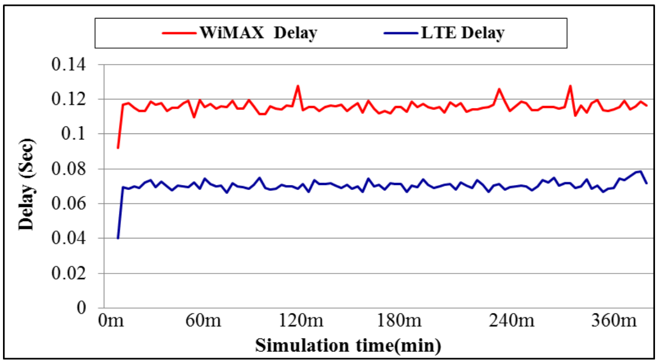

Fig. 7. Scenario_1 LTE and WiMAX Network Simulation Results for Delay Comparison

Maximum and minimum delays for the LTE network model were approximately 0.1276 sec and 0.0921 sec at t =124 min and t = 10 min, while those for the WIMAX network model were approximately 0.0800 sec and 0.0400 sec, respectively. The number of requests per second received by the server for both models was the same, but the time taken for the processing of the Distributed Client-Server model was less, compared to the LTE network model.

Scenario 2 Simulation Results for Delay Comparison

The Scenario 2 of the Distributed Client-Server model for both LTE and WiMAX network was simulated and the delay result is presented in figure 8.

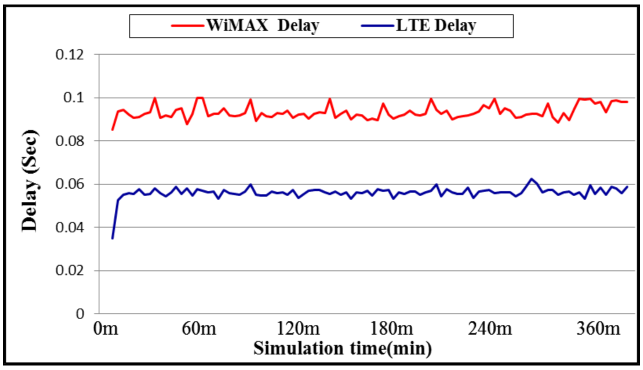

Fig. 8. Scenario_2 LTE and WiMAX Network Simulation Results for Delay Comparison

Maximum and minimum delays for the LTE network model were approximately 0.1000 sec and 0.0830 sec at t = 124 minutes and t = 10 min while those for the WIMAX network model were approximately 0.0621 sec and 0.0348 sec at t = 90 min and 9 min, respectively. The number of requests per second received by the server for both models was the same, but the time taken to process these requests by the Distributed Client-Server model was less compared to the existing Centralized model as a result of the Client-Server architecture.

CONCLUSION

In this paper a distributed Client-Server model was developed to compare the QoS with respect to delay in WiMAX and LTE Network in order to enhance the services that are provided to the end users. The addition of Server BSs and introduction of OFDM technique enhanced the performance of QoS with respect to delay parameter. The design was evaluated using the simulation tool OPNET modeler 16.0 and compared with the existing centralized model. The results obtained from the new distributed Client-Server model shows less network delay for WiMAX network and LTE network delay compared to the existing Centralized Model. Also, this Model should help the Internet Service Providers (ISPs) in term of data delivery by operating from many server BSs, and also this should reduce the cost of infrastructure development. As future work, the proposed model will be extended in order to consider the improvement of the QoS in terms of the Application Response Time and Throughput in addition to delay already considered in this paper.

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