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A DISTRIBUTED MODEL TO COMPARE QOS PERFORMANCE FOR VOIP OVER WLAN AND WIMAX NETWORK WITH RESPECT TO DELAY PARAMETER

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ABSTRACT

Worldwide Interoperability for Microwave Access (WiMAX) and Wireless LAN (WLAN) provides a solution to the increasing demands for wireless broadband Network which provide high-rate voice services at low cost and flexibility over IP-based networks. The Institute of Electrical and Electronics Engineers (IEEE 802.16) Standard introduces several advantages; one of them is Quality of Service (QoS) which is an important metric for transmission capacity requesting applications in WiMAX and WLAN Network. Despite the fact that it permits the Subscriber Station (SS) to change the saved transmission capacity through transfer speed demands in every edge, it cannot keep away from the danger of neglecting to fulfil the QoS prerequisites support at the Media Access Control (MAC) level. However, the existing VoIP over WLANs and WiMAX architecture does not provide sufficient QoS in both networks. In this paper a new Distributed Client-Server model to improve QoS performance for VoIP over WLAN and WiMAX network with respect to Delay parameter was developed. The model was simulated in the OPNET modeller (16.0) with Multiple Access Points (APs), Base Stations (BSs) as well as Subscribers Stations (SSs), and some selected server BSs that were selected using Nearest Neighbourhood Algorithm and Orthogonal Frequency Division Multiplexing (OFDM) techniques. The results obtained from this proposed model showed significant performance improvement in network Delay. The result furthermore shows that there is less delay in WiMAX network as compared to WLAN network.

Keywords- WiMAX, WLAN, QoS, VoIP, Delay and OPNET Modeler 16.0

INTRODUCTION

According to the WiMAX forum, which was established in June 2001, WiMAX stands for Worldwide Interoperability for Microwave Access. To fixed and mobile terminals across a vast geographic area, it offers wireless broadband. Line-of-sight and non-line-of-sight technologies are used to operate it over licensed and unlicensed frequencies. It guarantees to give last-mile wireless broadband internet connection with the ability to support data-intensive applications. According to Rakocevic et al. (2018), fixed WiMAX stations can provide data rates up to 1 Gbit/s in 2011 and up to 40 Mbit/s in 2005. One of the most recent innovations, it is categorized as 4G (Fourth Generation) technology. Compared to traditional cable modem and digital subscriber line (DSL) connections, which are both wired access technologies, WiMAX enables data rates up to 75 Mbit/s.

Wireless Metropolitan Area Network (WMAN) is WiMAX's foundation. WMAN was created by the IEEE 802.16 group and adopted by the HiperMAN Additionally, the implementation of WLANs in campuses, hotels, airports, healthcare facilities, group, or High Performance Radio Metropolitan Area Network, of the European Telecommunication Standard Institute. In the physical layer, WiMAX uses OFDM. In circumstances where there is no direct line of sight (NLOS), OFDM is based on the adaptive modulation technology. Line-of-sight (LOS) connections are not necessary for WiMAX communication when using base stations. In order to service a high number of users and to cover a wide area, WiMAX base stations have enough accessible bandwidth. (Sengupta, et al., 2018).

WLAN enables high-rate speech services at substantially lower costs and with greater flexibility, making it the most promising technology among wireless networks. VoIP over WLANs has rapidly expanded in popularity in the communication industry (Haghani & Ansari, 2020). This adaptation is spreading because VoIP over WLAN is more adaptable than conventional Public Switched Telephone Network (PSTN) systems (Xiong L. & Mao, 2017).

commercial use, education, and several other industries is fast growing. The transmission of voice, audio, and video conferencing packets is also supported by WLANs. (Yasukawa et al, 2019).

Ad-hoc and infrastructure architectures are the two primary types of service architectures used in WLANs. An access point (AP) and linkage to a wired backbone network are not necessary when using an ad-hoc architecture for connections between stations (STAs, or mobile nodes), which can connect to any other stations in the same network directly (Wang & Zhuang, 2018).

However, in the WLAN infrastructure topology, a wired backbone network can be connected to the network and the STA can communicate with another STA via an AP. This study will examine the infrastructure architecture in which an AP is used to transfer VoIP traffic between stations. A limited number of parallel voice nodes can be maintained by each AP according to a variety of industry requirements of AP for WLANs (Wang, et, al. 2017)

Due to the sensitivity of real-time applications, such as VoIP, to delays, jitter, and packet losses, the VoIP network needs to be correctly planned and configured in order to guarantee consistency and efficiency in real-time packet delivery (Leith et al., 2021).

Due to the fact that WiMAX is a wireless broadband technology, VoIP performance may be slightly impacted. WiMAX features a strong Quality of Service (QoS) characteristic that guarantees greater quality for interactive and real-time audio and video services. In the WiMAX QoS model, five service categories have been suggested and included: Unsolicited Grant Service (UGS), real-time Polling Service (rtPS), nonreal-time Polling Service (nrtPS), extended real-time Polling Service (ertPS), and Best Effort (BE) (Li, et al., 2019).

A rapidly developing technology called voice over IP allows voice data to be transmitted via IP-based networks. Due to its ability to transmit voice data as digital Internet Protocol packets across the TCP/IP-based Internet, Voice over Internet Protocol has emerged as a potential replacement for Public Switched Telephone Network. Parallel to this, the adoption of WiMAX networks built on the IEEE 802.16 standard is accelerating noticeably (Singh, 2023).

Numerous broadband wireless technologies, from 3G to 4G, have rapidly developed as a result of the rapid expansion of multimedia applications in the wireless environment. High bandwidth technologies like Worldwide Interoperability for Microwave Access (WiMAX) are now more in demand as a result of this. With the help of IEEE 802.16 standards, the ever-growing demand for multimedia applications in WiMAX networks has increased the Quality of Service (QoS). For various application kinds, the IEEE 802.16 offers QoS classes, and each service class is able to make simultaneous and distinct QoS requests (Adhicandra, 2020).

The term Quality of Service (QoS) describes the network's capacity (or ability) to deliver the specified quality of service to a subset of its traffic. The primary driver behind the IEEE802.16 and WiMAX standards' support for quality of service (QoS) is the demand for multimedia traffic with a variety of QoS requirements, including bandwidth and latency. When compared to other access network technologies, WiMAX's primary features are its greater range and more sophisticated support for Quality of Service (QoS) at the MAC level. WiMAX's connection-oriented design is one of its key tenets. It means that before a Subscriber Station (SS) can begin sending or receiving data, it must register with the base station. Temple & Jha, 2021).

The primary QoS requirements can be discussed by an SS and the BS (Base station) during the registration procedure. The BS manages the scheduling for both the uplink and downlink directions as the fundamental method for ensuring QoS in the WiMAX network. Various WiMAX service classes' QoS is guaranteed by a novel scheduling technique that is proposed in this paper. According to the QoS specifications and bandwidth request sizes, we suggest allocating slots (Jha, Temple, & 2021).

Furthermore, it has been suggested that the policy to provide slots so that the BS can do polling for each service class. The algorithm assigns slots to each service class while allocating resources. According to each connection's service class, the minimum and maximum bandwidth needs are used to determine the necessary number of slots. When determining the required slots for uplink and downlink scheduling, the algorithm considers the polling interval and packet size, respectively. The priority of a connection within a service class is determined by a distinct priority method used by each service class, either via packet waiting (Jha, & Temple, 2021).

Network delay is a major performance factor and parameter for computer and communication networks. A network's delay describes how long it takes for a piece of data to go from one node or endpoint to another across the network. According to Kim and Song (2022) it is often expressed in multiples or fractions of seconds (Kim & Song, 2022).

Depending on where a particular pair of connecting nodes is located, the delay may vary slightly. Users only consider the network's overall delay, however there are actually multiple components to the average delay. The time it takes to transmit a packet serially via a link determines the lowest level of delay that will be encountered; further levels of delay caused by network congestion may be added to this. IP network delays can be as little as a few milliseconds to as much as several hundred (Kim & Song, 2022).

The amount of time it takes packets to get from their source to their destination is called delay. Source processing delays, propagation delays, network delays, and destination processing delays are the main sources of delays. With elements including propagation, serialization, channel coding at the physical layer, and Medium Access delay at the MAC layer, packet delay when using wireless services is a significant issue. Similar forwarding and queuing delays at the network layer occur at the application layer. The 100 ms packet delays have no negative effects. But voice communications become useless after 150 millisecond delays (Hwang and Chom, 2019). One of the major issues with VoIP systems is QoS. VoIP is a delay-sensitive application since it needs packets to reach their destination as quickly as possible and on time. Furthermore, real-time applications were not addressed when IP-based networks were first developed for the purpose of sending data packets. Web browsing, email, audio data, and video apps all share bandwidth on the same network today due to the expanding number of internet users and their demands. In this paper a new Distributed Client-Server model to improve the QoS performance for VoIP over WLAN and WiMAX network with respect to Delay will be develop to improve the services that are provided to the end users. The model will be simulating 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

MATERIALS AND METHODOS

The approach is based on the software point of view that improve 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.

2.1 Architecture of Proposed Model at Abstract Level

The architecture of the proposed Distributed Client-Server model at an abstract level, where some of the client BSs receive network information from the nearest selected server BS is shown in Figure1. This framework consists of a hierarchical network based on a fixed WiMAX architecture (802.16d) and OFDM links to form distributed network. The diagram represents the proposed model in which the Subscriber Stations (SSs) can request the network information from the nearest client BS. These client BSs are getting the network information from the nearest server BSs, and the server BSs are getting this network information from the central server.

Working of the Proposed Model

To achieve the desired QoS in the fixed WiMAX network, the proposed model distributes the functionality of providing network information to multiple server Base Stations (BSs), so that in the case of failure of any of the BSs; the overall network system may not go down all together. In the proposed model, the BSs are classified into server BS and client BS. The server BSs will get the network information from the central server, and the client BSs will depend on the nearest server BSs for this network information. Figure 2 shows the system algorithms of the proposed model in the form of a flowchart.

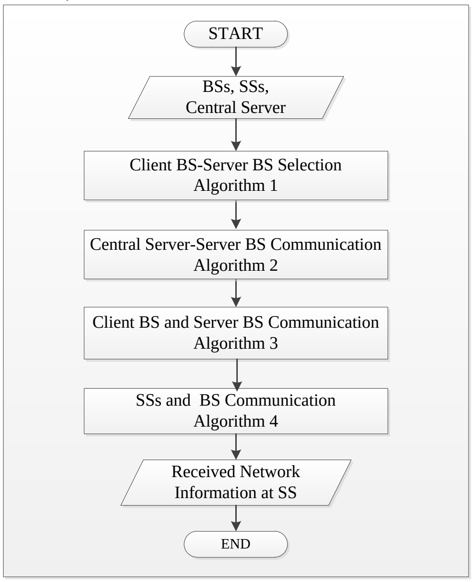

Figure 1. System's Flowchart for the Proposed Model

Different algorithms need to be designed that will work in different stages of the system flow as shown in Figure 1. These algorithms include the process of the client and server BSs selection, central server and server BS communication, client and server BS communication, and Subscriber Station and Base Station communication. Details of these algorithms are given in the next subsections.

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 Neighbourhood 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 Neighbour 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. The process of client and the server BS selection algorithm was designed for the purpose of selecting the nearest server BSs from the set of BSs register with the central server to provide network information to client BSs as described in the Figure 2.

```
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 BS at random from BSs
19.     ELSE
20.             Select the single value as Server BS from the set
21.     END IF
22. END
```

Figure 2. Client-Server BSs Selection Process

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 3. 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.

Figure 3. Central Server and Server BSs Communication Process Flow Chart

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 4.

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

Figure 4. Client BS and Server BSs Communication Process Flow Chart

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 5.

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.

Figure 5. SS and Client BS Communication Process Flow Chart

Distributed Client-Server Model Communication

The overall communication of the proposed Distributed Client-Server model is shown in Figure 6. All the network entities that include the Subscribers' Stations, client Base Stations, server Base Stations and the central server are involved in the communication for obtaining the network information.

The first part of Figure 6 shows the process of distributing the network information to the server BSs. At the start, the central server advertises its existence through ADV_EXT_MSG broadcast message. This message is received by all the BSs, whether client or server. As the server BSs have been selected from a list of candidate BSs through algorithm1, hence these server BSs request the network information from the central server through NW_INFO_REQ message. The central server asks the server BS to provide authentication through AUTH_REQ message. In response to AUTH_REQ, the server BS sends the authentication information through AUTH_REPLY message. The central server processes the authentication and provides the network information (NW_INFO) if the server BS is authenticated; otherwise it denies the request (DENY NW_INFO).

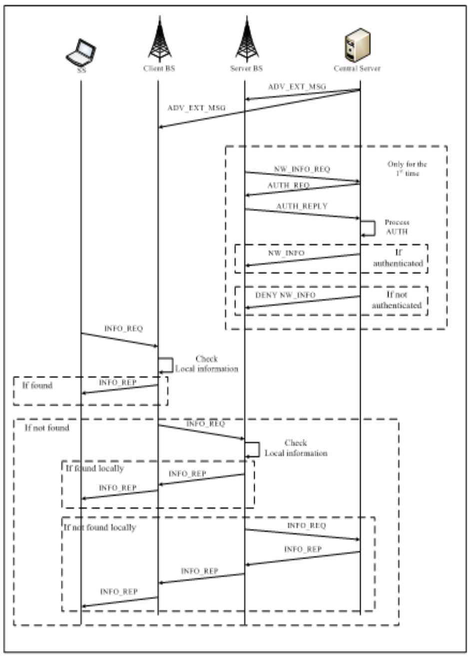

Figure. 6 Distributed Client-Server Model Communication

SIMULATION SETUP & 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. OPNET Modeler is a product of the OPNET Technologies Inc.

It is a Discrete Event Simulation (DES) program; events are handled in a chronological manner. It has a Graphical User Interface (GUI) with a "user friendly" sense. It has an enormous library at the service of the user. On request, OPNET Technologies can provide ready to use models. For the research to be done in this project, "OPNET Modeler Wireless Suite" was provided with an accompanying "WiMAX Model" Chan, et al., 2021),

3.1 OPNET Modeler

OPNET stands for "Optimized Network Engineering Tool." It is a comprehensive engineering system capable of simulating large communications networks with detailed protocol modeling and performance analyses Features such as its graphical user-friendly interface, object based modeling, integrated data analysis tools, and dynamic event scheduled simulation kernel have made OPNET a sophisticated tool for workstation based modelling and simulation (Petrinet, et al., 2022).

To simulate and analyze the Distributed Client-Server there is need of the fully simulated and accurate softaware beforehand. Therefore, as many nodes and sub-nodes, with their correct attributes, should be incorporated into the system model. However, this is not an easy task at all. Lack of fully simulated system model, usually causes researchers to fail at some point during their study in orther to get feasible results. It is true that commonly used soft wares like C, C++, Java, MATLAB, CORBA, NS-2, VNC, MSARQ, NMS and many other programming languages are strong and performing languages; however, these programs do not come with a model of a specific system (Petrinet, et al., 2022).

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. OPNET Modeler is a product of the OPNET Technologies Inc. It is a Discrete Event Simulation (DES) program; events are handled in a chronological manner. It has a Graphical User Interface (GUI) with a "user friendly" sense. It has an enormous library at the service of the user. On request, OPNET Technologies can provide ready to use models. For the research to be done in this project, "OPNET Modeler Wireless Suite" was provided with an accompanying "WiMAX Model" (Petrinet, et al., 2022).

The OPNET's sophistication, tools enable developers to model communications networks and distributed systems, thus allowing them to analyze the behavior and performance of the modeled systems through discrete event simulations (DES). Despite the availability of a large variety of simulation packages on the market, the OPNET Modeler was chosen for its following features (Kanagamathanmohan, et al., 2023).

Simulation Process Overview

OPNET's workflow scheme is divided into four steps: creating new network models; choosing individual statistics; running simulations, and viewing/analyzing results. The network models for both the existing Centralized scheme and newly proposed Distributed Client–Server model were created. All necessary network components were selected from the object palette and created within the workspace. Network component parameters and application settings were then chosen to include host IP addresses, packet and buffer sizes, etc. Afterwards, the network was formulated for the different applications required as well as made ready for the statistics needed for performance assessment.

Next, WiMAX custom applications were chosen and set from global statistic pools, including simulation duration and values per metric. In this thesis, the throughput, delay and application response time parameters are set to run for 360 minutes for both models. All the simulation errors encountered during simulation were displayed in the simulator windows. If there are simulation errors, then the simulation process is repeated from Step 2 of the simulation process in Figure 4.10 (set the parameters for the network component and choose the application). The absence of errors takes us to the next step in the simulation process.

The results obtained were analyzed with a view to analyze results and determine the efficiency and any network problems. The simulation process is complete when the desired results are obtained; otherwise, the entire procedure (from step 2) is repeated as illustrated in Figure 7.

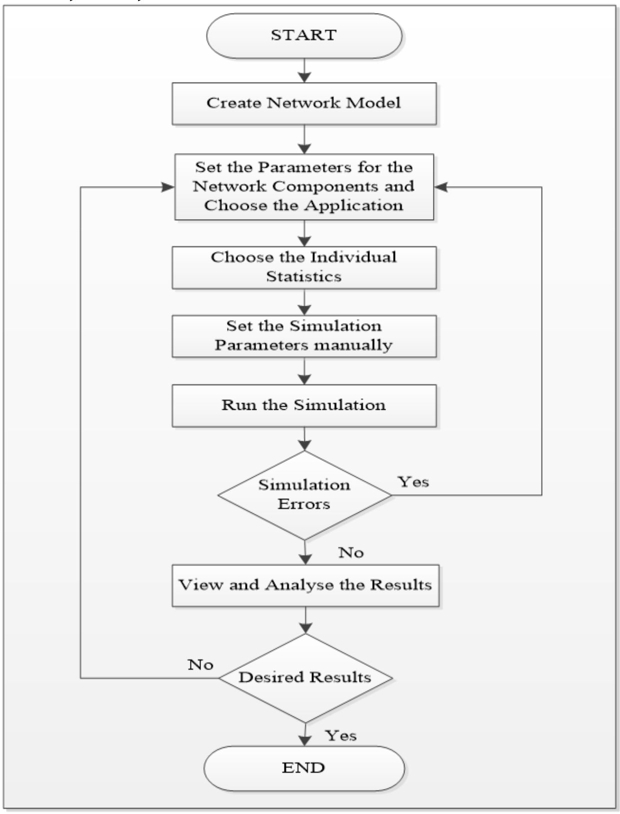

Figure 7. Simulation Process Overview

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. In Frequency Division Multiplexing bandwidth is divided in multiple subcarriers which are not overlapped with each other and the entire bandwidth is used by the subscriber. FDM systems are used in radio, satellite communications requiring a good amount of guard bands between adjacent frequency bands. In FDM system carriers are not orthogonal which make the transmission from a central server to BSs and to the subscriber station to experiences too much delay. In FDM the Downlinks and Uplinks sub-frames are duplexed using Frequency Division Duplex (FDD). The Frequency Division Multiplexing used FDD as duplexing technique for transmitting signals in both the downstream and upstream in opposite directions (Dahmouni.et al.,2022).

Existing Centralized 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, throughput and application response time parameters. 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. The goal is to minimize the information retrieval delay, application response time and to maximize the network throughput. In the proposed idea, some of the Base Stations are assigned as a server that at the same time can receive and send network information to the nearest client Base Station using the designed Nearest Neighborhood Algorithms.

The implementation of this proposed Distributed Client-Server model is logical in nature.

In this new model some Base Stations (BSs) are getting network information not only from the central server, but also from some selected server BSs. The Nearest Neighborhood Algorithms were used to select some server BSs that distribute the functionality of the central server by assigning network information to the nearest client BSs. In this model, the client BSs send network information requests to the server BS, and then the server BS sends an authentication request to the client BSs. The client BS sends an authentication reply containing authentication information. Thereafter, the server BS processes the authentication and if the authentication is verified the server BS sends the network information to the client BSs; otherwise the request is denied.

Also, as discussed previously, network information delivery in the Distributed Client-Server model should outperform that of the existing Centralized model by not operating from a single central server, but from several distributed server BSs.

Furthermore, the Distributed Client-Server model uses Orthogonal Frequency Division Multiplexing techniques to transmit network information from a central server to BSs. OFDM is a technique that allows sub-carriers to overlap and save bandwidth subject to inter-carrier interference. The OFDM systems usually have a greater Peak to Average Power Ratio (PAPR) compared to an FDM system. PAPR can be reduced by use of a scrambler module and other techniques in OFDM systems.

OPNET Simulation Setup Parameters

Simulation setup parameters for the existing Centralized and new Distributed Client–Server models. 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.

OPNET Simulation Setup Parameters

Simulation setup parameters for the existing Centralized and new Distributed Client–Server models are described in Table 2. 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.

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. Four different scenarios were designed for the Centralized model in a WiMAX network as described in the following sections as illustrated in figure 8.

Scenario 1

Scenario one (1) of the existing Centralized model comprises five (3) WiMAX BSs simulated with thirty (30) SSs, ten (10) SSs around each BS without any server BS. 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 8.

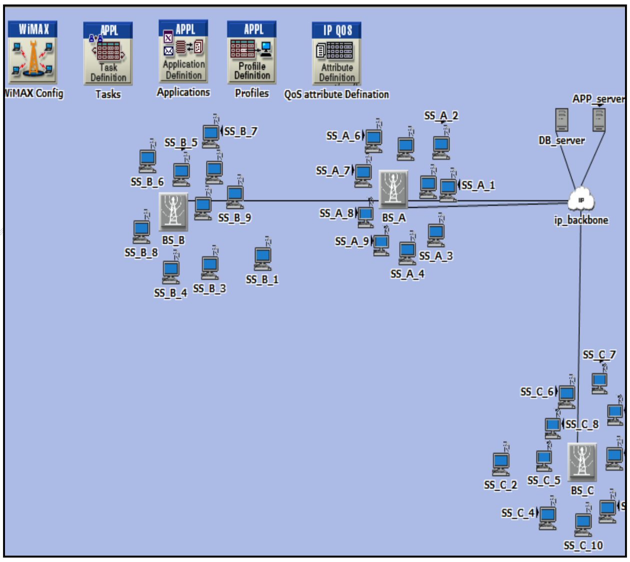

Figure 8. Scenario 1 for the Existing Centralized Model

Scenario 2

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. 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 9.

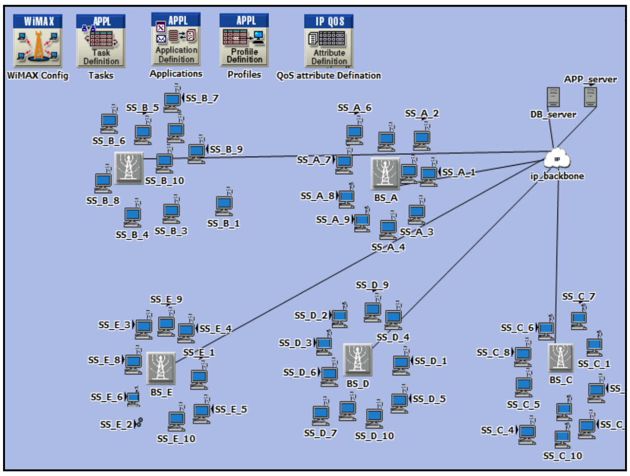

Figure 9. Scenario 2 for the Existing Centralized Model

Scenario 3
In scenario three (3) 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 1 as shown in Figure 10.

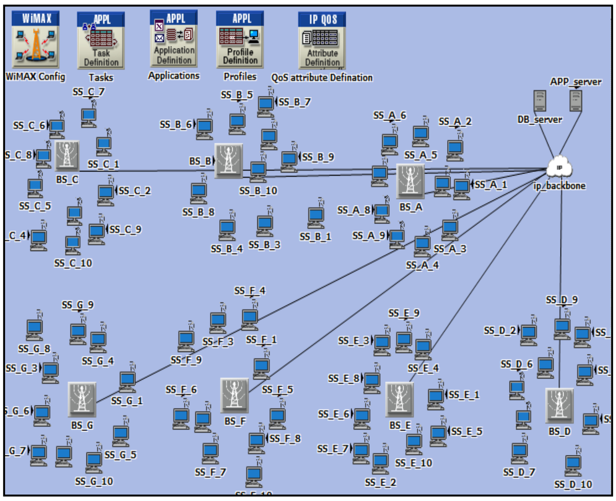

Figure 10. Scenario 2 for the Existing Centralized Model

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, throughput and application response time 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 Neighbour 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.

Scenario 1
The first scenario consisted of three (3) WiMAX BSs with 30 SSs, where 10 Subscriber Stations are placed around each BS. All BSs were connected to the IP backbone (Internet) using point-to-point protocol (ppp) with BS (A) as server BS selected by the designed Nearest Neighbourhood Algorithm, leaving all remaining BSs as clients. Basic parameters associated with WiMAX Configuration attributes, applications' configurations, profiles and tasks' definitions, QoS attribute definition, BS configurations and SS for the model were configured as described in Figure 11.

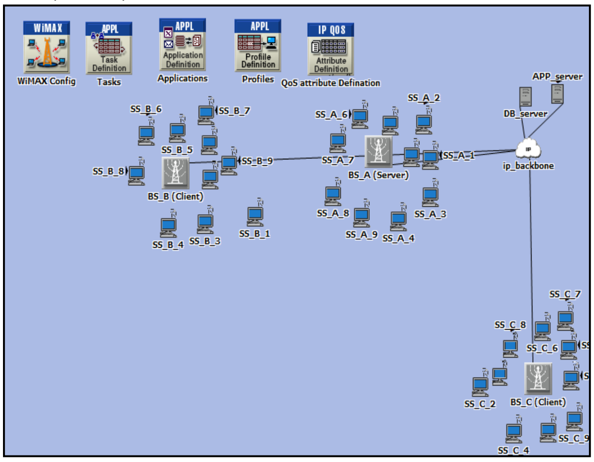

Figure 11: Scenario 1 for the Distributed Client–Server Model

Scenario 2

In scenario two (2) 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 Neighbourhood 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 shown in figure 12.

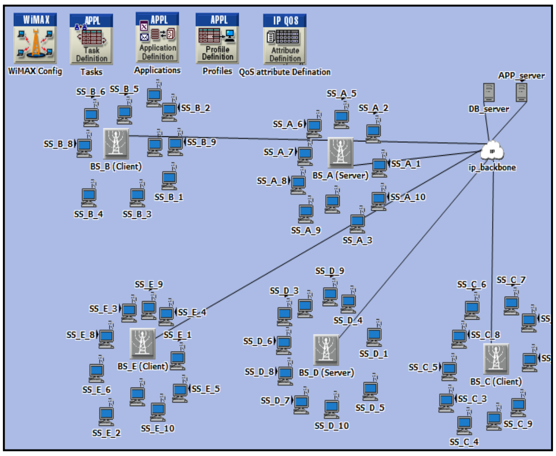

Figure 10. Scenario 2 for the Distributed Client–Server Model

Scenario 3

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 Neighbourhood Algorithm with the remaining BSs as designated clients BSs as illustrated in Figure 12. All other parameters configuration remained as configured in scenario1.

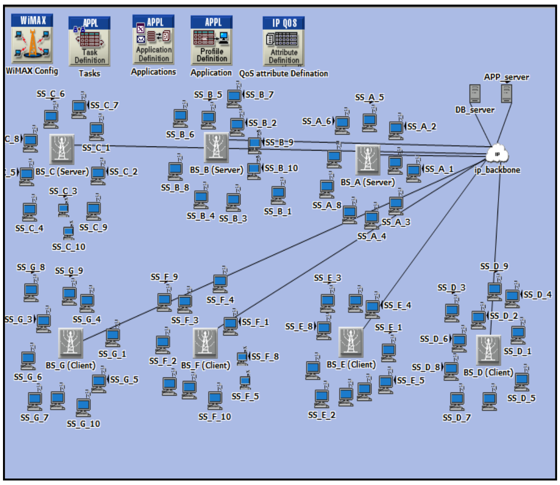

Figure 12. Scenario 3 for the Distributed Client–Server Model

RESULT AND ANALYSIS

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 analysed. A comparison between the existing Centralized model and the proposed Distributed Client-Server model was also discussed.

4.1 Scenario 1 Simulation Results for Delay Comparison

Figure 13 described the delay simulation results for the existing Centralized and the new Distribute Client-Server models in the WiMAX network scenario 1. The network delay for both models as presented was successfully calculated.

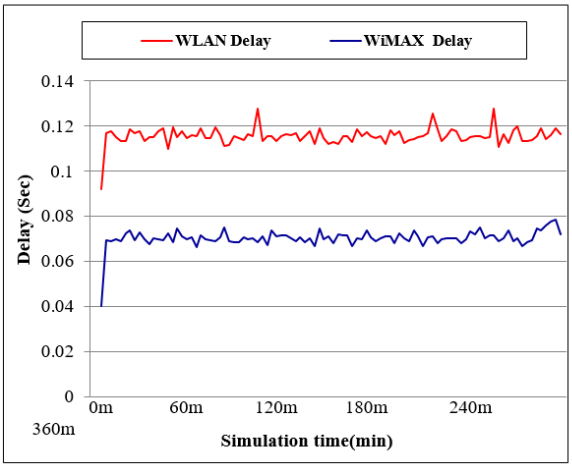

Figure 13. Scenario 1 Simulation Results for Delay Comparison

Maximum and minimum delays for the existing Centralized model were approximately 0.1467 and 0.1223 sec, respectively, while that for the Distributed Client-Server model was 0.0972 and 0.0557 sec. The proposed model's maximum delay value was at t = 320 minutes. The Centralized model's maximum response time was at t = 10 minutes. The number of requests per second the server received in scenario one for both models was equal, but the time taken to process network information from the Distributed Client-Server model was less compared to the Centralized model as a result of the centralized architecture of the existing Centralized model.

Scenario 2 Simulation Results for Delay Comparison

The Scenario2 of the Distributed Client-Server model for both WLAN and WiMAX network was simulated and the delay result is presented in figure 14.

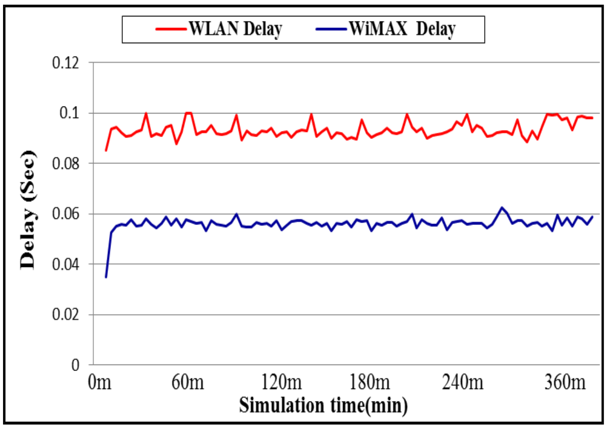

Figure 14. Scenario 2 Simulation Results for Delay Comparison

Maximum and minimum delays for the WLAN 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 WLAN network model.

These results further described that the Distributed Client–Server model delay for WLAN and WiMAX Network is less compared to the Centralized model in the WLAN and WiMAX Network; due to the introduction of OFDM techniques for network transmission and the addition of the server BSs as presented in figure 14.

Scenario 3 Simulation Results for Delay Comparison

The Scenario1 of the Distributed Client-Server model for both WLAN and WiMAX network was simulated and the delay result is presented in figure 15.

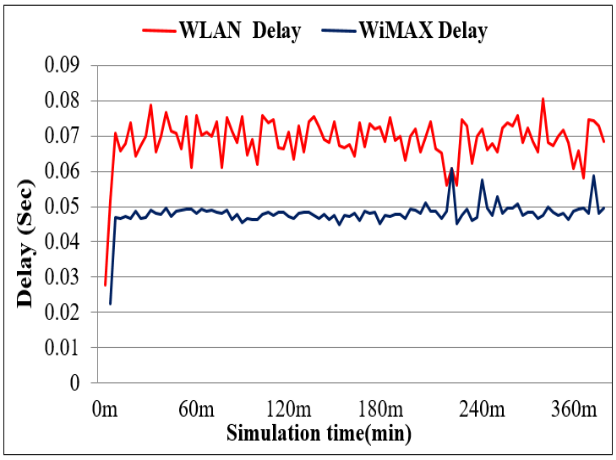

Figure 15. Scenario 3 Simulation Results for Delay Comparison

The maximum and minimum delays for the existing Centralized model were approximately 0.0905 and 0.0768 sec at t = 250 min and t = 08 min, while those for the Distributed Client-Server model were approximately 0.0607 and 0.0225 sec at t = 270 min and 08 min, respectively. The number of requests per second received by the server in scenario four (4) for both models was the same, but the time taken to process them by the distributed model was less compared to the Centralized model as a result of the Client-Server architecture.

In scenario two for both models, seven (7) WiMAX BSs and seventy (70) SSs were simulated with three (3) server BSs and four (4) client BSs in the proposed Distributed Client-Server model selected by the Nearest Neighborhood Algorithm. This to distribute network information to nearest client BSs as discussed in sections 3 and section 4 of this paper. These results also confirmed that the new Client–Server model had less delay compared to the Centralized model for the WLAN and WIMAX Network; due to the introduction of OFDM techniques for network transmission in the distributed model as compared to the FDM used by the Centralized model. This could be also attributed to the fact that even though the total number of WiMAX BSs and SSs were the same for both models, the topology of the new Client–Server model contained three (3) server BSs as discussed in section 4 of the paper, thus, minimized the network delay as described in Figure 14.

CONCLUSION

In this paper a distributed Client-Server model was developed to improve QoS with respect to deal in WiMAX and WLAN Network 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 WLAN network delay compared to the existing Centralized Model. The result furthermore shows that there is less delay in WiMAX network as compared to WLAN network. Also, this Model will 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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