IMPROVING QUALITY OF SERVICE WITH RESPECT TO DELAY IN FIXED WIMAX NETWORK

Ibrahim, A. L.[1], Md Said, A.[2], Nisar, K.[3], and Mu'azu, A. A.[4]

[1]*Universiti Teknologi PETRONAS Malaysia, ibrahim_g01867@utp.edu.my*
[2] *Universiti Teknologi PETRONAS, Malaysia, abass@petronas.com.my*
[3]*Universiti Utara Malaysia, Malaysia, kashif@uum.edu.my*
[4]*Universiti Teknologi PETRONAS Malaysia, abuaminu_g01797@utp.edu.my*

ABSTRACT. Worldwide Interoperability for Microwave Access (WiMAX) is a wireless network that has been designed to serve all types of traffic over network. In this paper, we propose a new distributed model to improve Quality of Service (QoS) with respect to delay in fixed WiMAX network to deliver the best services for WiMAX users. Also in the paper, the WiMAX delay at base station is analyzed and compared with the centralized model. The new distributed Master-Slave model designed includes three Base Stations (BSs), ninety Subscribers Stations (SSs) and one Master BSs. The proposed new model has been evaluated using the simulation tool OPNET modeler 16.0. The results obtained show a drastic decrease in network delay.

Keywords: Delay, fixed WiMAX, Master-Slave model, Base Station, Subscriber Station, OFDM, OPNET Modeler

INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communication standard designed for delivering up to 120 Mbit/s data. WiMAX passes the range of Wireless LAN (WLAN) and provide large area network covering radius of 50km. It offers data transfer rates which are better than cable-modem and Digital Subscriber Line (DSL) connections [1]. WiMAX is similar to Wi-Fi but delivers much higher data rate reaching larger distance. WiMAX Internet connectivity emerges to connect multiple devices which are subsequently connected to other devices to deliver Internet to home, business as well as other places. WiMAX operates in both 10-66 GHz (licensed frequency band) and 2-11 GHz (unlicensed frequency band) for Line Of Sight (LOS) and Non-Line of Sight (NLOS) operations, respectively (Ali & Tofik, 2012).

Traffic over WiMAX Network are categorized into five classes as in [3]; i) the Unsolicited Grant Service (UGS) for targeted traffic with constant bit rate (for example Voice Over IP without silence suppression) ii) enhanced real time polling service (ertPS) for targeted traffic with variable bit rate but guaranteed delay and data rate iii) real time polling service (rtPS) for application that generate data at variable rate frequently iv) non-real time Polling service (nrtPS) targeted traffic with accommodating delay and guaranteed minimum data rate, and v) Best Effort (BE) which does not have QoS requirement.

Fixed WiMAX is targeted for providing fixed and nomadic connectivity and falls under the IEEE 802.16-2009 standard specification. Fixed WiMAX is capable of becoming a replacement for DSL, cable or network backhaul (IEEE,2009). In future, WiMAX will transform the world of broadband by enabling the less cost-effective deployment of metropolitan area networks based on the IEEE 802.16d standard to provide reliable network to end users. The fixed WiMAX BSs provide wireless internet access to SSs within a fixed radius. WiMAX standard specifies two layers; namely PHY and MAC to contribute in achieving QoS provisioning in a fixed WiMAX network. Time Division Duplexing (TDD), Frequency Division Duplexing (FDD) and Orthogonal Frequency Division Multiplexing (OFDM) are the standardized technologies for QoS provisioning at the PHY layer of the fixed WiMAX. TDD scheme is involved in QoS provisioning by separating the downlink and uplink bandwidth (Sathya & Kalaiarasi, 2012).

Delay is regarded as among the important measures of QoS and can be caused by transmission error, Automatic Repeat Request (ARQ) or simply slow error correction. It further sub-divided into queuing delay, processing delay, transmission delay and propagation delay. Among those delays, the queuing delay is considered to be the most controllable [6]. The delay processes are carried out through the Delay Processing Unit (DPU). It is the kernel component in charge of controlling queuing delay. DPU is made up of three sub-components which include the Queuing Delay Predictor (QDP), Delay Processor (DP) and Packet Dropper (PD). QDP has two primary functions, to predict the subsequent delay value and to adjust the threshold position based on the predicted delay value as shown in figure 1 (Wang et al., 2011).

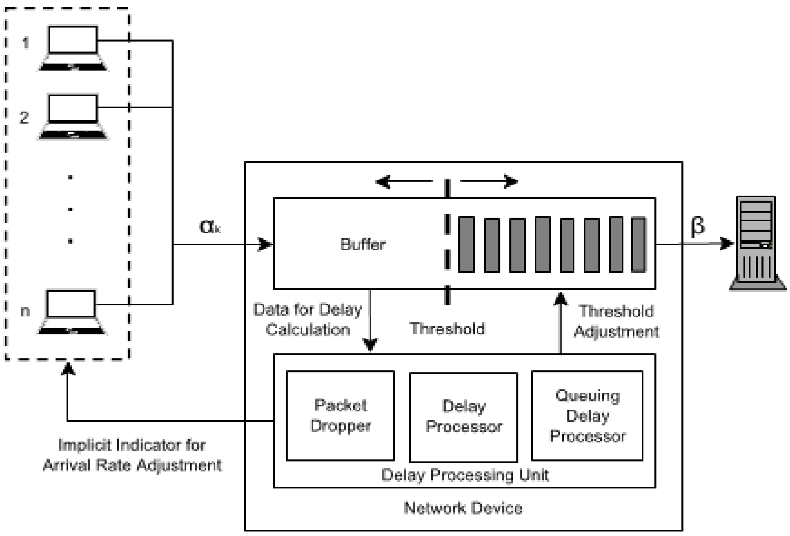

Figure 1. Delay Processing Unit

In our paper however, a new distributed Master-Slave model is proposed to enhance the QoS performance with respect to delay over fixed WiMAX Network using point-to-multipoint connection and multicast transmission based on OFDM techniques for Network distribution. Nearest Neighborhood Algorithms will be used for Master-slave BSs selection. The proposed model was evaluated using the simulation tool, OPNET modeler 16.0 and compared with the existing centralize model. The result obtained from the proposed model show drastic decrease in network delay as compared to the centralized model. This approach could effectively enhance the QoS performance of delay to enhance the services provided to the end users.

PROPOSED DISTRIBUTED MASTER-SLAVE MODEL

In this model OPNET Modeler 16.0 are used to designed and simulate the Network, as OPNET Modeler is one of the strong sophisticated simulation software package that can be used to design and model communications networks and distributed systems (Yekanlu & Joshi, 2009). Also an OFDM technique was applied to distribute the networks between central server, BSs and SSs, because it is a multiple carrier transmission technique currently in use for high speed bi-directional wireless data communication transmission (IEEE, 2005).

The network model and configuration of Basic parameters associated with WiMAX Configuration attributes, Application Configuration, Application Profile, Task Definition, BSs and Subscribers Station for the proposed model are configured to satisfy the requirements of the proposed model. Algorithm 1 describes the process of Master-Slave BS selection from the BSs.

Algorithm 1. for the Process of Master-Slave BS Selection

```
START
Each BS BSi from set of base stations BS={ BS_1, BS_2, BS_3, ..., BS_n}
    Register with the central server
Let P= {P_1, P_2, P_3,..., P_m} ⊆ BS be the set of m Base Stations (Candidates for Master) and m<n
Input Q, the Slave Base Station which don't have network information
    Set 1 ≤ K ≤ n
    Set i = 1
    DO
    {
        Compute distance from Q to Pi
        IF(i ≤ K) THEN
            Include Pi in the set of Nearest Neighbors base stations
        ELSE
            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
            END IF
            Include Pi in the set of Nearest neighbor base stations
        END IF
    }
    WHILE (Nearest Neighbor base station with network information is found)
    IF(two or more base stations have the same distance and are in final Nearest Neighbor set) THEN
        Select Master at random from base stations
    ELSE
        Select the single value as Master from the set
    END IF
END
```

Master-Slave Communication

The Figure 2 below shows the communication between Master BSs and Slave BSs for getting network information, where a Master BS will advertise an existence message of which the slave BS sends network information request to master BS. The Master BS will then send an Authentication Request to slave BS for security and others, then slave BS send authentication Reply to master BS. If authentication is verified then the network information will eventually be sent to the slave BS.

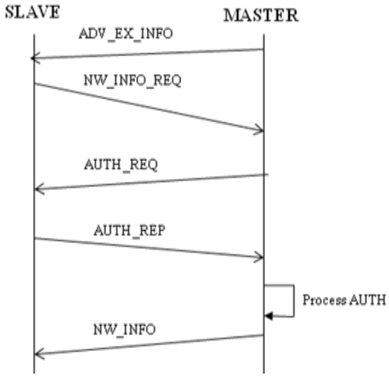

Figure 2. Master-Slave communication

Algorithm 2. Master–Slave Base Station Communication

Algorithm 2 shows the process of Master-Slave Communication of the proposed model.

```
START
    Take input (Master Base Station M, Slave Base Station Si) from Algorithm_1
    M has network information
    M advertises its existence through MASTER_ADV message
    Each Slave BS Si when receives MASTER_ADV message
      IF Si don't have network information earlier received Send NW_INF_REQ message to Master M
      ELSE

      END IF
    Master M sends AUTH_REQ to validate Slave Si from which got request
    Slave Si sends AUTH_REP containing the authentication information
  IF (authentication information is verified) Master M sends NW_INF to Slave Si
  ELSE
      Master M sends message that node Si is not authenticated
  END IF
 END
```

Delay Calculation

Delay can be defined as the time taken for the packets to arrive at destination from the source and it is normally measured in multiples or fractions of seconds. The primary sources of delay could be classified into: propagation delay, source processing delay, network delay and destination processing delay (Haidar & Farah, 2011).

The delay can be calculated using the following formula:

$$Delay = \frac{\sum_{t_n}^{t_{n+1}} DeliveryTime - \sum_{t_n}^{t_{n+1}} ArrivalTime}{\sum_{t_n}^{t_{n+1}} \mathrm{Re}\,ceivedpacket} \qquad (1)$$

Where *DeliveryTime* is the time packet from a frame was delivered, *ArrivalTime* is the time packet arrived at destination and *RecievedPaket* is the number of packet successfully arrived in frame n between the start time t_n, of frame n and the start time t_{n+1}, of the next frame $n+1$ (Haidar & Farah, 2011).

Table 1 below shows the simulation parameters setup used in the scenarios including the additional BSs, SSs, Master BSs and simulation time.

Table 1. Simulation Setup Parameters

S/ No	Scenarios	No. of BSs	No. of SSs	No. of Master BSs		Simulation Time
				Centralized Model	Master-Slave Model	
1	1	3	90	0	1	1 hour
2	2	5	150	0	2	1 hour

Scenarios for the Centralized Model

In scenario 1 of the the Centralized Model, 3 WiMAX BSs were developed with 90 SSs out of which 30 SSs are around one BS. All the BSs are connected with IP backbone (Internet) using point- to- point protocol (ppp), without any master BS. While scenario 2 is an extension of Scenario 1 and it shows the developed Centralized model with 5 WiMAX BSs and 150 SSs. 30 SSs are around each BS without any master BS. All other parameters are as in scenario_1. All Basic parameters associated with WiMAX Configuration, Application Configuration, Application Profile, Task Definition, QoS attributes, BSs and SSs are configured as shows in Figure 3.

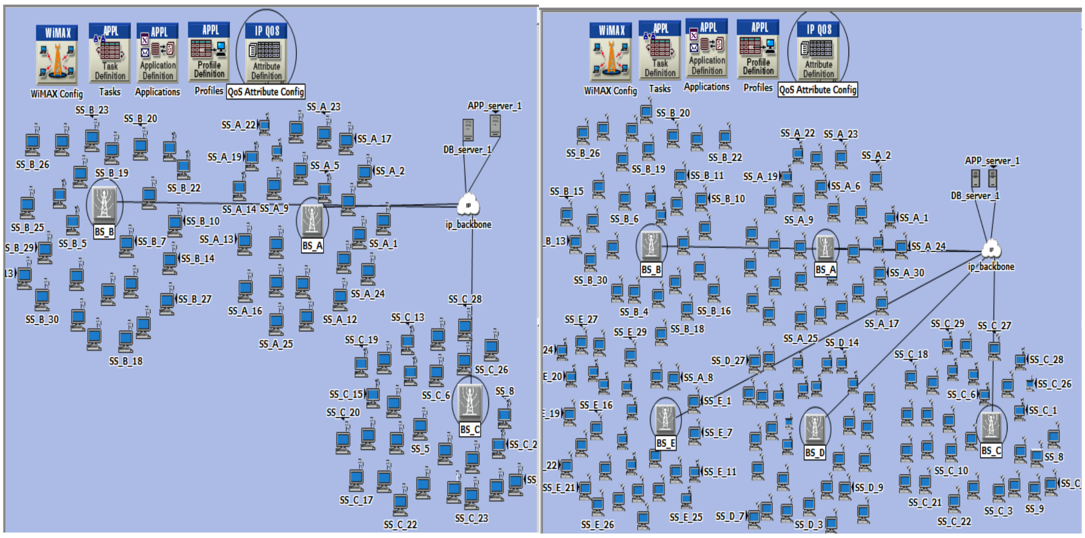

Figure 3 (a) Centralized Model Scenario_1

Figure 3 (b) Centralized Model Scenario_2

Scenarios for the New Distibuted Master-Slave Model

Scenario 1 of the Distibuted Master-Slave Model consists of 3 WiMAX BSs with 90 SSs, 30 SSs around each BS with BS A as a Master BS selected by the Nearest Neighborhood Algorithms. All the BSs are connected with IP backbone (Internet) using point-to-point protocol (ppp). While Scenario 2, is also an extension of Scenario 1 of the distributed Master-Slave where 5 WiMAX BSs were developed with 150 SSs, 30 SSs around each BS with BS_A and BS_D as Master BSs selected by Algorithm 1 while the remaining are slaves.All Basic parameters associated with WiMAX Configuration, Application Configuration, Application Profile, Task Definition, QoS attributes BSs and SSs are configured as shown in Figure 4 (a) and (b) respectively.

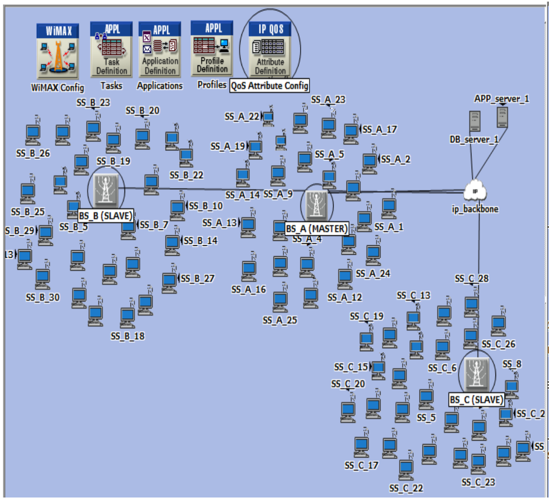

Figure 4 (a) Distributed Model, Scenario 1

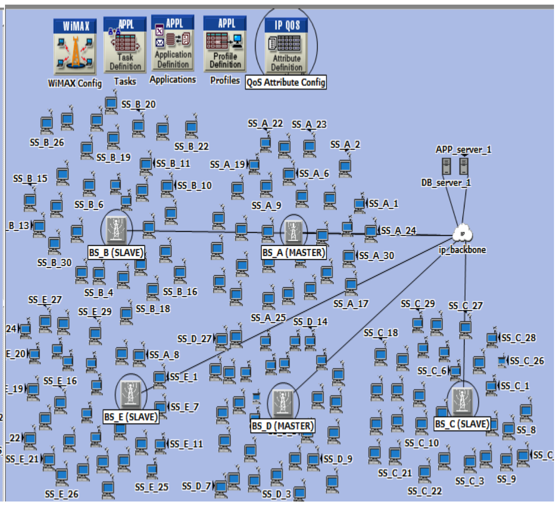

Figure 4 (b) Distributed Model, Scenario 2

RESULTS & ANALYSIS

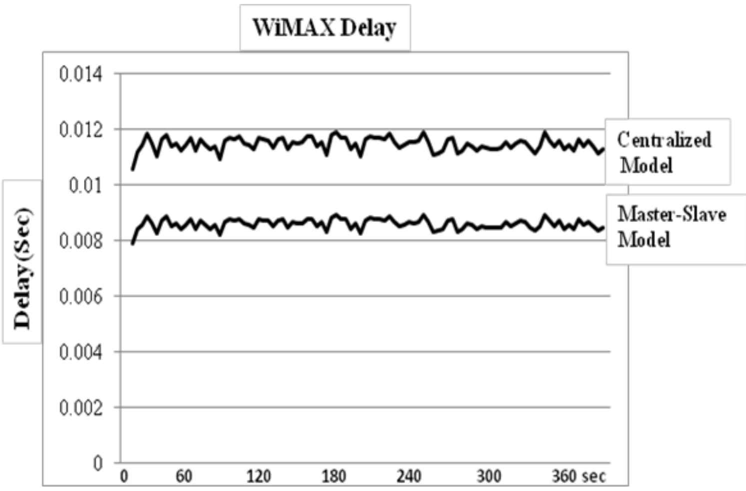

Figure 5. Centralized & Proposed Master-Slave Models (Scenario 1)

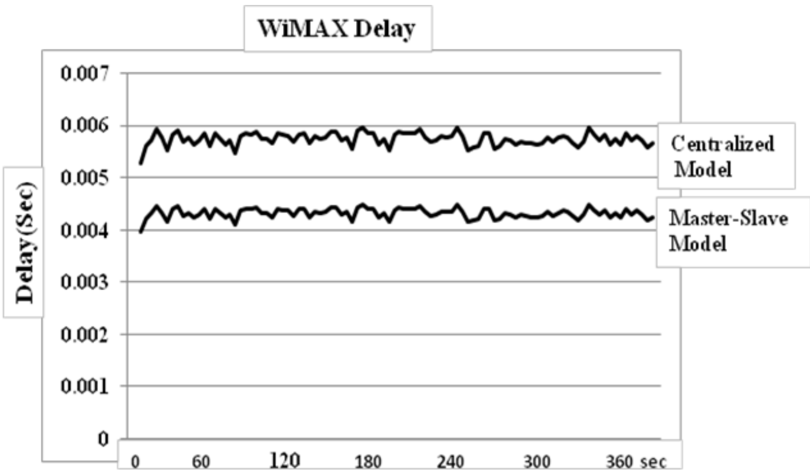

Figure 6. Centralized & Proposed Master-Slave Models (Scenario 2)

Delay can be caused by transmission error, ARQ or simply slow error correction, Figure 5 and 6 show the delay of the centralized and the new distributed Master-Slave model in fixed WiMAX with respect to time 3600 seconds for both scenarios 1 and 2. In general, WiMAX supports high data rates and possess high ability of handling load due to which the delay remains less. However, comparing the result obtained in figure 5 and 6; we can observe that the result of the proposed distributed Master-Slave model has an improved performance as compared to the existing model. Meanwhile, the result calculated by equation (1) also shows that the delay reduces from 0.0125sec to 0.0096sec in scenario 1 and 0.0615sec to 0.0044sec in the scenario 2 respectively. Despite the fact that the number of BSs, SSs, size of data being communicated and load of traffic are increased in scenario 2, the introduction of additional number of master BSs improved the QoS delay performance.

The proposed Master-Slave model has less delay as compared to the existing model due to the fact that in the existing model the SS have to communicate with the central server every time when they required the network information which increased the network delay; whereas in the proposed model the Slave BSs communicate with the nearby Master BSs to get the network information.

CONCLUSIONS AND FUTURE WORK

Wireless communication mostly concern with the QoS performance. In this paper we have proposed a new distributed Master-Slave model to improve quality of service with respect to delay in fixed WiMAX Networks to improve the services that are provided to the end users. The introduction of master BSs improves the performance of QoS with respect to delay. However, the network is distributed in such a way that the master BSs selected by the designed Nearest Neighborhood Algorithms can store some network information from the central Server and provide it to the nearest slave BSs. This model significantly enhances the system's overall performance from the earlier centralized model.

The model was evaluated using the simulation tool, OPNET modeler 16.0 and compared with centralized model. The results obtained from the new Distributed Master-Slave model shows less network delay as compared to centralized model which greatly improves the performance of QoS delay.

As future work, the proposed algorithms will be completed with some topology changes to increase the coverage area of WiMAX through distributed master BSs and consequently, may improve the WiMAX QoS delay performance.

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