Hybrid WiFi and WiMAX in Disaster Management for PPDR Services

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***Abstract*—Wireless communications system plays an important role for the PPDR or also known as public protection and disaster relief organizations. The organizations involved are fire and rescue team, police department and may also involved with any other private association. Since these organizations are from a different level of backgrounds, there is also a discrepancy with their communication technologies thus create interconnection obstruction and may degrade the efficiencies between different jurisdictions. This research proposes a hybrid communication architecture for hybrid WiFi and WiMAX networks. These networks are interconnected using a WiFi/WiMAX router. The research also suggests the optimum number of WiFi users/responders that could optimally support the network using WiMAX as the backhaul connection. In addition to that, the performance of the application assigned to the Wifi users that could beneficial to the given bandwidth is measured as well. The results are simulated using OPNET Modeler and evaluated in terms of QoS parameters. This architecture could solve the interoperability difficulties, and also benefited to both responders and PPDR organizations.**

***Index Terms*— Hybrid; PPDR; QoS; WiFi; WiMAX;.**

I. INTRODUCTION

Public Protection and Disaster Relief (PPDR) is well known as one of the consortium that involved in the disaster recovery management [1]. Generally it will accommodate the emergency communications system for the first responders during a disaster situation. Since there are multiple organizations involved, their different communication technologies will creates interoperability argument, especially in an emergency situation [2]. Consequently, this research proposed an integration of broadband wireless network, particularly focusing on WiFi and WiMAX. It also evaluates the optimize the number of applications that can be sustained in the hybrid network.

However, in order to have a consistent link between these two homogenous networks, a unique gateway is needed which known as WiFi/WiMAX gateway [3]. As described in Figure 1, the gateway works as in intermediate for the WiFi users through WiMAX [4][5]. On top of that, to restraint the allocation between WiFi and WiMAX, a controlled resource is placed at the gateway [6].

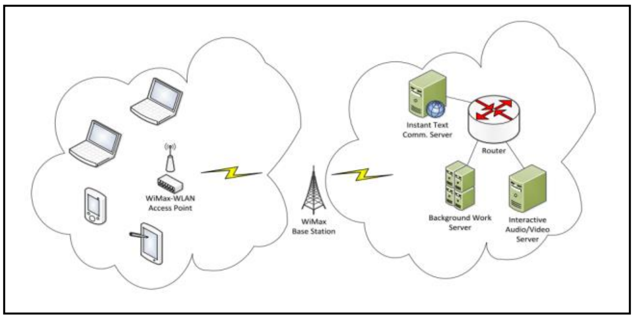

Figure 1: WiFi-WiMAX hybrid topology [3]

The structure of the paper is organized into a few sub-sections. The related work of communication system being used in PPDR operations is discuss in Section II. In Section III, the recommended architecture that can be used for emergency situations is described [7]. Section IV explains the simulation parameters used and results analysis. Lastly, in Section V is the conclusion of the investigation.

II. HYBRID WIFI AND WIMAX APPLIED IN DISASTER SITUATION

When an emergency call has been received, the responsible department are sent to the incident scene. At this moment, they have to set up the communications links particularly if the main communication system was destroyed or damaged. As an example, the fire department's command center will need to have a live video streaming from the disaster area for their further action, medical information from hospital databases for the people involved and for the most important thing is when the victims need to communicate with their families. The coverage of WiFi is only up to approximately 200 m which are not satisfactory enough used in a disaster emergency situations, where commonly the sector could spread out to kilometers. Since WiMAX coverage possibly up to 50km, therefore the research choose WiMAX network to be integrated with WiFi [8].

III. SIMULATION ENVIRONMENT

This research is focusing on the applications and functionalities that can be held for emergency responders for the PPDR operations. Besides that, it also discussed the performance of the traffic or application assigned, showing that they meet the QoS requirement.

OPNET Modeler is the network simulation tool used in the research [8]. The traffics/ applications assigned to the PPDR responders/ WiFi users are VoIP, video conferencing, web browsing and file transfer [10][11]. Table 1 and 2 described the simulation parameters used for WiFi and WiMAX network.

Table 1
Simulation Parameters for WiFi

WiFi Parameter	Value
PHY Profile	802.11n
Frequency	5.0 GHz
Min Data Rate	6.5 Mbps
Max Data Rate	60 Mbps
Transmit Power	0.04 W

Table 2
Simulation Parameters for WiMAX

WiMAX Parameter	Value
Bandwidth	10 MHz
Operating Frequency	2.5 GHz
Max Sustained Reserve Traffic Rate	2.8 Mbps
Min Reserved Traffic Rate (rtPS)	140 kbps
PHY Profile	OFDM

IV. Result and Discussion

The parameter used to analyze the results are throughput, delay and packet dropped. The research evaluates a few scenarios to figure out the recommended architecture. In the 1st part, the amount of WiFi users/ responders that can be supported in one CPE for the PPDR operations is evaluated. Meanwhile, based on the same topology, the researcher analyze the performance of the traffic or application assigned which shown in 2nd scenario.

<u>Scenario 1</u>

In this situation, 20 of WiFi users/responders is placed on a single CPE. However, to investigate further, it computes a second CPE that attach to addition 20 WiFi users. Therefore, totally there are 2CPEs and 40 WiFi responders. The aim of this topology is to determine the possible amount of WiFi users/responders that possibly supported in one of the WiMAX BS. The results obtained are explained as follows; for the WLAN and WiMAX link, the throughput produced are nearly identical measured on both side of the APs.as shown in Figure 2 and Figure 3.

The throughput measured for both WiMAX and WiFi sides are almost the same. In details, the results are shown in Figure 2, the maximum throughput obtained for a WiMAX link is 2.8 Mbit/s whereas the minimum is 2 Mbit/s. Meanwhile, throughput achieved for a WLAN link is 2 Mbit/s. The differences show there is packet loss between those link as described in Figure 4. This is happened because of the overflow of the buffer. As the solution, the size of the buffer is changed into a bigger size, which will also expand the delay in the network. Thus after conducted a few trials, the research found the preferable size of the buffer that can be applied in the scenario. However, for a WiMAX link, there is zero loss, since all of the information is all received at the receiver point

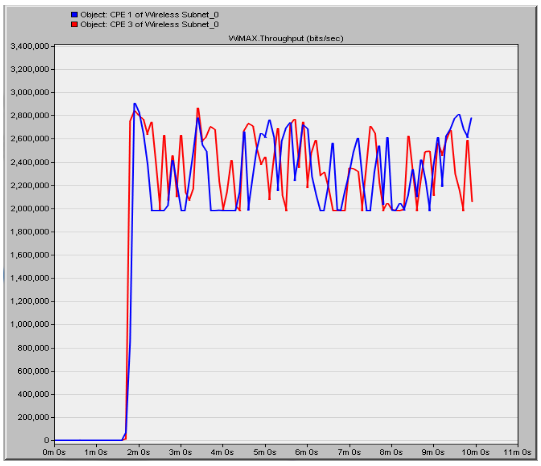

Figure. 2: WiMAX Link Throughput (bits/sec)

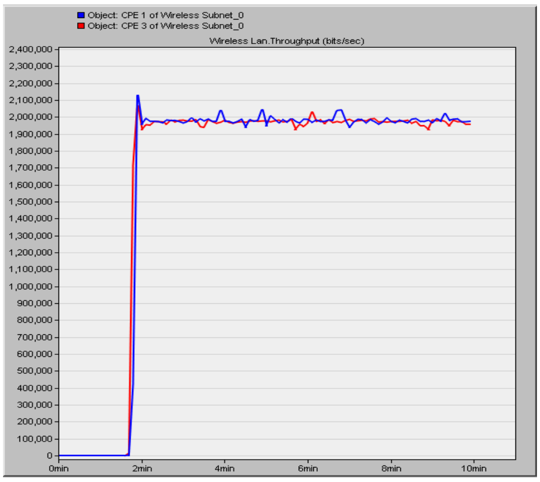

Figure 3: WiFi Link Throughput (bits/sec)

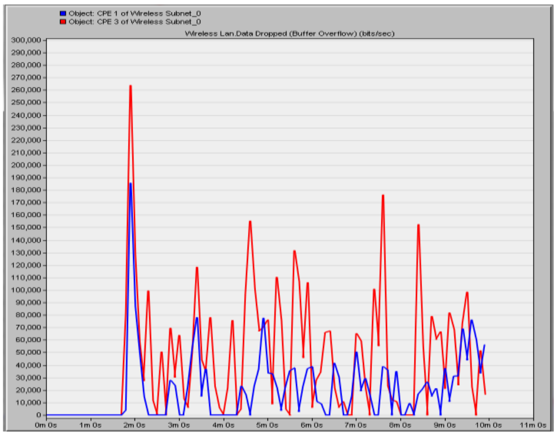

Figure 4: Data dropped of WiFi link

Based on simulation results in scenario 1, the optimum number of WiFi responders could accommodate in a single WiMAX BS is 40, which 20 WiFi responders for each CPE. This is because when the number of users increased, there is packet dropped occurring at the WiMAX link, which is between the CPE and the core network. This could be a worse situation for the PPDR responders as there is an information burst while communicating.

Scenario 2

For this part, the research analyzes the performance of the application/traffics placed on the WiFi users/responders as described in Table 3. The applications are divided into two main traffic which is voice and video as heavy traffic and file transfer and HTTP browsing as the low bit rate traffic.

Table 3
Application Assigned to 20 WiFi Users

WiFi users (amount)	Application Assigned
1	Video
6	VoIP
6	Http Browsing
7	File Transfer

In order to investigate the quality of the application assigned to the responders for the PPDR operations, the researcher measured several QoS parameters such as throughput, end-to-end delay, jitter, packet loss and Mean Opinion Score (MOS) value as discussed below.

VOIP

The research used the G.711 codec type with a minimum and a maximum bit rate is 64 kbps and 96 kbps respectively. Therefore, it can be can see that throughput for all the VOIP responders are stabilizing around 96 kbps showing that it satisfied the VOIP requirement.

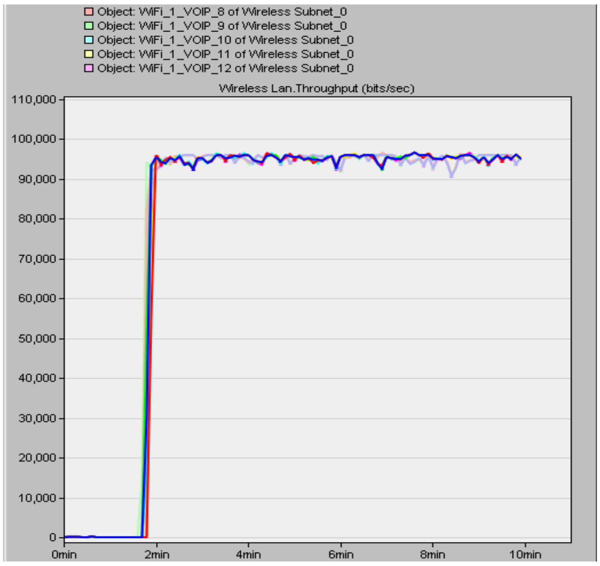

Figure 5: Throughput of all VOIP responders

The research also measured the end-to-end delay, MOS value, and jitter as depicted in Figure 6, 7 and 8 respectively. Based on Figure 6, the value of end-to-end delay for all VOIP responders is between 0.007 and 0.0053 seconds. Meanwhile, Figure 7 described the reading of MOS value obtained for the WiFi users/responders with the VOIP task. The measurement outcomes explained as excellent which is scored between 3.85 to 4.05 [12].

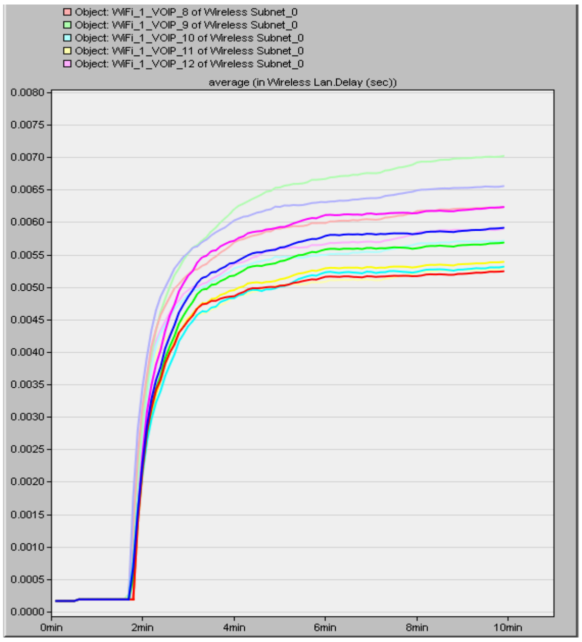

Figure 6: End-to-end delay of all VOIP responders

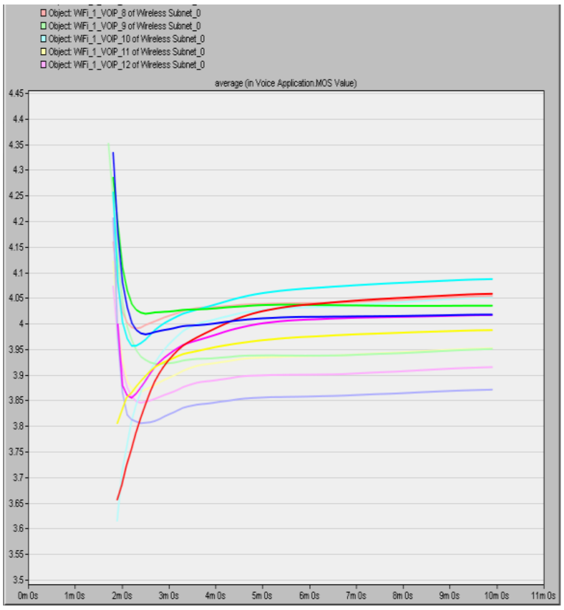

Fig.7. MOS value of all VOIP responders

The next parameter evaluated in the project is the average jitter reading as explained in Figure 8. It shows that the jitter is zero which means there is no delay occurred during the transmission.

As the conclusion, the performance for the VOIP responders is within the acceptable performance for PPDR operations. The throughput shows an optimum bit rate, with a minimum end to end delay with less than 1 second as required in the service level agreement. Other than that, the quality of video and audio transferred in the scenario performed a good quality satisfaction. Also to mention is the average jitter that shows there are no packet losses happened in the system.

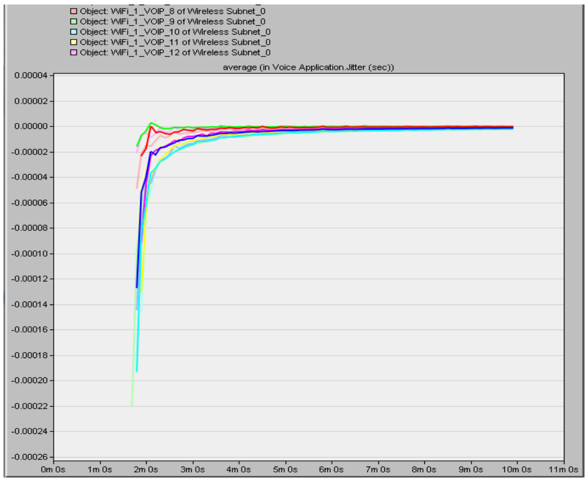

Figure 8: Average jitter of all VOIP responders

<u>Video</u>

In [13], several video quality testing has been conducted to estimate the acceptable video applications by the first responders. The recommended minimum end to end delay is 1 second.

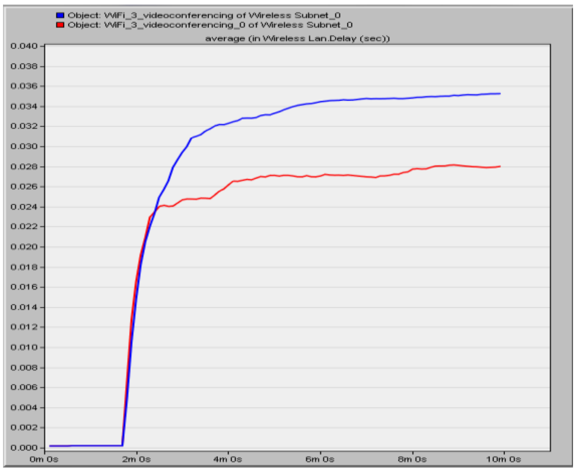

Figure 9: Video Users End- to- End Delay

The graph in Figure 9 explains that until the end of the simulation time, the average delay for the 1st responder is 0.036 seconds while 0.028 seconds is for the 2nd responder which both of them are far apart from 1 seconds and therefore offers acceptable performance for PPDR responders.

<u>File Transfer Protocol/ Web Browsing</u>

The last part of this paper shows the performance of the file transfer and web browsing applications which are assigned to the Best Effort QoS in WiMAX link. As a matter of that, this research measured the throughput for all the emergency responders with the FTP and web browsing applications as depicted in Figure 10 and Figure 11.

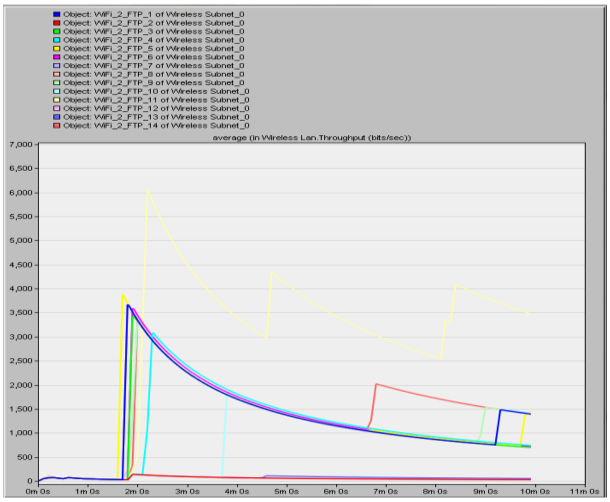

Figure 10: Throughput of all FTP responders

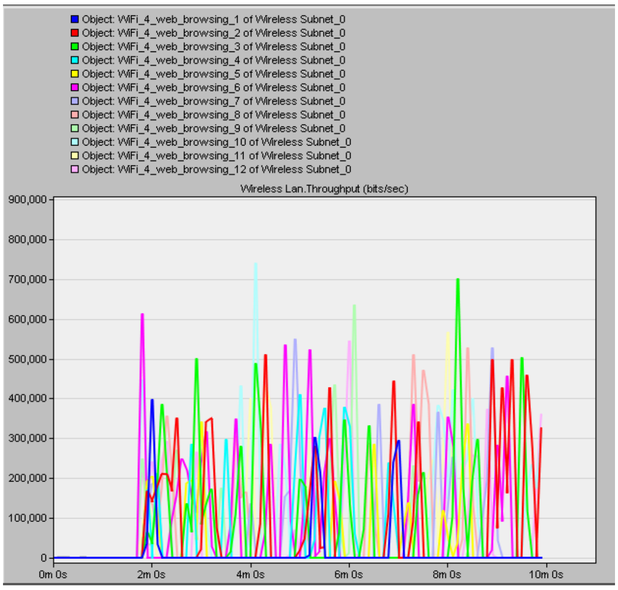

Figure 11: Throughput of all web browsing responders

Based on the results in Figure 10 and Figure 11, throughput for FTP and web browsing application varies for each responder as they share the same amount of available bandwidth after VOIP and video have been served. However, the most noticeable that it shows that all of the users gain throughput which also means that there are no single dropped for the WiFi and WiMAX link. For these applications, the research did not measure the end-to-end delay as there is no necessity for it, however, the adequate throughput for web browsing and FTP is minimum 28Kbps [14].

V. Conclusion

As the conclusion, a detail investigation has been done in this research for hybrid WiFi and WiMAX networks. In order to evaluate the QoS parameters, there are two main parts in this paper; in the first part, we investigate the optimum number of WiFi users/responders that could be supported by a single CPE. The second part measures the output based on the QoS parameters as discussed in the paper [15].

Based on the summarize obtained from the research, the next plan is to proceed with the hybrid network for WLAN and LTE (Long Term Evolution) network as the future work.

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