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WiMAX Quality of Service Deployment in Disaster Management

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***Abstract*—There are five different Quality of Service (QoS) classes defined by the IEEE 802.16e-2005: UGS, ertPS, rtPS, nrtPS and BE. It is well known that BE provides the lowest level of quality compared all other classes. In this paper, we investigate the performance of rtPS and BE QoS classes in an emergency and natural disaster scenario. We use the OPNET modeler for simulation purposes in order to evaluate rtPS and BE performance with particular focus on video conferencing/streaming and web browsing applications. It is possible that during a disaster BE is the only available service. Simulation results revealed that in certain situations, a user with BE QoS could provide higher throughput compared to the rtPS case. Consequently, we also evaluate the video conferencing/streaming application for the BE QoS case. Simulation results show that for a defined maximum number of users in the network and a certain combination of users that are allocated a QoS and a selected application e.g., web browsing or video conferencing, BE is shown to demonstrate a higher throughput than rtPS. The simulation results are discussed in the main body of the paper.**

***Keywords*—QoS,BE, rtPS, throughput.**

I. Introduction

In many practical applications or situations where emergency communication is required, very often where the major communication is down such as Long Term Evolution (LTE). It also happened during times of catastrophe such as earthquakes or tsunamis, when the entire incumbent communications infrastructure been destroyed or damaged. An ad-hoc communications system that requires relatively fast and robust links must be deployed in a very short time to support the communication needs of the rescue and recovery operations. Therefore in this particular scenario, Worldwide Interoperability for Microwave Access (WiMAX) appears to be a viable solution. WiMAX network can be deployed in the risk and inaccessible areas for example in the place where the disaster happened (earthquake, seaquake, flooding, and forest fires) and even in the proximity of a possible hazard such as volcanoes and nuclear power stations [1]. Hence, communication infrastructure that needs to be fast and easily deployed plays a paramount role insuporting communications among the emergency response personnel, disparate agencies and the outside world.

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Nowadays modern disaster response often requires the transmission of a variety of information such as texts, voices, videos and other types of data. The selection of WiMAX-based communication architecture is the best solution due to its capabilities in terms of coverage, data rates, user mobility and even enables meeting different QoS constraints in relation to different types of applications and traffic. In particular, in the case of an emergency communications system, it is possible to allocate network resources properly to assign priority to critical applications, such as real-time applications. This is impossible in the case of basic WiFi systems that assign to all services the same level of QoS [2].

Fig. 1 shows architecture for an efficient disaster management system. People at the operation site communicate with each other using cellular phones, notebooks, PDAs or any communication tools and transfer all the information to the Monitoring Centre.

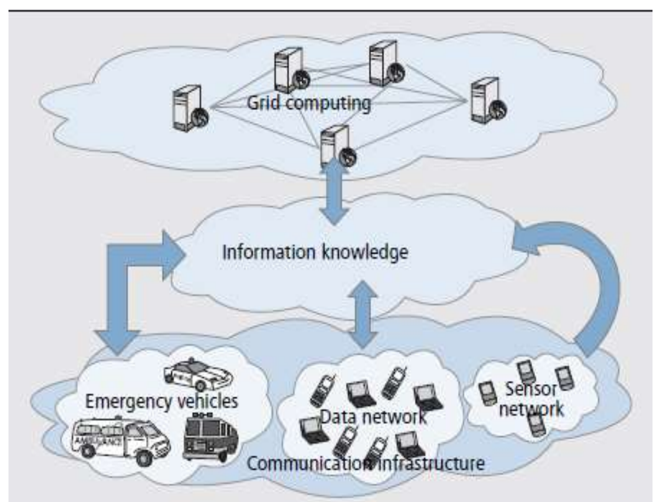

Figure 1. Architecture of a disaster management system [1]

Continuing from our previous project [3], research was done to map the best quality of service for hybrid network (WiFi+WiMAX and WiFi+LTE) and analyse the performance for the rtps and BE QoS users. However, in this project for simulation purposes we have selected WiMAX network for testing these initial results because it has a private network which would be easy to implement the result rather than going to LTE which needs large scale deployment. Therefore we believe if these results are working for WIMAX, we also believe the same approach can be used on LTE network.

However before moving on to LTE, we need to verify the results in WiMAX network and then proceed to LTE.

The rest of this paper is organized as follows. In Section II, we briefly review the WiMAX QoS embodied in the IEEE 802.16 architecture. In Section III and IV, we discussed the WiMAX technology for the disaster management situations. The proposed scenario for emergency situation together with simulation parameter results is presented. Finally, we summarize our results in Section V and provide our conclusion in Section VI.

II. IEEE 802.16 Architecture

There are two basic operational modes delineate by the IEEE 802.16 standard: point to multipoint (PMP) and mesh networks [4]. However in this paper, we only considered the PMP network on an OFDMA system. The IEEE 802.16 Medium Access Control (MAC) layer consists of 3 sublayers: Security Sublayer (SS), MAC Common Part Sublayer (CPS) and Service-specific Convergence Sublayer (CS). This Sublayer is designed to support and mange different kinds of traffic and applications through five different service classes: Unsolicited Grant Service (UGS); Extended Real-time Polling Service (ertPS); Real-time Polling Service (rtPS); Non-real-time Polling Service (nrtPS) and Best Effort Service (BE) [6].

UGS is designated for constant bit-rate data which has fixed size packets at periodic intervals such as VoIP. The BS will always have to allocate a fixed number of slots based on the maximum sustained reserve traffic rate parameter (mstr). The rtPS class is similar to UGS but with variable packet size for example MPEG video data. For rtPS, BS will allocate slots based on the bandwidth requirements and the request size. The ertPS class was added in the 802.16e to combine the UGS and rtPS classes. It is suitable for variable rate real-time applications that have data rate and delay requirements such as VoIP with silence suppression. The way that BS allocates slots for the nrtPS class is quite similar to the rtPS except that if the request size equals zero, then BS does not allocate any slots at all. Lastly, BE class is designed to support data streams with no throughput or delay guarantee such as data transfer and web browsing application [7].

III. WiMAX in Disaster Situations

During the emergency situation, planning the best platform for a disaster management communication system is vital. As stated before, WiMAX-based network seems to be the most innovative network architecture for efficient emergency communications systems scenarios [8]. With its ability to provide high-speed transmission of up to 63 Mbps for downlink and 28 Mbps for uplink, with a range of more than 11 km, secure and reliable communications, it is an ideal choice for wide area communications. For example in the 2010 Haitian Earthquake response, VoIP, video and applications such as Skype, Ushahidi, Sahana, Facebook, Twitter, and Google Maps were being used by the disaster responders for the emergency communications [9].

There are two scenarios that have been used by the WiMAX Extensions for Remote and Isolated Research Data Networks (WEIRD) project; Environmental Monitoring and Fire Prevention. For the environmental operation, several video cameras and wireless sensor networks were installed around the area to record any occurrence that happened. Next all the data was collected and transmitted to the Monitoring Centre using a Mobile WiMAX link to be analyzed. The same procedure goes for the Fire Prevention Scenario, images and text description taken from the operation site were being transmitted to the Fire Station District Civil Protection Coordination Centre (DCPCC) using Mobile WiMAX. For this case, real-time data such as voice and VoIP application have been used and utilized [10].

In our proposed architecture, we are analyzing the performance of the rtPS and Be QoS. We also considering not only the real time applications but also the non-real time applications have been used. Currently in WiMAX there are 5 different QoS and it is commonly known that rtPS provides higher quality and BE provides the worst quality. However in the case of a disaster, there is a need to have any type of communication. In the case of a disaster it is desirable to get more from the system performance what the conventional system can do. One of the conventional thinking is the rtpS QoS will always give the best performance with the higher throughput while BE QoS is like a backup.

In this paper we are showing in some specific scenarios and some specific applications that this conventional thinking has not always happened and is not always right. In some specific scenarios it is possible to get a better throughput with BE rather than rtPS and this could be a very good addition to the emergency rescue services who would need extra bandwidth without the need to deploy extra base stations. In fact, in some disaster scenarios, the particular environment can limit the number of base stations in the area and hence higher throughput could be the main requirement to be satisfied.

Conventional WiMAX standard defines 5 levels of quality of service and in this level video conferencing/streaming is assigned to the rtPS classes. However there are number of scenarios where video conferencing can work with the BE QoS for example in the WiFi network. Therefore, we anticipated that such scenarios will happen in emergency situations therefore we would like to try these unusual scenarios where video conferencing could be required to operate with the BE. Eventhough video conferencing is not used over BE classes but let’s assume for this particular case the user does not have any other choice. So our systems solution is to provide this user with enough throughputs so that the user can run video conferencing/streaming application over BE QoS class which is not commonly possible. We also propose not only video streaming for rtPS QoS user but also web browsing for the rtPS user.

IV. Simulation

The model consists of 1 BS and 10 SS and is simulated using the Opnet simulator. rtPs and BE are involved in evaluation with the following traffic combinations: 8 video conferencing connections and 2 http browsing. The video conferencing traffic is given the rtPS treatment whereas the http browsing is specified to the BE scheduling type. The service flows for both classes are classified to Silver. The traffic parameters and simulation parameters are summarized in Table 1 and 2 respectively.

Table 1: Traffic Parameters

Application	Parameters
Video Conference	Frame size :128x120 resolution Frame inter arrival time : 10 fps
Web browsing (HTTP)	HTTP Specification : HTTP 1.1 Inter arrival time :Exponential 360 seconds

Table 2: Simulation Parameters

Parameter	Value
PHY Profile	OFDMA
Bandwidth	10 Mhz
No. of Subcarriers	1024
TTG (Transmit-receive Transition Gap)	106 µs
RTG (Received-transmit Transition Gap)	60 µs
Min Reserved Traffic Rate (rtPS)	140 kbps
Max Sustained Reserve Traffic Rate	2.8 Mbps
Poll interval rtPS	5 ms
Subframe ratio (DL/UL)	1:1

V. Results and Analysis

The simulation has been carried out to compare the performance of the rtPS and BE QoS in WiMAX network. The first part: Fig.2, Fig.3 and Fig.4 demonstrate the situation where BE QoS could perform better than rtPS QoS users in a WiMAX network. The second part: Fig.5, Fig.6 and Fig.7 reveal that BE QoS is also likely applied to the video conferencing application which possible to be used during an emergency situation.

A. *Part A*

Fig. 2 shows the average throughput for rtPS and BE QoS users. For both BE QoS (user 1 and 2), the average throughput is around 2.4 Mbps and 2.1 Mbps respectively. However for remaining 8 rtPS QoS users the average throughputs are ranged between 1.1 Mbps to 1.2 Mbps. It clearly shows that the BE users have higher throughput than the rtPS. This scenario can be further investigated from Fig.3, we can see that for both BE users there is no packet drops between the BS and SS link. Meaning there is no data loss from the source to the destination that will likely degraded the file transmission. The delay measured for the video conferencing and http application is detailed in Fig.4. It is shown that the average delay ranged from 0.008 to 0.0035 seconds for the BE users. The average amount for the rtps users ranged from 0.007 to 0.003 seconds which is smaller than the 150 milliseconds specified by the WiMAX forum as the acceptable delay for video conferencing application.

Figure 2. Average throughput for rtPS and BE

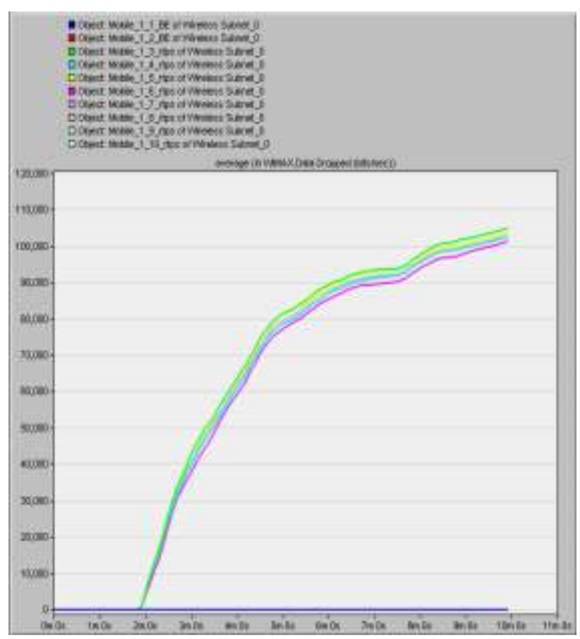

Figure 3. Average data dropped for rtPS and BE

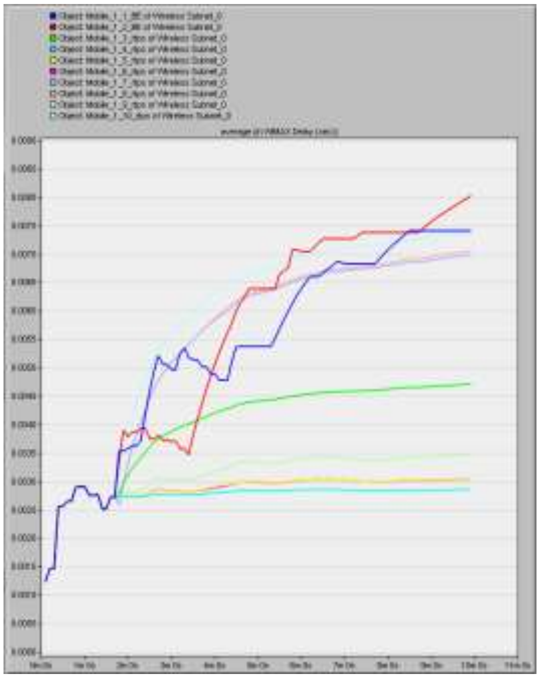

Figure 4. Average delay for rtPS and BE

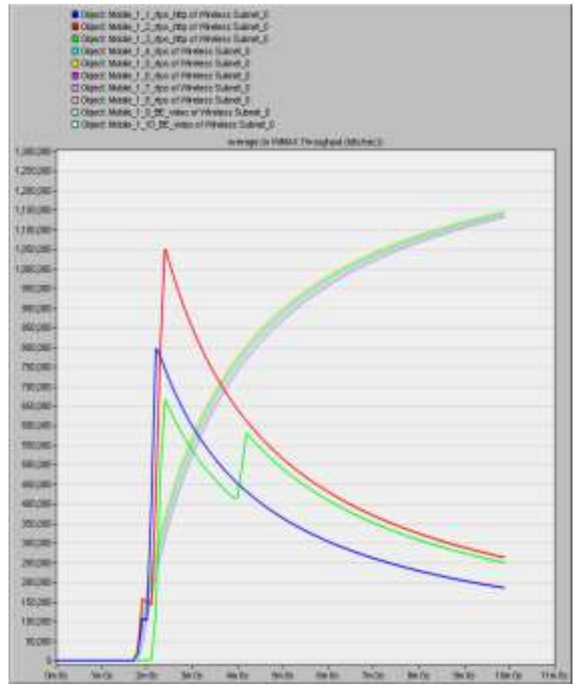

Figure 5. Average throughput for rtPS and BE

B. ***Part B***

The following figures are the results to evaluate the BE QoS with the video conferencing applications. Eventhough it is an unusual case however based on this discovery it can be very useful to the rescue team during disaster or an emergency situation.

The next model contains 10 users with the specific QoS allocation; 3 rtPS (web browsing), 2 BE (video conferencing/streaming), and 5 rtPS (video conferencing/streaming) applications. Fig.5 explains that the average throughput for the 3 rtPS (web browsing) users are ranged between 650 kbps and 1.05 Mbps meanwhile for the 2 BE and 5 rtPS (video conferencing/streaming) applications the throughput is 1.15Mbps respectively. Therefore it shows that BE QoS could also functioning with the video conferencing applications and eventually perform slightly higher throughput compared to the rtPS (web browsing) application.

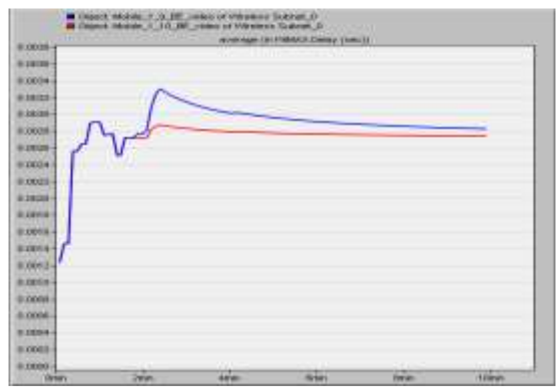

Figure 6. Average delay for BE users

Figure 7. Average delay for rtPS users

VI. Conclusion

This study has explored the details and performance of rtPS and BE scheduling classes in the WiMAX network. This proposed technique is to address the critical issue in disaster situation where the conventional communication network was destroyed. From this paper it can be concluded that BE QoS could perform better than rtPS depending on the total number of users in the network and with determined combination number of QoS users. Besides that we also found that BE is also probably suitable for the video conferencing applications. Therefore based from this study, the rescue operation could be running successfully. Our impending work will focus on the bigger scale of network and provides different QoS support to different types of traffic variation.

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