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Effect of Scheduling Algorithms on QoS of WiMAX

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Abstract - Designing a heterogeneous [1] network including systems providing different QoS, such as the emerging WiMAX, is a difficult task. The integration of a WiMAX access system with Differentiated Services (DiffServ) enhances the overall performance of the network. This paper investigates the interworking between WiMAX and DiffServ networks, by reducing the end to end delay. Scheduling improve the QoS of WiMAX. We investigated and evaluated different types of scheduling techniques aiming to determine the one that is most efficient in Wimax network. There are three different scheduling schemes viz. strictly priorty (SP), weighted round robbin (WRR) and weighed fair queuing (WFQ). These proposed schemes improves QoS to a great extend. We compared these three techniques by performing simulations using NS2. This simulation provides an intuitive model set up capability that includes core components such as animator, packet tracer analyzer, protocol designer and protocol stack. From the results of our simulation we find WF as the best scheduling algorithm when considering end to end delay and WF outperforms others for all classes of Qos Key words—QoS, DiffServ, WiMAX.

***Keywords* - Scheduling Algorithms, QoS, WiMAX, WiMAX architecture.**

I. INTRODUCTION

WiMAX stands for Worldwide Interoperability or Microwave Access. It is the technology aimed to provide wireless data access over long distances. It is based on Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard. Wireless communication applications have expanded from simple vice services to integrated data services, it use to support huge data rates if it comes to fulfill demand of resources. WiMAX has already become popular technology for broadband access in Wireless Metropolitan Area Networks (WMAN) environment. It offers a rich set of features and flexibilities in terms of deployment options and it supports new applications. The physical layer of WiMAX is based on Orthogonal Frequency Division Multiplexing (OFDM), which is widely recognized as the modulation technique for mitigating multipath fading problem associated with any broadband wireless system. WiMAX is capable of supporting very high peak data rates. In fact a peak data rate of 74Mbps can be achieved when operating with a 20MHz wide spectrum. Under very good signal conditions, even higher peak rates may be achieved by

Using multiple antennas and spatial multiplexing.WiMAX provides Quality of Service (QoS) that supports five different categories of services namely: Unsolicited grant services (UGS), Real time polling services (rtPS), Non- real-time polling service rate (nrtPS), extended real-time polling service (ertPS) and Best-Effort services (BE). As such, scheduling class services must ensure there is efficiency and fairness in meeting the various QoS requirements. The scheduling class services in wireless networks includes priority scheduling and queuing for bandwidth allocation based on traffic scheduling algorithms within wireless networks. Since the scheduling algorithm is still an undefined territory, designing an efficient scheduling algorithm that can provide high throughput with minimum delay is indeed a challenging task for system developers. Although there are various studies on scheduling algorithms, there is a clear absence of a comprehensive performance study that provides a unified platform for comparing such algorithms. Therefore, this research paper is aimed to investigate and compare several scheduling algorithms in terms of performance and abilities to support multiple classes of service. Besides that, to identify significant scheduling algorithms for the Uplink and Downlink channels that use QualNet-5.0. Finally it aims to measure the important metrics of the scheduling algorithms.

II. WiMAX ARCHITECTURE

The basic IEEE 802.16 [2] architecture consists of one Base Station (BS) and one or more Subscriber Station (SS). BS acts as a central entity to transfer all the data from SSs through two basic operational modes: mesh and point-to multipoint (PMP). Figure 1 shows the IEEE 802.16 QoS Architecture. Meanwhile, transmissions take place through two independent channels: Downlink Channel (from BS to SS) and Uplink Channel (from SS to BS). The Uplink Channel is shared among all SSs, while the Downlink Channel is used only by BS. In the mesh mode, subscriber stations (SS) can communicate with each other as well as with the base station (BS). This means that traffic can be routed through other SSs. Also the traffic can occur directly among SSs. Therefore, within the mesh mode, uplink and downlink channels are defined as traffic in the direction to and from the BS, respectively.

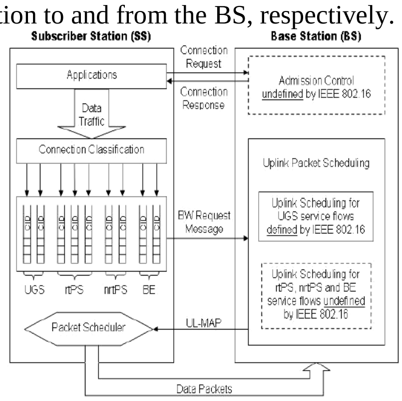

Fig.1. IEEE 802.16 QoS Architecture

In the PMP mode, the SSs are only allowed to communicate through the BS. In this way, the provider can control the environment to ensure that the Quality of Service (QoS) meets the requirements of its customers. In the PMP mode, traffic only occurs between the Base Station (BS) and Subscriber Stations (SS).

III. WiMAX QoS

WiMAX standard defines 5 service classes to support its wide range of applications as endorsed by IEEE 802.16.

3.1 Unsolicited Grant Services (UGS)

This class of service is designed to support fixed-sized data packets at a constant bit rate (CBR) such as E1/T1 lines that can sustain real-time data stream applications. This service provides guaranteed throughput, latency and jitter to the necessary levels as TDM services. UGS is used mainly to support Constant Bit Rate (CBR) services found in voice applications such as voice over IP.

3.2 Real-time Polling Services (rtPS)

This class of service is designed to support real-time service flow that generates variable-sized data packets on a periodic interval with a guaranteed minimum rate and guaranteed delay. The mandatory service flow parameters that define this service are inclusive of minimum reserved traffic rate, maximum sustained traffic rate, maximum latency and request/transmission policy. rtPS is used extensively in MPEG video conferencing and streaming.

3.3 Non-real-time Polling Service (nrtPS)

This class of service is designed for non-real-time traffic with no delay guaranteed. The delay tolerant data stream consists of variable-sized data packets. The applications provided by this service are time-insensitive and a minimum amount of bandwidth. This service is especially suitable for critical data application such as in File Transfer Protocol (FTP)

3.4 Extended real-time Polling Service (ertPS)

This class of service provides real-time applications which generate variable-sized data packets periodically that require guaranteed data rate and delay with silence suppression. This service is only defined in IEEE 802.16e-2005. During the silent periods, no traffic is sent and no bandwidth is allocated. However, there is a need to have a BS poll during the MS to determine the end of the silent periods. ErtPS is featured in VoIP with silence suppression.

3.5 Best-Effort Services (BE)

This class of service provides support for data streams whereby no minimum service-level guarantee is required. The mandatory service flow parameters that define this service include maximum sustained traffic rate, traffic priority and request/transmission policy. BE supports data streams found in Hypertext Transport Protocol (HTTP) and electronic mail (e-mail).

IV. Scheduling Algorithms

The main focus is to examine the scheduling schemes in WiMAX network. In order to specify high network performance, an efficient scheduling algorithm [3] is essential as it manages and controls the provision of an efficient level of QoS support. Although many scheduling algorithms have been proposed in the literature for WiMAX network, the design of the algorithms are challenged by having to support different levels of services, fairness and implementation complexity. Many researchers have compared their proposal schemes on different scheduling schemes, but there is no common, simple and standardized packet scheduling to make their comparison. In this study, six carefully selected scheduling algorithms in WiMAX wireless network are investigated. These algorithms which are considered the most dominant and popular include Diffserv-Enabled (Diffserv), Round-Robin (RR), Self-Clocked-Fair (SCF), Strict-Priority (SP), Weighted-Fair Queuing (WFQ) and Weighted Round Robin (WRR) [5]. Furthermore, these common packet scheduling schemes provides QoS support for real time applications in IEEE 802.16 system.

4.1 Diffserv-Enabled (DE)

Diffserv is a simple, scalable and measurable mechanism for classifying and managing network traffic. Besides, it provides low-latency with guaranteed service to critical network traffic as well as to non-critical services. It relies on the principle of traffic classification by involving the 6-bit Differentiated Services Code Point (DSCP) field in the header of IP packets to classify the packet and indicate the per-hop behaviour (PHB). DSCP replaces the outdated IP precedence in classifying and prioritizing types of traffic. Every router on the Diffserv network is configured to differentiate traffic differently, ensuring preferential treatment for higher priority traffic on the network.

4.2 Round-Robin (RR)

It is designed for a time-sharing system whereby the scheduler assigns time slots to each queue in equal portions without priority. It starts with the highest priority queue with packets, services a single packet, then visits the next lower priority queue with packets, and continues servicing every single packet from each queue. This is carried on until each queue with packets has been serviced once. Every queue is allocated with the same portion of system resources regardless of the channel condition, ultimately utilizing the same resources. However, the RR scheduler has the same bandwidth efficiency as a random scheduler, so it cannot guarantee different QoS requirements for each queue.

4.3 Self-Clocked-Fair (SCF)

It is an efficient queuing [4] scheme which satisfies the quality of services (QoS) [6] in broadband implementation. The algorithm is based on the concept of virtual time that adopts the concept of an internally generated virtual time as the index of work in progress. It links virtual time to the work progress in the fluid-flow fair queuing (FFQ). As virtual time function is involved in determining the order of which packet should be served next, the virtual time that is produced depends very much on the progress of work in the actual packet based queuing system. This scheme is efficient for the internal generation of virtual time as it involves negligible overhead. This is because virtual time is easily computed from the packet situated at the head of the

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queue. In addition, the SCFQ algorithm can accomplish easier implementation and it can maintain the fairness attribute in virtual time function.

4.4 Strict-Priority (SP)

In Strict-Priority algorithm, the selection order is based on the priority of weight order. The packets are first categorized by the scheduler depending on the quality of service (QoS) classes and then allocated into different priority queues. The algorithm services the highest priority queue until it is empty, after which, it moves to the next highest priority queue. Thus, strict-priority algorithm may not be suitable in WiMAX network. This is because there is no compensation for inadequate bandwidth. Also this technique is only appropriate for low-bandwidth serial lines that currently uses static configuration which does not automatically adapt to changing network requirements. Finally, this process may result in bandwidth starvation for the low priority QoS classes whereby the packets may not even get forwarded and no guarantee is offered to one flow.

4.5 Weighted-Fair-Queuing (WFQ)

This algorithm is employed for uplink [7] traffic in WiMAX with different size packets. As it caters to different size packets, it emphasizes emphasizes on providing fair scheduling for the different flows by assigning finish times to the packets. The finish times are based on the size and weight of the packets. In general, the WFQ algorithm outperforms the WRR due to variable size packets. However, the weaknesses of WFQ algorithm are, the start time of a packet is not taken into consideration, and it can lower the scheduler system if many packets occur in the priority region.

4.6 Weighted Round Robin (WRR)

It is a scheduling algorithm implemented for resource sharing in a computer or network. In fact, WRR is an extension of the Round Robin (RR) algorithm. In a network, WRR serves a number of packets that are computed by normalizing weight of data divided by the average of packet size from nonempty connection queue. It begins by classifying packets into a variety of service classes followed by assigning a queue that is determined by the different percentage of bandwidth. Finally, it is serviced in round robin order. Since the bandwidth is assigned according to the weights, the algorithm will not provide good performance in the presence of variable size packets. However, WRR method makes certain that all service classes have access to at least some configured amount of network band width to avoid bandwidth starvation.

V. Simulation Model

The purpose of this simulation study is to investigate and evaluate different types of scheduling techniques in order to determine the one that is most efficient in WiMAX network.

Table 1 Simulation Parameter

Parameter	Value
BS range radius (m)	1000
MS range radius (m)	500
Frequency band (GHz)	2.4
Channel bandwidth (MHz)	20
Frame duration (ms)	20
FFT size	2048
Number of MS	10-50
Number of BS	1
BS transmit power P_t $dBm/height$ (m)	20/5
MS transmit power P_t $dBm/height$ (m)	15/1.5
Services types (QoS)	BE, nrtPS, rtPS, ertPS, UGS
Simulation time (s)	30

The simulations are performed using ns2 simulation. This simulation provides an intuitive model set up capability that includes core components such as animator, packet tracer analyzer, protocol designer and protocol stack. The system parameter used in this simulation study consists of a single cell with a BS, and a number of MS that varies from 10 to 50 MS. Table 1 summaries the simulation parameters used in the experiments with 20MS.

VI. Simulation Results

Six experiments with varying simulation parameters were carried out and the findings show varying results. The results of experiment 1 are shown in Figure 2 that SP, WRR, and WF are the best scheduling techniques in WiMAX network with respect to the end-to-end time delay.

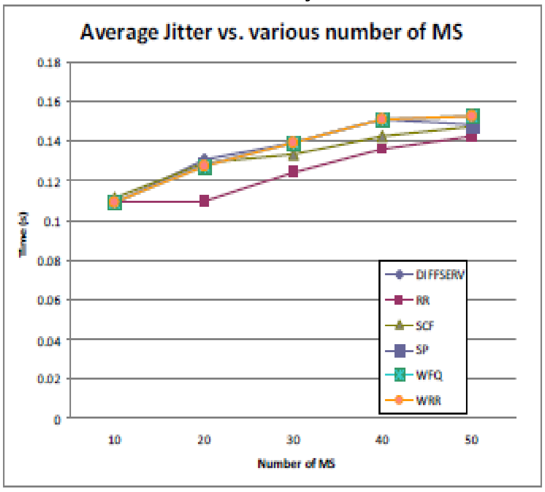

Fig.2. The Amount of End-To-End Delay.

Meanwhile the results tabulated in Figure 2 shows that Diffserv has the lowest performance in producing the highest amount of end-to-end delay time. On the other hand, WF shows the best performance as the average end-to-end time delay has the lowest reading. Finally, it can be concluded that there is much difference in terms of the average end-to-end delay time among RR, SCF and WRR.

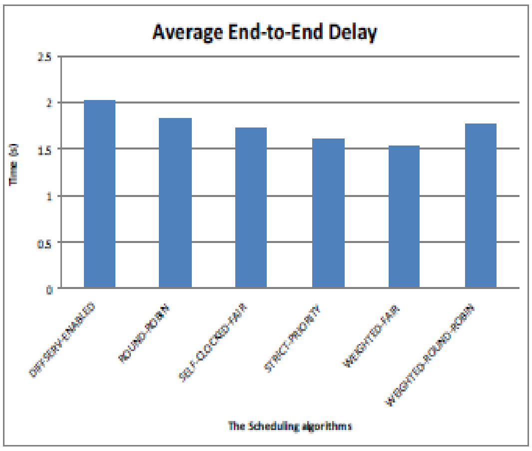

Fig.3. Total Average of End-To-End Delay Time

The total end to end delay is reduce in the three techniques discuss give better results. The results of experiment 2 and figure 3 are that WF outperforms SP and WRR as it achieves the shortest amount of end-to-end delay time for all the classes of QoS. However, WF achieves the same amount of end-to-end delay time for the class BE and nrtPS. It is also noted that BE achieves the shortest amount of end-to end delay time for the three algorithms, while UGS produces the longest amount of end-to-end delay time for all the three algorithms.

VII. Conclusions

In conclusion, the investigation of the behaviours of several wireless scheduling algorithms namely Diffserv, RR, SCF, SP, WFQ, WRR has shown the strengths of some of the scheduling algorithms that were under study. One of the best scheduling algorithms is WF, in terms of the amount of end-to-end delay. Since in the proposed scheme the end to end delay between any two nodes get reduced, so the communication becomes fast and we can cover large area through WiMAX. Also the QoS is improved by decrease in the end to end delay. We can vary other parameters like jitter delay, packet delivery ratio (PDR) to improve QoS. As the scheduling in WiMAX wireless network is a challenging topic, future works should include further investigation on scheduling algorithms under different bandwidth request mechanisms and CAC schemes.

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