Comparison of Various Scheduling Algorithms in WiMAX: A Brief Review

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ABSTRACT
WiMAX Technology is also one of the emerging wireless technology that provides us high speed mobile data and telecommunication services. It provided several services such as data, voice, and video including different classes of Quality of Services (QoS), which in turn were defined by IEEE 802.16 standard. Scheduling in WiMAX became one of the most challenging issues, since it was responsible for distributing available resources of the network among all users; this leaded to the demand of constructing and designing high efficient scheduling algorithms in order to improve the network utilization, to increase the network throughput, and to minimize the end-to-end delay. In this paper, I have presented a brief study to measure the performance of several scheduling algorithms in WiMAX, which were Strict Priority algorithm (SP), Round-Robin (RR), Weighted Round Robin (WRR), Weighted Fair Queuing (WFQ) and Self-Clocked Fair (SCF).

Keywords
SP, RR, WRR, WFQ, SCF

1. INTRODUCTION
WiMAX stands for Worldwide Interoperability for Microwave Access. It supports both fixed and mobile wireless broadband. Various advance features of WiMAX are OFDM-based physical layer, High data rate, Adaptive modulation and coding, Multiple-antenna techniques, Quality of Service support, IP-based architecture etc. WiMAX is a wireless system that is designed for metropolitan area. Therefore, WiMAX should support Non-LOS channel, pedestrian mobility, and high data rate. The core technique of WiMAX is based on the IEEE 802.16 family standard. [1]

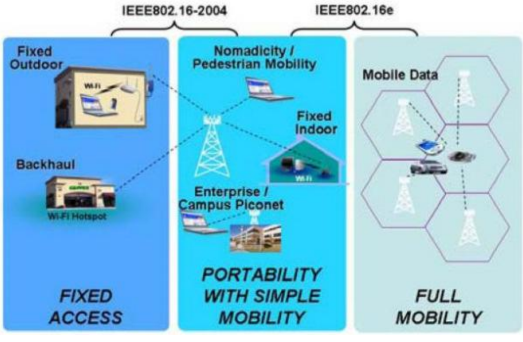

Fig 1: Working of WiMAX

From the above figure, we can roughly see how WiMAX works. First, we use 802.16-2004 to build a wireless WiMAX Line-of-Sight (LOS) backhaul. Since 802.16-2004 is a LOS version, we can support data rates up to hundreds of mega bits per second. Second, we use 802.16e to support the Non-LOS environment in the metropolitan area. The physical (PHY) layer and MAC design of WiMAX is based on the IEEE 802.16 standards. IEEE 802.16 standard has defined four PHY layers for design of broadband wireless system. They are WirelessMAN SC (original 802.16): single carrier PHY layer for 11GHz in Line of Sight (LOS) condition, WirelessMAN SCA: single carrier PHY from 2GHz to 11GHz, from point to multipoint transmission., WirelessMAN OFDM (802.16-2004): 256 point FFT OFDM PHY layer for point to multipoint in non-LOS conditions for 2GHz to 11GHz. WiMAX accepted this PHY layer for fixed transmission, known as fixed WiMAX. and WirelessMAN OFDMA: 2048 point FFT OFDMA PHY layer for point to multipoint in nonLOS conditions for 2GHz to 11GHz [2].

The rest of this paper is structured as follows. Section 2 presents the WiMAX Architecture. The various types of Quality of service (QoS) classes defined by MAC layer are included in section 3, section 4 comprises of WiMAX Scheduling and the brief review of various scheduling algorithms are presented in section 5. Finally, section 6 concludes the paper.

2. WiMAX ARCHITECTURE
WiMAX based on the standard IEEE 802.16, which consist of one Base Station (BS) and one or more Subscriber Stations (SSs), as shown in Figure 1, the BS is responsible for data transmission from SSs through two operational modes: Mesh and Point-to-multipoint (PMP), this transmission can be done through two independent channels: the Downlink Channel (from BS to SS) which is used only by the BS, and the Uplink Channel (from SS to BS) which is shared between all SSs, in Mesh mode, SS can communicate by either the BS or other SSs, in this mechanism the traffic can be routed not only by the BS but also by other SSs in the network, this means that the uplink and downlink channels are defined as traffic in both directions; to and from the BS. In the PMP mode, SSs can only communicate through the BS, which makes the provider capable of monitor the network environment to guarantee the Quality of Service QoS to the customers [4]. An essential principle of WiMAX technology is that it is connection oriented. Connection oriented means that before the SS can start to send or receive data. SS must register itself to the base station in order to initial Quality of Service (QoS) needs with the BS. Voice over IP (VOIP) is one of the important applications for WiMAX in order to support bidirectional voice conversation. Since its introduction, VoIP has been building up more and more prevalence and some services have widened their coverage [13].

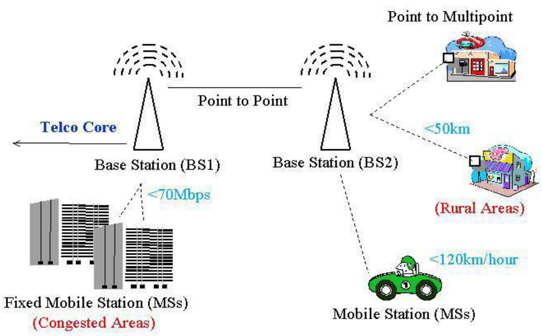

Fig 2: WiMAX Architecture

3. QUALITY OF SERVICE

QoS parameters are the classes that the BS in a network should support to be able to support a wide variety of applications. The IEEE 802.16 Medium Access Control (MAC) specifies five types of QoS classes: Unsolicited Grant Service (UGS), real-time Polling Service (rtPS), extended real-time Polling Service (ertPS), non real-time Polling Service (nrtPS), and Best Effort (BE) QoS classes and those parameters include: [5]:-

- **Unsolicited Grant Service (UGS):-**UGS is primarily intended for Constant-Bit-Rate (CBR) services such as VoIP, which means that achieving low latency and low jitter is very important latency and jitter as possible.
- **Real-Time Polling Service (rtPS):-** The Real-Time Polling Service (rtPS) on the other hand is designed to support real-time service flows that generate variable size data packets on a periodic basis, such as MPEG video.
- **Extended Real-Time Polling System:-**The ertPS is built on the efficiency of both UGS and rtPS. The BS provides unicast grants in an unsolicited manner like UGS. Whereas the UGS allocations are fixed in size, the ertPS allocations are dynamic.
- **Non-Real-Time Polling Service (nrtPS):-** This service class is intended to support non-real-time service flows that require variable size data packets, and a minimum data rate such as FTP.
- **Best Effort (BE):-**The BE service is intended to support data streams that don't require minimum guaranteed rate, and could be handled on best available basis.

4. WiMAX SCHEDULING

Scheduling is critical component of WiMAX network that impacts significantly on its performance. Scheduling schemes help in providing service guarantees to heterogeneous classes of traffic where there are a variety of different quality-of- service (QoS) requirements. Two types of scheduling schemes are supported by WiMAX i.e. uplink request/grant scheduling and downlink scheduling. The downlink scheduling scheme in the base station (BS) determines the transmission period and burst profile for every connection for downlink traffic, based on the QoS profile as well as channel/queuing related criteria.

Downlink scheduling is simpler than scheduling in the uplink direction [7]. This is because in the downlink the BS has knowledge of all queues assigned to SSs, whereas it does not have in the uplink because the links are wireless in nature with random characteristics of channel and also the BS does not have complete information of all SSs [11].

5. SCHEDULING ALGORITHMS

The WiMAX MAC layer is designed to support different types of applications and services having very different QoS requirements. The IEEE 802.16 standard does not specify the scheduling algorithm to be used. Vendors and operators have the choice among many existing scheduling techniques; they can also propose their own scheduling algorithms [6]. Many optimization criteria can be considered for scheduling algorithms such as the total maximum data rate, fairness, and operator revenue optimization. The description of some scheduling techniques is presented in the following. In this section, we present some well-known existing scheduling algorithms [3]:-

- **Strict Priority (SP):-** Strict-Priority packets are first classified by the scheduler according to the QoS class and then placed into different priority queues. It services the highest priority queue until it is empty, and then moves to the next highest priority queue. This mechanism could cause bandwidth starvation for the low priority QoS classes [8].

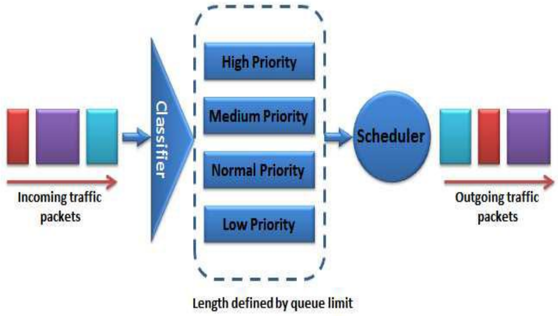

Fig 3: Strict Priority Scheduler

- **Round-Robin (RR):-**It serves each priority queue, starting with the highest priority queue that contains packets, services a single packet, and moves to the next lower priority queue that contains packets, servicing a single packet from each, until each queue with packets has been serviced once. It then starts the cycle over with the highest priority queue containing packets [8].

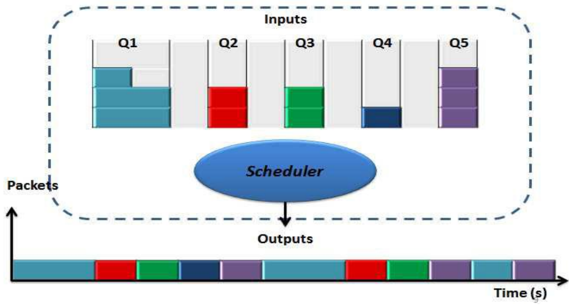

Fig 4: Round Robin Scheduler

- **Weighted Round Robin (WRR):-** Packets are first classified into various service classes and then assigned a queue that can be assigned a different percentage of bandwidth and is serviced in round robin order. WRR ensures that all service classes have access to at least some configured amount of network bandwidth to avoid bandwidth starvation. In order to provide the correct percentage of bandwidth to each class all of the packets in tall queues are of same size [9].

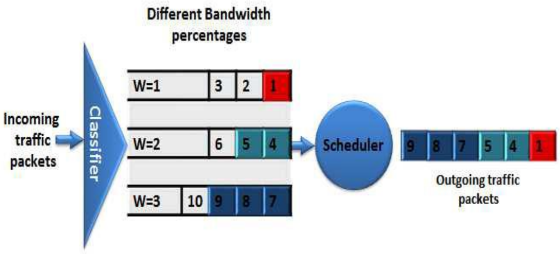

Fig 5: Weighted Round Robin Scheduler

- **Weighted Fair Queuing (WFQ):-** As shown in Figure 6, each flow are assigned different weight to has different bandwidth percentage in a way ensures preventing monopolization of the bandwidth by some flows providing a fair scheduling for different flows supporting variable-length packets by approximating the theoretical approach of the generalized processor sharing (GPS) system that calculates and assigns a finish time to each packet [10].

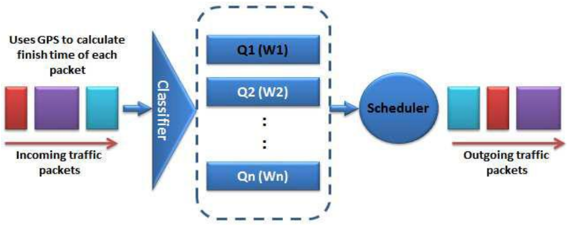

Fig 6: Weighted Fair Queuing Scheduler

- **Self-Clocked Fair (SCF) Queuing:-**SCF Scheduler generates virtual time as an index of the work progress; this time is computed internally as the packet comes to the head of the queue. The virtual time determines the order of which packets should be served next, Figure 7 illustrates the work progress of SCF scheduler.

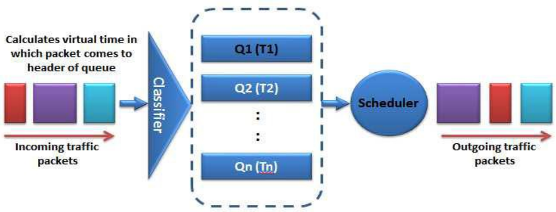

Fig 7: Self-Clocked Fair Scheduler

7. CONCLUSION

In this paper, various scheduling algorithms such as Strict Priority algorithm (SP), Round-Robin (RR), Weighted Round Robin (WRR), Weighted Fair Queuing (WFQ) and Self- Clocked Fair (SCF) have been reviewed and the working of their respective schedulers have been studied in case of data communication. It has been analyzed that the Strict Priority (SP) scheduling algorithm does not perform well as compared to other scheduling algorithms due to the reason of its bandwidth starvation.

8. REFERENCES

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