A Simple Qos Scheduler for Mobile Wimax

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***Abstract*—**WiMAX is defined as Worldwide Interoperability for Microwave Access by the WiMAX Forum, formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standard, officially known as WirelessMAN. The attractive features of WiMAX technology are very high throughput and Broadband Wireless Access over a long distance. A detailed simulation environment is demonstrated with the UGS, nrtPS and ertPS service classes for throughput, delay and packet delivery ratio for a mixed environment of fixed and mobile WiMAX. A simple mobility aspect is considered for the mobile WiMAX and the PMP mode of transmission is considered in TDD mode. The Network Simulator 2 (NS-2) is the tool which is used to simulate the WiMAX network scenario. A simple Priority Scheduler and Weighted Round Robin Schedulers are the WiMAX schedulers used in the research work

Keywords**—**ertPS, Mobile WiMAX, scheduler.

I. Overview of WiMAX

THE wimax evolved in 2001 from the IEEE standard 802.16. The fixed WiMAX emerged in the year 2004 based on the IEEE802.16d Air Interface Standard as an alternative to cable and DSL services. In December 2005, Mobile WiMAX – IEEE 802.16e technology was developed as an amendment to the 802.16 standard. The WiMAX Forum has defined the network architecture for an end-to-end Mobile WiMAX network

The Forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL".

The bandwidth and reach of WiMAX make it suitable for the following potential applications:

- *Connecting Wi-Fi hotspots* with each other and to other parts of the Internet.
- Providing a *wireless alternative* to cable and DSL for last mile (last km) broadband access.
- Providing high-speed mobile data and telecommunications services (4G).
- Providing a diverse source of Internet connectivity as part of a business continuity plan. That is, if a business has a fixed and a wireless internet connection they are unlikely to be affected by the same service outage.
- Providing *Nomadic connectivity*

A. About Mobile WiMAX (IEEE 802.16e)

IEEE 802.16e-2005 (formerly named, but still best known as, 802.16e or Mobile WiMAX) provides an improvement on the modulation schemes stipulated in the original (fixed) WiMAX standard. It allows for fixed wireless and mobile Non Line of Sight (NLOS) applications primarily by enhancing the OFDMA (Orthogonal Frequency Division Multiple Access).

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B. Key benefits of Mobile WiMAX

- Improved Air Interface
- High Data Rates
- Quality of Service (QoS)
- Scalability
- Security.
- Mobility

C. WiMAX QoS

The *WiMAX* air interface supports two modes of transmission, point-to-multipoint (PMP) and Mesh modes. In a PMP mode, a single base station (BS) serves multiple subscriber stations (SS). In a mesh mode, traffic occurs between the subscriber stations also. The Mobile *WiMAX* Standard supports Time Division Duplex (TDD) mode. In the TDD mode, the uplink and downlink data are transmitted with the same frequency. A TDD frame consists of downlink and uplink sub frames.

WiMAX communication is connection oriented. A connection is identified by a 16-bit connection identifier (CID). When the base station or the subscriber station creates a connection, it associates the connection with a service. A service flow is a unidirectional flow of packets with a particular set of **QoS** parameters. A service flow is identified by a 32-bit service flow identifier (SFID).

D. MAC Scheduling

The scheduling service in Mobile **WIMAX** MAC is designed to efficiently deliver broadband data services including voice, video and other data over changing broadband wireless channel. The MAC scheduler must efficiently allocate available resources in response to bursty data traffic and time-varying channel conditions. The scheduler is located at each base station to enable rapid response to traffic requirements and channel conditions. The

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CQICH channel provides fast channel information feedback to enable the scheduler to choose the appropriate coding and modulation for each allocation. The scheduling service is provided for both downlink and uplink traffic. The MAC supports frequency –time resource allocation on a per-frame basis. The resource allocation is delivered in MAP messages at the beginning of each frame. Therefore, the resource allocation can be changed from frame to frame in response to traffic and channel conditions. The amount of resources in each allocation can range from one slot to the whole frame. The MAC scheduler handles data transport on a connection-by-connection basis. Each connection is associated with a single scheduling service that is determined by a set of QoS parameters, as in the table I, quantifying the aspects of its behavior.

TABLE I
MOBILE WIMAX APPLICATIONS AND QOS

QoS Category	Applications	QoS Specifications
UGS Unsolicited Grant Service	VOIP	Maximum Sustained Rate Maximum Latency Tolerance Jitter Tolerance
rtPS Real-Time Polling Service	Streaming Audio or Video	Minimum Reserved Rate Maximum Sustained Rate Maximum Latency Tolerance Traffic Priority
ertPS Extended Real-Time Polling Service	Voice with Activity Detection (VoIP)	Minimum Reserved Rate Maximum Sustained Rate Maximum Latency Tolerance Traffic Priority
nrtPS Non-Real-Time Polling Service	File Transfer Protocol (FTP)	Minimum Reserved Rate Maximum Sustained Rate Traffic Priority
BE Best-Effort Service	Data Transfer, Web Browsing	Maximum Sustained Rate Traffic Priority

Each frame consists of downlink (DL) and uplink (UL) sub frames. A preamble is used for time synchronization.

The downlink map (DL-MAP) and uplink map (UL-MAP)define the burst-start time and burst-end time, modulation types and forward error control (FEC) for each MS. Frame Control Header (FCH) defines these MAP's lengths and usable subcarriers. The MS allocation is in terms of bursts Scheduling is the main component of the MAC layer that helps assure **QoS** to various service classes. The scheduler works as a distributor to allocate the resources among MSs.

In OFDMA, the smallest logical unit for bandwidth allocation is a slot. The definition of slot depends upon the direction of traffic (downlink/uplink) and subchannelization modes. For example, in PUSC modein downlink, one slot is equal to twenty four subcarriers (one sub channel) for three OFDM symbols duration. In the same mode for uplink, one slot is fourteen subcarriers (one uplink subchannel) for two OFDM symbols duration.

The mapping process from logical subchannel to multiple physical subcarriers is called a permutation. Basically there are two types of permutations:

Distributed and adjacent: The distributed subcarrier permutation is suitable for mobile users whereas adjacent permutation is for fixed (stationary) users. After the scheduler logically assigns the resource in terms of number of slots, it may also have to consider the physical allocation; the main task is to decide how to allocate the number of slots in a frame for each user.

In systems with OFDM PHY, the scheduler considers the modulation schemes for various subcarriers and decides the number of slots allocated. In systems with OFDMA PHY, the scheduler needs to take into consideration the fact that a subset of subcarriers is assigned to each user.

Scheduler designers need to consider the allocations logically and physically. Logically, the scheduler should calculate the number of slots based on **QoS** service classes. Physically, the scheduler needs to select which sub channels and time intervals are suitable for each user. There are three distinct scheduling processes: two at the BS - one for downlink and the other for uplink and one at the

MS for uplink: At the BS, packets from the upper layer are put into different queues. The DL-BS scheduler decides which queue to service and how many service data units (SDUs) should be transmitted to the MSs. Since the BS controls the access to the medium, the second scheduler - the UL-BS scheduler - makes the allocation decision based on the bandwidth requests from the MSs and the associated **QoS** parameters. Once the UL-BS grants the bandwidth for the MS, the MS scheduler decides which queues should use that allocation. The requests are per connections, the grants are per subscriber and the subscriber is free to choose the appropriate queue to service.

II. RELATED WORK

In [1], the technical aspects of the mobile WiMAX are described in detail. The WiMAX forum [2] gives the approved standards of the IEEE 802.16 for both fixed WiMAX and mobile WIMAX. In [3], Aymen Belghith and Loutfi Nuaymi explains the design and implementation of a **QoS**-included WiMAX module for NS-2 simulator. The WiMAX scheduler, which consists of a base station scheduler and a subscriber station scheduler based on the NIST module helped to understand the design methodology of a scheduler. The various steps involved in the creation of a new service flow is thoroughly explained. The scheduling of UGS, rtPS and BE is investigated for various WiMAX scheduling algorithms. In [4], Aymen Belghith and Loutfi Nuaymi analyzes the capacity estimations of WiMAX under rural and urban scenarios. In both [3] & [4], they have implemented Round Robin (RR) scheduler, maximum Signal-to-Interference (mSIR) scheduler, Weighted Round Robin (WRR) scheduler and Temporary

Removal Scheduler (TRS) schedulers. The RR scheduler equitably distributes channel resources to all the SSs. The mSIR scheduler allocates radio resources to SSs that have the highest SNR. The WRR scheduler is an extension of the RR scheduler. The TRS scheduler temporarily blocks the SSs that have the SNR smaller than the threshold. They have also combined TRS scheduler with the RR and mSIR schedulers.

In [5], Jenhui Chen, Chih-Chieh Wang along with the other researchers in their team have designed and implemented the WiMAX simulation module for NS-2. Their work is very useful in understanding the working of the WiMAX system. The class diagram of the designed WiMAX module and the diagrammatic representation of the MAC simulation architecture of IEEE 802.16 are very unique. Such an excellent and elaborate description of the base station and subscriber station is not available elsewhere in the literature. Their WiMAX module is based on the IEEE 802.16 standard with the PMP mode for the NS-2. The fundamental functions of the service-specific convergence sublayer (CS), the MAC common part sublayer (CPS), and the PHY layer are implemented in their module. They have also included a simple Call Admission Control (CAC) mechanism and the scheduler

III. Simulation Module

The developed 802.16 based *WiMAX* module named as Mac802_16 class is in accordance with the specifications of the IEEE 802.16 standard and based on the NS-2 version 2.29. The module consists of a Traffic Generating Agent (TGA), the Link Layer (LL), the interface queue (IFQ), the MAC layer and the PHY layer. The TGA generates VoIP, MPEG, FTP, HTTP and other traffics. The traffic is classified into five different types of service, the UGS, rtPS, ertPS, nrtPS and BE. Each service is assigned with the priority as mentioned in table II.

Table II
Priority Of Service Classes

Service Class	Priority Assigned
UGS	1
ertPS	2
rtPS	3
nrtPS	4
BE	2

All the packets will be transferred to different types of priority queues according to their service types with the help of CS layer SFID-CID mapping mechanism. The data packets are treated as MSDUs and allowed to pass into the *WiMAX* module in a round robin manner. The *WiMAX* module in the SS receives the MSDUs according to the scheduled time obtained from UL-MAP. The network interface will then add a propagation delay and broadcast in the air interface. The channel object used is the Wireless PHY channel.

The Call Admission Control and also the bandwidth request and grant mechanisms are taken care of by the MAC management. The scheduler () function is in charge of selecting queued MSDUs according to the admitted bandwidth. A Weighted is Round Robin scheduler is used. If all the services in priority are served, then the scheduler will serve the next priority i+1 and so on. The process will be repeated until whole available bandwidth is exhausted or remaining required services are served. A lower preferred traffic is able to obtain a bandwidth for transmission if the traffic load is heavy.

IV. Simulation Scenario

The topology of the network has a serving base station to which two fixed subscriber stations and six mobile stations are connected. The maximum topography in X & Y dimension is 400. The various stations are located initially with respect to the data provided in the table III.

Table III
Simulation Topology

Station ID	X Dimension	Y Dimension	Z Dimension
Station 0	200	200	0
Station 1	100	200	0
Station 2	129	271	0
Station 3	200	300	0
Station 4	271	271	0
Station 5	300	200	0
Station 6	271	129	0
Station 7	200	100	0
Station 8	129	129	0

As the flying aspects of the stations are not taken into account in the research work, the Z dimension is considered as 0 for all the stations. A position handler is also included in the simulation module which takes care of the tracing of the mobile nodes. The position handler keeps track of the speed with which the mobile nodes are moving and send periodical updates regarding the current location of the mobile nodes to the base station. As already mentioned earlier, a simple mobility of the mobile nodes is considered for the simulation. All the stations are attached to the base station. Three kinds of service flows, UGS, ertPS and rtPS are generated from the traffic generating agents in the SSs, MSs and the base station. The simulation model consists of six UGS traffic, five ertPS traffic and five rtPS traffic connections. The data rate of UGS traffic & ertPS traffic is 64 Kbps and that of the rtPS traffic is 1024 Kbps. The packet size is 200 for all the three traffic connections. The maximum packet size is also considered as 268435456 for all of them. The priority order of the traffic as per table 1 is scheduled in the weighted Round Robin manner.

The various other simulation parameters considered are given in table IV. The simulation is run for 10 seconds. The various results obtained are shown below.

TABLE IV
SIMULATION PARAMETERS

Channel Type	Wireless Channel
Radio Propagation Model	Two Ray Ground Propagation
Network Interface Type	WirelessPhy
MAC Type	MAC/802_16
SInterface Queue Type	Drop tail/Priority Queue
Link Layer Type	LL
Antenna Model	Omni Antenna
Maximum packet in ifq	50
Routing protocol	DSDV
Number of mobile nodes	6

V. Simulation Results

The packet delivery ratio of the three cases are plotted as in Fig 1. The packet delivery ratio of the channel is *chpdr*. He desired rate of the packet delivery *drpdr* is initially very high and decreases and then linearly increases. The packet delivery of the new proposed algorithm is *nrpdr* which also initially increases and decreases and then gradually increases.

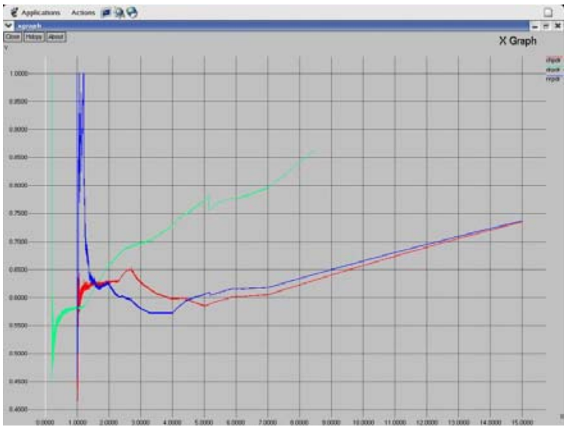

Fig. 1 Packet Delivery Ratio

The delay involved in the channel is *chdel*. The desired delay is *drdel*. The delay due to the new algorithm is *nrdel* which is very lesser than the desired rate of delay which is very evident from the graph in Fig. 2.

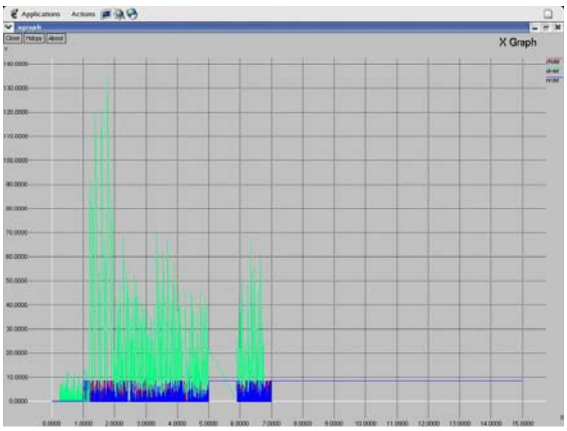

Fig. 2 Delay

The throughput that could be achieved in all the three cases are plotted as in Fig 3. The maximum throughput of 1.45 Mbps which is represented as *nrthr* is achieved for the new algorithm proposed. The maximum channel throughput, *chthr* is 1.3 Mbps. The desired maximum throughpu, *drthr* is only 1.3 Mbps.

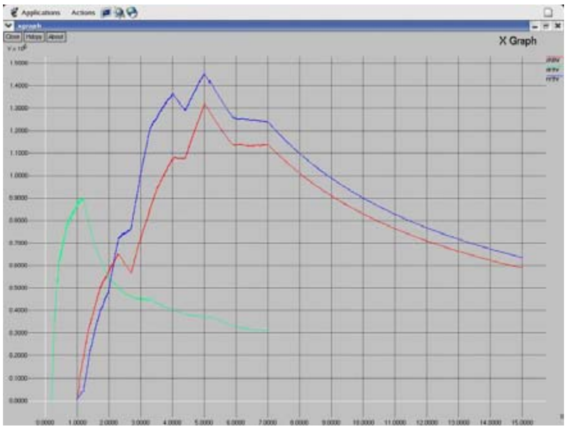

Fig. 3 Throughput

VI. Conclusion

The WiMAX simulation module includes a basic point-to-multipoint (PMP) IEEE 802.16 function, a simulation scenario of mixed connectivity of fixed and simple mobile WiMAX environment. The three different traffic service connections such as UGS, ertPS and nrtPS are considered. The detailed simulation environment is demonstrated. The simulation results of the packet delivery ratio, delay and throughput are analyzed in detail for the three different connections. The peropoded algorithm is efficient as the throughput achieved is very high and the delay involved is very less.

For future work, the simulation environment will be modified. All the five different service classes will be considered. The full mobility aspects of the Mobile WiMAX will be considered alongwith Hand Over techniques.

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