International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 8 5229 - 5234

WiMAX Scheduling Algorithm Key Issue and Design Challenges: Survey

Abhay Pandey
Department of Electronics and Communication Engg.
Ujjain Engineering College, Ujjain, India
ap.311pandey@gmail.com

Bhavana Jharia
Department of Electronics and Communication Engg.
Ujjain Engineering College, Ujjain, India
bhavanajharia@yahoo.co.in

Abstract **-** In recent time to satisfy the growing demand of broadband wireless access by using scare Resource of bandwidth is a biggest challenge for Researchers, in this time WiMAX (Worldwide Interopretability for Microwave Access) emerged as a better solution to fulfill that demand. WiMAX provides faster internet connectivity in Urban Areas as well as remote areas also where to deploy the DSL (Digital Subscriber Line) or other wired technology is difficult task. WiMAX structure is based on IEEE 802.16 OSI standard and defines the PMP (Point to Multipoint) and Mesh modes for transmission of information. To provide authentic services for voice, data and videos WiMAX define the various QoS parameters at Media Access Control (MAC) layer. In order to meet the QoS requirement Novel scheduling approach are required. In these papers efforts are made to examine and compare the various scheduling algorithm and its design challenges to implement the effective scheduling algorithm. It also discusses the various QoS parameters associated with scheduling approaches.

Keywords—*WiMAX; QoS; SCHEDULING; MAC; IEEE 802.16*

****

I. INTRODUCTION

WiMAX (World Wide Interpretability for Microwave Access) is most prominent choice for Broadband Wireless Access (BWA) in metropolitan Area because of its unique qualities like effective recourses utilization, scalable OFDMA, MIMO antenna technology and Adaptive modulation and coding (AMC)[3].it is a better alternative approach against DSL (Digital Subscriber Line) and cable modem. The IEE 802.16 is a standard that defines the various family of broadband wireless radio interface. Theoretically, a WiMAX base station can provide broadband wireless access in range upto30 miles(50kms) for fixed stations and 3 to 10 miles (5 to 15 kms) for mobile station with a maximum data rate up to 70 mbps as compare to IEEE 802.11a with 54 Mbps up to several hundred meters[4]. WiMAX technology defines the layer 1 as physical layer and layer2 is defined as MAC (medium access control layer) of OSI's seven layer model. In broadways main purpose of WiMAX technology to provide fast and reliable internet connectivity among huge number of subscribers with limited existing bandwidth and to accomplished that work the effective utilization of radio resources are required .the scheduling algorithm is one of the way not only efficient utilization of radio resources but also satisfied the QoS requirements.

This paper is focusing on various scheduling approaches their comparison based on various parameters and its Design issues. The paper are organized as follows section II gives brief introduction of WiMAX architecture .section III and IV covers the related previous research works and definition of QoS parameters respectively. Section V covers the various QoS classes while in VI and VII we describe the scheduling algorithm and its design challenges, finally conclusion are presented.

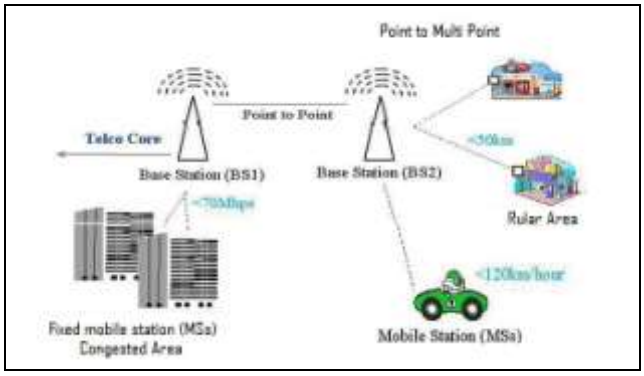

Fig 1: WiMAX Deployment Scenario

II. WiMAX ARCHITECTURE

A basic WiMAX architecture consist of at least one base station and one or more subscriber set (SS) or mobile stations (MS).The WiMAX is an example of connection oriented technology and to established the connection between SS and BS, SS first scan the downlink channel for its availability and perform the registration process after Successful registration only registered SS can communicate with base station. The BS always used the Downlink Channel (BS to SS) for broadcasting the message to all registered SS. Allotment of bandwidth and other resources to SS is based on various factors like priority and requirement of application. Fig 1 shows the basic deployment of WiMAX technology. IEEE 802.16 standard supports the two modes or topology for communication: PMP (point to multipoint) and mesh topology, PMP is a centralized topology in which the BS is center unit and all traffic is routed only through the BS to SS, while in mesh topology the two SS can communicate with each other and other SS also without involving the BS. Generally for deployment of WiMAX network PMP mode are recommended as compare to mesh topology

2.1 Layered Architecture

The IEEE 802.16 architecture supports 7 layer OSI layer model. the protocol architecture layer are shown in Fig 2 it can be seen that the IEEE 802.16 define the lowest two layer physical layer as layer 1 and the MAC layer (layer 2).The physical layer is responsible for connection between two communication devices, while the MAC layer are responsible for establishment and maintenance of the connection. One of the operating band profile for WiMAX is 3.5 GHz with subcarrier spacing of 10.94 KHz allowing 128,512,1024 and 2048 FFT size with channel bandwidth of 1.25 MHz,5MHz ,10 MHz and 20 MHz respectively[5].the transmission and reception between BS and SS is based on OFDMA(Orthogonal Frequency Division Multiplexing).
MAC layer are responsible for resources management and scheduling among multiple SS.MAC layer is also subdivided in three layers called convergence sub layer, common part sub layer and the security sub layer.

Convergence layer control the communication with upper layer and rearrange it according to lower layer supported packet format, it also performs the basic function of QoS management, common part sub layer perform basic functioning of MAC layer such as allotment of bandwidth, connection establishment and maintenance of the connection between the both sides while the security sub layer assure the secure connection between two devices by using authentication, encryption ,secure keys, and integrity control across BWA.

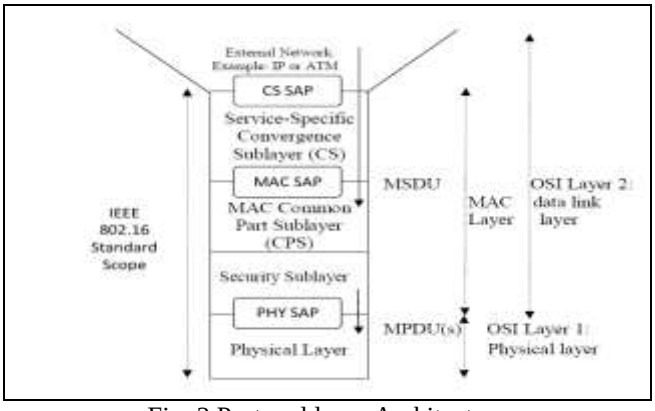

Fig: 2 Protocol layer Architecture

2.2 Simulator Tools

NS-2(Network Simulator) plays a vital role in area of research of WiMAX technology. NS-2 is freely available software tools and Scalability and reliable implementation of parameters are some unique qualities of it However installing NS-2, execution of simulation and analysis the result may not be a easy task [6].OPNET is a another simulating tools which are extensively used for WiMAX analysis. OPNET is an example of commercial simulating software that means they would not provide free installation, any sources code and related packages to the general users for free. All the users have to pay for getting license. It is easier to design and implement communication networks, devices, protocols, and applications as compare to other tools. As a commercial service provider OPNET provides relatively more authentic graphical tools and visual analysis of various parameters for users. The OPNET consist of graphical editor which is used to implement network topology and entities from the application layer to the physical layer. Object-oriented programming technique is used to mapp graphical design to the implementation of the real systems. QualNet is also one of the powerful simulating tools to implement and analysis of WiMAX ,it is an example commercial simulating software.

QualNet provides a better platform for designing protocols, creating and animating network scenarios, and analyzing their performance. As above discussed tools are the simulating tools that are generally used to simulate and analysis the WiMAX environment while the choice of simulation tools are based on many factor such as module, algorithm, protocol which we want to use and modified it must be supported, programming language in which we want to write the code that also be compatible to it, Speed of execution, memory and CPU consumption is also a parameters that also affect the choice of simulating tools.

III. PREVIOUS RESEARCH

There are several research had been made to design the efficient scheduling algorithm to satisfy the various QoS some of them are listed below.

In [2] the authors represented the simple Bandwidth scheduling algorithm to meet the QoS requirements they proposed the uplink scheduling model. In [7] researchers proposed priority based fair scheduling in which the traffic control for subscriber set is based on priority of QoS service class and specially stress are given to analysis oflatency parameter. In [9] the author came with new concept of urgency index (UI) as the system parameter to monitor different traffic services, UI is a system variable which reflects the urgency of bandwidth need for specific service flow. In [3] the researchers provided in depth study various scheduling algorithm and compare them at various QoS parameter. In [5] author proposed a traffic aware scheduling algorithm for VoIP application and compares this algorithm with other conventional methods. In paper [10] presents an estimation of Quality of Experience (QoE) matrices based on Quality of Service (QoS) matrix in WiMAX networks. In [11] author proposed wireless fair intelligent congestion control scheme to avoid the congestion and evaluate its performance on various QoS parameter. In [14] the researchers proposed the persistent scheduling for VoIP to minimize the overhead to increase the VoIP capacity. In [13] the author proposed the scheduling algorithm to provide QoE and improve performance by controlling the transmission rate of packet until minimum transmission rate for particular link. In [15] paper focused on a different scheduling approaches which quit fair not only among the user as well as among the service flow. In this paper researchers proposed QoE based scheduling for two different service flow classes Unsolicited Grant service (UGS) and Real time polling service.

IV. QoS PARAMETERS

QoS (Quality of Service) is an assurance of successfully delivery of data streams from source to destination but this assurance cannot exceed the physical limitation of physical media. QoS parameter is an index that helps to decide the performance of wireless networks. QoS parameter also helps to decide which service application having the higher priority than others which are competing for limiting bandwidth spectrum. the following QoS parameters are explained below

4.1 Throughput:-It is defined by the average rate of successfully delivered packet over a communication network. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is generally calculated in (bit/s or bps), and sometimes in data packets per second or data packets per time slot. Equation1 shows the mathematical formula for throughput calculation where Packet $Size_i$ represent the i_{th} packet reaching the destination while PA_n stands for time when first packet left the sources and PS_o stands for time when last packet arrived at destination.

$$TP = \frac{\sum_i \text{Packet Size}_i}{PA_n - PS_o}$$

Equation 1: Throughput Calculation

4.2 Average Delay or Latency: - Delay or Latency is the time required to travel the packet from sources to destination. Its calculation is the combination of all types of delay such as propagation delay, processing delay and queuing delay. Equation 2 shows the delay calculation where PA_i is the time when i_{th} packet reach the destination while PS_i is the time when i_{th} packet left the sources ,n is the no. of packets under consideration.

$$TP = \frac{\sum_i PA_i - PS_i}{n}$$

Equation 2: Average Delay or Latency

4.3 Jitter or Delay variation: - This parameter defines the variation in delay to arrival of different packets from sources to destination. Generally this parameter shows the stability and consistency of the channel or Network.

4.4 Traffic priority:- The is the distinct value which depends upon priority of service flow Given two service flow identical in all QoS parameters beside priority, the higher priority services should be given lower delay and higher buffering preference.

4.5 Maximum sustained traffic rate:- This parameters describe maximum information rate supported by particular service ,the rate is expressed in bits per second.

4.6 Minimum reserved traffic rate: - This parameter describe the minimum data rate required for service. The rate is expressed in bits per second and specifies the minimum amount of data to be transported in given averaged time.

4.7 Maximum latency:-The value of this parameter defines the maximum latency between the reception of packet by the BS or SS on its network interface and forwarding of the packet to its RF interface.

4.8 Request/transmission policy:-The value of this parameter provides the capability to specify certain attributes for the associated service flow. This attributes include option for PDU formation and for uplink service flow, restriction on types of bandwidth request option that may be used.

V. QoS SERVICE CLASSES

In WiMAX technology each application having its own QoS parameter constraints according to that IEEE 802.16 defines five service classes. This service class helps the BS scheduler to allocate the resource bandwidth on the basis of priority and its requirement. Brief introduction of service classes and its comparison are given below:

5.1 Unsolicited Grant Service (UGS):- The UGS service type is design to support real time data traffic consisting of fixed size of data packet transfer at constant interval. Maximum sustained traffic; Maximum Latency and tolerated delay are some of the QoS requirement for UGS.UGS supports the constant bit rate application such as T1/E1 circuit and VoIP without suppression of silence in it

5.2 Extended Real Time polling service (ertPS):- This service class consist of all features of UGS except bandwidth allocation, in ertPS bandwidth are allocated dynamically while in UGS it is in static. This service are implemented to support VoIP with suppression of silence time in that bandwidth is allocated only when voice is sent over the channel while at the time of silence there are no bandwidth are assigned.

5.3 Real time polling service (rtPS):- The rtPS supports the real-time application which demands packet transfer at periodic intervals. The demand of bandwidth are varying in this service class so it supports the dynamic bandwidth allocation The rtPS is similar to UGS service class but Maximum sustained traffic and minimum reserved service rate QoS parameter is considered additionally. It can support MPEG (Moving Picture Expert Group) applications for which variable size data packet are transferred.

5.4 Non Real time polling service (nrtPS):- The nrtPS compatible for the application for which minimum data rate are required. It also supports the application which is delay tolerated File transfer protocol (FTP) is one of the applications which are based on this service class.

5.5 Best Efforts (BE):- The BE service is designed to support the application for which no service guarantee are required .The bandwidth is allocate the MS if and only if the other class is not using the bandwidth. To transfer the mail from sender to recipient is typical example of this service

class which required no QoS guarantee except the reliable delivery of massage.

TABLE I - COMPARISION OF WiMAX QoS SERVICE CLASSES [1]

QoS	Pros	Cons
UGS	No overhead, meet guaranteed latency for real time service.	Bandwidth may not be utilized fully since allocations are granted regardless of current need.
ertPS	Optimal latency and overhead efficiency	Need to use the polling mechanism (to meet the delay guarantee) and a mechanism to let the BS know when the traffic starts during the silent period.
rtPS	Optimal data transport efficiency	Require the overhead of bandwidth request and the polling latency (to meet the delay guarantee)
nrtPS	Provide efficient service for non real time traffic with minimum reserved rate.	Not Applicable
BE	Provide efficient service for BE traffic.	No service guarantee; some connection may starve for long period of time.

VI. SCHEDULERS

Scheduler is an essential component of WiMAX technology to decide the priority and management of the expensive resources like bandwidth for any WlMAX applications. In this section we proposed the classification and various types of schedulers and the algorithm for its implementation. The classification of scheduler are shown in Fig3

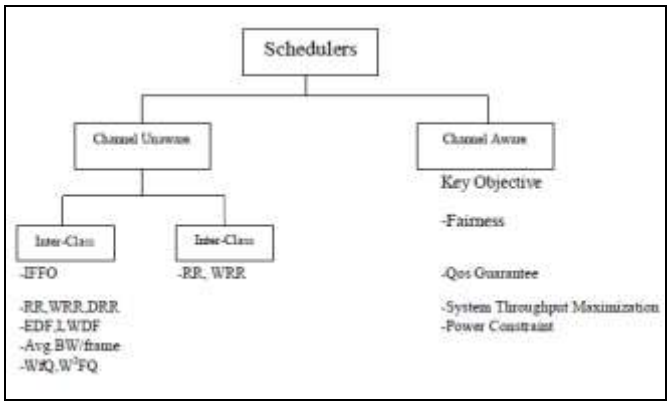

Fig: 3 Classifications of WiMAX Schedulers

The schedulers are broadly categorized as channel aware and channel non aware type which is based on knowledge of channel. The description of these is given below.

6.1 Channel Unaware schedulers

Generally the design of channel unaware schedulers based on assumption that channel are error free , it doesn't utilized the information of channel condition such as power level in such type of schedulers it is easier to prove the assurance of QoS.

6.1.1 Inter-class scheduling: In inter class scheduling algorithm the resources are distributed according to the priority of service class. In this scheduling algorithm each service class consider separately and each having its own queue. The real time traffic normally assign the higher priority than non real time traffic so according to that the priority order of service class from highest to lowest are UGS, ertPS, rtPS, and BE, Apart from that one Downlink connection always having the higher priority Uplink connection.

a. Round Robin Scheduling (RR):- The RR is most common used scheduling algorithm because it designed in such a manner that each user having the equal opportunity. In RR scheduling each priority queue starting from the highest priority are serve first that contain the packets and transmitting the single packet and then switch to next lower priority queue and again serve the single packet this process is continue until the each queue with single packet have serviced once. Then it again same process is repeated starts from the higher priority queues.

b. Weighted Round Robin (WRR):- weighted round robin scheduling is very similar to RR scheduling but it assign weights to each packet of queue. Queue length and packet delay or no of slots are the parameter which decides this weights. The assigned weights are changed dynamically according to the requirement. The main advantage of WRR is its simplicity to its implementation.

6.1.2 Intra-class scheduling: -
In this type of scheduling resources are allocated within the same service classes given the QoS requirement.

a) Earliest Deadline first(EDF):-. EDF algorithm are mostly Implemented for Wide area network and specially real time application. As it name suggested this algorithm assign the deadline to each packet and assign the highest priority for the packet having earliest deadline. In this algorithm priority are decided according to the delay parameter, the packet having least delay is considered as highest priority .Generally the UGS and rtPS service class uses this algorithm. Those SS belonging to nrtPS service doesn't consider delay as a parameter, The EDF will serve this type of packet at last or if there are no packets are available for UGS or rtPS service class.

b) Weighted Fair Queuing (WFQ):-Many scheduling algorithm each having single queue but it is not practical to have single queue for each conversation. In WFQ algorithm traffic is divided in to the limited no of queue. When packet comes in classifier it assign one of the queue and which queue is served first is decided by the WRR.WFQ can be designed to serve bit by bit.

c) Deficit Round Robin (DRR):- In DRR, Each connection is assigned a state variable called deficit counter. The value of deficit counter is increased when active connection has its turn. When the value of targeted packet value is smaller or equal the deficit counter the packet is transmitted and the counter is decreases by packet size. The packet are continuously transmitting as long as deficit counter allows if the value of targeted packet is small is longer the deficit counter then we moves to next active connections.

d) Proportional Fair (PF) :- proportional fair algorithm are given to more preference then DRR scheduling algorithm where higher throughput are required because the PF scheduler gives the higher priority to those active connection having best ratio of current achievable rate to average rate. In every frame transfer PF scheduler follows the same order and repeat the following sequence until the all frame are not served. R(t) is current achievable rate which is no. of bytes that can be sent in a single slot ,It is determined by the current modulation and coding schemes (MCS) while the T(t) is called average rate.

Table 2: comparative study of algorithms [3]

Algorithm	Advantage	Disadvantage
Round Robin (RR)	Simplest algorithm, designed for time sharing systems	It cannot guarantee different QoS requirement for each queue.
Weighted Round Robin (WRR)	WRR is based on RR but it take into account processing capacity of each queue.	WRR will not provide good performance in case of variable packet.
Earliest Deadline First(EDF)	Based on delay factor, good choice for UGS and rtPS services	It is not good option for nrtPS service.
Weighted Fair Queue(WFQ)	It performs better as compare to WRR in presence of variable data packet	It will service packets even if they would not have started service, because it doesn't consider start time of packet.
Proportional Fair (PF)	Simple implementation multi user diversity gain.	No QoS guarantee.

6.2 Channel Aware scheduling:- The above all scheduling algorithm we didn't consider the channel parameters such as losses attenuation etc and consider the channel are loss less ,But many times this parameter can plays a vital role in successfully transmission of data. the channel aware scheduling can be classified into four classes based on objective: fairness, QoS guarantee, system throughput maximization or power optimization.

VII. DESIGN CHALLENGES

To design the efficient scheduling algorithm the many design issue is need to take care by the researchers first one are fairness, designed algorithm having the fairness to allocate the bandwidth and each and every packet is need to transfer at least once. Most of the scheduling algorithm is channel unaware types in that always consider the cannel is lossless but most of the practical channel is lossy. The third are implementation complexity, the algorithm should have the less complex the algorithm so that it can be implemented and modification could be done easily. The fourth and last one compatibility, Implemented algorithm must be compatible with previous scheduling algorithm so that new algorithm can be implemented in older or existing system.

VIII. CONCLUSIONS

In this paper we presented the various scheduling algorithm and their QoS requirements, this algorithm can be implemented in BS or SS. Algorithm comparison based on various aspects of designing so that it help implemented the new scheduling algorithm. The efforts are also made to provide extensive survey on different scheduling classes and their comparison it help to decide which QoS parameter are need to take care for particular service classes. Our future Work will be to implement one of the algorithm and suggestion for improvement their performance on the basis of latency, throughput and other QoS parameter. We will also provide the efforts to compare various types of algorithm for any of the scheduling class on the basis various QoS Parameter.

REFERENCES

[1] Loutfi Nuyami ,*WiMAX Technology for BroadBand Access*,3rd ed. Wiley,2007
[2] Chakchai So-In and Abdel -karim Tamimi "Scheduling in IEEE 802.16e Mobile WiMAX Networks :key issue and survey"*IEEE journals in selected area in Communication Febuary 2009*
[3] Brijesh Kumar and Pooja Gupta "Scheduling algorithm in WiMAX Networks"*Second IEEE conference pp-461 to 468 2012*
[4] Wei Wang and Hamid Sharif "Implementation and performance Evaluation of QoS Scheduling in Mobile WiMAX NS-simulator" *IEEE Conference Aug 2010*
[5] Ehsan Haghani and Nirwan Ansari " VoIP Traffic Scheduling in WiMAX Network" IEEE Conference pp1-5 Aug 2008
[6] Barun Kumar Saha and Sudip Misra "A Web –Based Integrated Environment for simulation and Analysis with NS-2" IEEE Wireless communication pp 109-115 Aug 2013
[7] Yang Wang and Sammy Chan "Priority based Fair Scheduling for Multimedia WiMAX Uplink Traffic"IEEE Confernce pp 301-305 Sep 2008
[8] Kalpaltha Shankarsubramaniam and Srikant Shubramanium " A Performance of Uplink Scheduling in WiMAX Network" IEEE Conference pp 377-382 Sep 2012.
[9] Maode Ma and Sanjay Kumar Bose " An Efficent Scheduling Algorithm for QoS Provisioning in WiMAX Networks" IEEE Conference Aug 2008

[10] Victor A. machado and Nandamudi L.Vijaykumar " A New Proposal to provide Estimation of QoS and QoE over WiMAX Networks" IEEE Conference January 2011
[11] Saruchi Singla and Maninder Sing Kamboj " Analysis of Packet Scheduling in WiMAX Network" International conference on Recent advance and future trends in IT pp13 -17 2012
[12] Fatima Furqan and Doan B.Hoang "wireless Fair and Intelligent Congestion Control –A QoS performance evaluation".13th International conference on parallel and distributed computing pp3-9 Jan 2012
[13] Tarik ANOUARI and Abdelkarim HAQIQ " Improved QoE Based Scheduling algorithm in WiMAX Networks".IEEE Conference July 2014
[14] Shweta Shrivastava and Rath Vannithamby "Performance Analysis of Persistent Scheduling for VoIP in WiMAX Networks" IEEE Conference March 2009
[15] Lishui Chen and Qing Guo "A Multi Round Resources Allocation Scheme for OFDMA-Based WiMAX based on Multiple service Classes" IEEE Conference pp 260-264 feb 2014