International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 1, Issue 9, ISSN No. 2455-2143, Pages 162-168
Published Online July – August 2016 in IJEAST (http://www.ijeast.com)

STUDY OF DIFFERENT WIMAX QOS SCHEDULING ALGORITHMS

Alka Yadav
M.tech. student in Electronics and Communication Department,
St. Margaret Engineering College,
Neemrana, Rajasthan, India

Vinit Chauhan
Assistant Professor, Electronics and Communication Department,
St. Margaret Engineering College,
Neemrana, Rajasthan, India

***Abstract*-This paper is only based on the study of different WiMAX Qos Scheduling algorithms. In this Qos parameters Unsolicited Grant Scheme (UGS), Extended Real Time Polling Service (ertPS), Real Time Polling Service (rtPS), Non Real Time Polling Service (nrtPS) and Best Effort Service (BE). Each of these has its own QoS parameters such as minimum throughput requirement and delay/jitter constraints are discussed. Scheduling algorithms study is also done in this paper.**

Keywords- Qos (Quality of services), Scheduling algorithms

I. INTRODUCTION

IEEE 802.16 defines five QoS service classes: Unsolicited Grant Scheme (UGS), Extended Real Time Polling Service (ertPS), Real Time Polling Service (rtPS), Non Real Time Polling Service (nrtPS) and Best Effort Service (BE). Each of these has its own QoS parameters such as minimum throughput requirement and delay/jitter constraints [2]. The WiMAX has the following Quality of Services [1]-

A. Unsolicited grant services (UGS)

This class of service is used to support the fixed-sized data packets at a constant bit rate (CBR) such as E1/T1 lines. It can sustain real-time data stream applications. This provides guaranteed throughput, latency and jitter to the some necessary levels as TDM services. UGS is used to support Constant Bit Rate (CBR) services which are found in voice applications such as voice over IP [1].

B. Real-time Polling Services (rtPS)

This class of service is used to support real-time service flow which generates a variable-sized data packet on a periodic interval with a guaranteed minimum rate and guaranteed delay. The compulsory services that are defined in this service are the inclusive of minimum reserved traffic rate, maximum latency, maximum sustained traffic rate, and request / transmission policy. The rtPS is used extensively in MPEG video conferencing and streaming [1].

C. Non-real-time Polling Service (nrtPS)

This class of service is used for non-real-time traffic with no delay guaranteed. The delay tolerant data stream consists of variable-sized data packets. The applications which are supported by this service are time-insensitive and require a minimum amount of bandwidth. This service is suitable for the critical data application like in the File Transfer Protocol (FTP) [1].

D. 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 defined in IEEE 802.16e- 2005. During the silent periods, there is no traffic in network and no bandwidth is allocated. So there is a need to have a BS poll during the MS to find out the end of the silent periods. The ertPS is featured in VoIP with silence suppression [1].

E. Best-Effort Services (BE)

This class of service provides the support for data streams in which no minimum service-level guarantee is required. The compulsory service flow parameters that define this service include maximum sustained traffic rate, traffic priority and request / transmission policy. BE service supports

International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 1, Issue 9, ISSN No. 2455-2143, Pages 162-168
Published Online July – August 2016 in IJEAST (http://www.ijeast.com)

data streams that found in Hypertext Transport Protocol (HTTP) and electronic mail (e-mail) [1].

1. Scheduling

The scheduling class services in wireless networks includes priority scheduling and queuing for bandwidth allocation based on traffic scheduling algorithms within wireless networks. The scheduling algorithm is still an undefined area, designing an efficient scheduling algorithm that can provide high throughput with minimum delay is definitely a challenging task for system developers [1]. To improve the scheduling in WiMAX, many research papers written by different authors have been reviewed which had been published in different journals. The review/survey has been carried out various researches on WiMAX which supported to go in the correct direction to select the proposed work to do research.

2. *Literature review on Different Scheduling Approaches*

D. David Neels et al. proposed a novel Priority based Scheduling scheme that uses the Artificial Intelligence for supporting the various services by considering the QoS constraint of each class. Authors performed the simulation study to evaluate the throughput and fairness performance of the already implemented Round Robin (RR), Max CINR (MC), Fair Throughput (FT), Proportional Fair (PF) and proposed NFPS scheduling algorithms. The results show that slow mobility does not affect the performances and faster mobility and the increment in users beyond a particular load have their say in defining average throughput, average per user throughput, fairness index, average end to end delay and average delay jitter. The proposed scheme provides QoS support for each class efficiently [6].

Ali Heidari Khoei et al. performed a detailed simulation to examine the efficiency of the main scheduling algorithms as FIFO, WFQ, PQ and MDRR and the performance of each scheduler is evaluated to support the various classes of quality of service and various applications. The appropriate selection of scheduling algorithm can improve the required quality of service for different traffic types of users. The best scheduling algorithm in this evaluation is determined based on the throughput, minimum jitter, and maximum received traffic for each servicing class and specific Application [9].

Gaurav Sharma et al. investigate the performances of the MPEG-4 High quality video traffic in the WiMAX network by using various service classes. To analyze the QoS parameters, the WiMAX module developed using the popular network simulator NS-3. Various parameters that determine QoS of real life usage scenarios and traffic flows of applications is analyzed. The objective is to compare different types of service classes with respect to the QoS parameters, such as, throughput, packet loss, average delay and average jitter.

The performance analysis of the different service flows BE, nrtPS, rtPS and UGS, on QoS parameters like throughput, packet loss, average delay and average jitter was analyzed and compared when the video traffic is passed in traffic with increasing number of nodes over WiMAX network. During the analysis rtPS service flow comes out to be better than all other three service flow for average jitter and packet loss. The variation in value of the average jitter is very less in case of rtPS service flow and it has least jitter value for maximum number of nodes i.e. 10 than all other service flows. In case of average delay the value for rtPS service flow is high than the BE and nrtPS service flow but there is very slight variation in value with increasing number of nodes which increases rapidly in case of other two. The delay is maximum in UGS service flow for video traffic as it is VBR traffic. rtPS service flows shows the least packet loss while streaming video traffic with increased number of nodes and throughput is much higher as compared to BE and nrtPS service flow and is nearly equal to UGS service flow with increased number of nodes. As the UGS service flow does not utilize the network resources effectively when the traffic is not Constant Bit Rate (CBR) traffic and streaming video traffic is Variable Bit Rate (VBR) traffic. The bandwidth can be periodically requested in the rtPS service flow instead of fixed bandwidth already being allocated, which may or may not get used. Authors concluded that for streaming video traffic rtPS service flow is best suited.

Avinash Kaur et al. evaluated and compared various existing algorithms. A new bandwidth allocation scheduling algorithm is proposed by the authors for the IEEE 802.16 WiMAX protocol in order to improve the Quality of Service (QoS). The centralized bandwidth allocation scheduling algorithm does not require any explicit information from the sender for bandwidth allocation. It estimates and measures the current sending and receiving rate of each flow of information between different nodes of a network. The amount of bandwidth allocated to different services is defined that identifies the priority of these services. The compensation mechanisms for bandwidth allocation techniques are adopted according to QoS needs for identifying bandwidth allocation on different nodes. Different parameters like packet delay, limitation of data, packet loss, network throughput, load balancing on various nodes and QoS of the network are quantitatively measured and improved.

International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 1, Issue 9, ISSN No. 2455-2143, Pages 162-168
Published Online July – August 2016 in IJEAST (http://www.ijeast.com)

3. Taxonomy of Scheduling Algorithm

Scheduling algorithms are implemented at both the BS and SSs. A scheduling algorithm for the uplink traffic is faces different challenges that are not faced by an algorithm for the downlink traffic. An uplink scheduling algorithm does not have all the information about the SSs such as the queue size. An uplink algorithm at the BS side has to coordinate its decision with all the SSs in the network where as a downlink algorithm is only concerned in communicating the decision locally to the BS. The scheduling algorithms in WiMAX are classified into three categories:

a. Homogenous scheduling algorithm
b. Hybrid scheduling algorithm
c. Opportunistic scheduling algorithm

The Homogenous scheduling algorithms are individual algorithms which are designed and implemented. Algorithms in this category do not address the issue of link channel quality.

The Hybrid scheduling algorithms are designed with two or more homogenous schedulers to form a hybrid scheduler and these scheduling algorithms in an attempt to satisfy the QoS requirements of the four scheduling services. An important aspect of algorithms in this category is the overall allocation of bandwidth among the scheduling services.

The Opportunistic scheduling algorithms mainly focus on exploiting the variability in channel conditions in WiMAX.

a. Homogenous schedulers

(i) Weighted Round Robin (WRR)

WRR is a homogenous scheduling algorithm and its complexity is O (1). In WRR procedure, packets are categorized into different service classes. Then packets are assigned to a queue that can be assigned different percentage of bandwidth and served based on Round Robin order this algorithm address the problem of starvation by guarantees that all service classes have the ability to access at least some configured amount of network bandwidth.

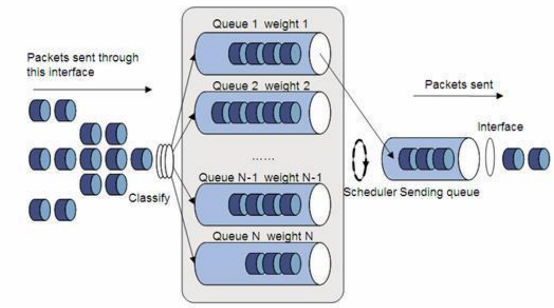

Fig.1 WRR Scheduling Algorithm

WRR algorithm indicates the low average throughput of ertPS SSs. Very high average delay for the ertPS class except when the concentration of ertPS SSs is the highest and poor performance when the packet size of the traffic is large. This behaviour is indicated by the low average throughput of rtPS and nrtPS SSs, even under high concentration of rtPS and nrtPS SSs. For the rtPS QoS class the WRR always maintains almost high fairness, because some real time packets rtVR connections are dropped under high burstiness and thus the throughput of rtVR decreases. WRR does perform well compared to the WFQ in queue management and resource utilization since it always maintains almost high fairness. The delay for the two real-time classes (UGS & rtPS) increases with time until exceeding the maximum delay limitation as required by their QoS latency parameters. WRR outperformed the rest scheduling algorithms by producing the highest rate of throughput of data packet in the network. WRR technique shows the most favourable results as the average jitter has low reading. WRR is very useful algorithm for which the scheduler uses it only for one time. But when the case of hierarchy of WRR then it is challenging task to use because the peer-connection QoS requirements must be translated into scheduler at each level and when the network is dynamic, buffer length & trade-off between the throughput and queue delay is difficult to control.

(ii) Weighted Fair Queuing (WFQ)

It is a homogenous scheduling algorithm and its complexity is O (N). Weighted Fair Queuing 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. WFQ algorithm indicates the low average throughput of ertPS SSs. When the concentration of SSs of the nrtPS class is high, the fairness among SSs of the ertPS class under the WFQ algorithm is the lowest. WFQ allocates bandwidth to the SSs. This algorithm indicates a high average delay for the ertPS SSs when their concentration is low. The increase in average delay of SSs results in an increase in packet loss, although the relationship between average delay and packet loss is not as explicit it may result in a decrease in the average delay.

This is because the average delay does not include the delay of dropped packets. Proposes a scheduler uses WFQ as the downlink as well as the uplink scheduling algorithm. WFQ does not perform well compared to WRR and RR in queue management and resource utilization. It achieves the same amount of end-to-end delay time for the class BE and nrtPS. BE achieves the shortest amount of end-to end delay time for the Diff-Serve, WRR, SP. The WFQ algorithm results in superior performance compared to the WRR algorithm in the presence of variable size packets.

(iii) Round Robin (RR)

The Round Robin as a scheduling algorithm is the most basic and least complex scheduling algorithm. It has a complexity value of O (1). RR is the best scheduling algorithms with queue management and resource utilization than any other scheduling algorithms like WFQ, WRR, DS etc. It dominated other algorithms when the number of MSs became more than 50 and the most efficient in terms of overall throughput 125Kbps.

RR algorithm was the best in terms of packet latency. The RR technique shows most favourable results as the average jitter has low reading. The RR scheduler provide a better sojourn time while delivering fewer data packets but it is not performed in case of the real time streaming video.

(iv) Earliest deadline first (EDF)

It is a work conserving algorithm which was originally proposed for the real-time applications in wide area networks and its complexity is O (N). The algorithm assigns deadline to each packet and allocates bandwidth to the SS that has the packet with the earliest deadline. Deadlines can be assigned to packets of a SS based on the SS's maximum delay requirement. The EDF algorithm is more suitable for SSs belonging to the UGS and rtVR scheduling services, SSs in this class have stringent delay requirements. SSs belonging to the nrtVR service do not have a delay requirement; the EDF algorithm will schedule packets from these SSs only if there are no packets from SSs of UGS or rtVR class. The EDF algorithm schedules SSs based on their delay requirements only, the average throughput will be low. This will reflect a low average throughput of rtPS SSs. The EDF algorithm indicates a lower average throughput for the nrtPS class when the concentration of ertPS or rtPS SSs is the highest since the algorithm provides strict priority to SSs with delay requirements (ertPS and rtPS SSs). A high average delay for the ertPS SSs when their concentration is low. This behaviour is due to a low threshold assigned for the ertPS class. The fairness of EDF algorithm is the worst among the (WFQ, WRR, RR, and TRS) algorithms because some real time packets rtVR connections are dropped under high burstiness, and the throughput of rtVR decreases.

(v) 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. Strict-priority algorithm may not be suitable in WiMAX network because there is no compensation for inadequate bandwidth. This technique is only appropriate for low-bandwidth serial lines that currently uses static configuration which does not automatically adapt to changing network requirements.

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. For BE and nrtPS traffic class almost had no traffic because the Strict-Priority scheduler caused bandwidth to be starved for low priority traffic types, the higher priority traffic had a higher throughput and the lowest priority traffic had low throughput. SP produce almost the same amount of overall average for the throughput 110Kbps.

(vi) Temporary Removal Scheduler

The Temporary Removal Scheduler (TRS) scheduler involves the process of identifying the packet call power that is depending on radio conditions and then temporarily removing them from a scheduling list for a certain adjustable time period TR. In the poor radio conditions, the whole process could be repeated up to L times at the end of which, the removed packed is added to the scheduling list, independently of the current radio channel condition. If we consider the latency as a function of rtVR + nrtVR traffic load, then TRS scheduler provides a decrease in the latency.

(vii) Maximum Signals to Interference Ratio

The scheduler mSIR (Maximum Signal to Interference Ration) is based on the allocation of radio resources to subscriber stations which have the highest SIR. This scheduler allows a highly efficient utilization of radio resources. With the mSIR scheduler, the users with a SIR that is always small may never be served. . If the latency is considered as a function of rtVR traffic load it is verified that the mSIR scheduler provides a decrease in the latency. TRS can be combined with the mSIR scheduler. The mSIR scheduler provides high throughput with a good SIR.

The author proposed an algorithm and compared with mSIR and PF. The delay stays low for proposed algorithm regarding the other algorithms even when the number of users increase, since in proposed cross-layer algorithm QoS of each SF is considered more than others and as ertPS service classes are more sensitive to delay constraints, takes more transmission opportunities than other types of SFs. MAX-SNR doesn't take into account the type of service flows and schedules the connections which have the best channel first. MAX-SNR with the most through-put value, it schedules connections without considering the quality of services and selects the connection with the best SNR for transmission. The spectral efficiency of the MAX-SNR scheme increases with respect to the number of users. But in proposed algorithm both the SNR and the QoS constraints are taken into account to guarantee the required QoS performance.

(viii) Self-Clocked Fair (SCF) Queuing

It is an efficient queuing scheme that satisfies the quality of services (QoS) in broadband implementation. It adopts the concept of an internally generated virtual time as the index of work in progress. The SCFQ algorithm can accomplish the easier implementation and it can maintain the fairness attribute in virtual time function. There is large difference in terms of the average end-to-end delay time among RR, SCF and WRR. SCF produced almost the same amount of overall average for the throughput 110Kbps which is better than WRR.

SCF shows the higher performance when compared to WFQ & DS with respect to queue management and resource utilization. SCF produced overall average for the throughput 110Kbps which is greater than WFQ.

(ix) Deficit Fair Priority Queuing (DFPQ)

DFPQ with a counter was introduced to maintain the maximum allowable bandwidth for each service class. The counter decreases according to the size of the packets. The scheduler moves to the other class once the counter falls to zero. DFPQ has been used for inter-class scheduling. The problem with which DFPQ was introduced because queue length can be also used to set the priority level, e.g., more bandwidth is allocated to connections with longer queues. The direct negative effect of priority is that it may starve some connections of lower priority service classes. The throughput can be lower due to increased number of missed deadlines for the lower service classes' traffic. In DFPQ and SS-assisted algorithms, the average end-to-end delay for real-time packets increases at the beginning of the simulation time to its maximum value and then decreases to become almost stable. This increase is due to the fact that during the beginning of the simulation time, the SSs and the BS are busy attempting to complete the ranging process; arriving packets are delayed causing a relatively high average delay. The DFPQ scheduler yields a higher average end-to-end delay for real-time classes than SS-assisted algorithms. DFPQ only focuses on achieving high bandwidth utilization by dynamically dividing the bandwidth between the UL and DL sub frames.

b. Hybrid schedulers

(i) TRS+RR scheduler

It is the hybrid scheduling algorithm in which Temporary Removal Scheduler is combined with Round Robin to obtain the desired results. It involves identifying the packet call power, depending on radio conditions, and then temporarily removing them from a scheduling list for a certain adjustable time period TR. The scheduling list contains all the SSs that can be served at the next frame. When TR expires, the temporarily removed packet is checked again. If an improvement is observed in the radio channel, the packet could be topped up in the scheduling list again, otherwise the process is repeated for TR duration. In poor radio conditions, the whole process could be repeated up to L times at the end of which, the removed packed is added to the scheduling list, independently of the current channel condition. TRS+RR scheduler serves the highest number of SSs simultaneously in the same frame. The TRS+RR scheduler serves all the SSs that belong to the scheduling list. The TRS+RR scheduler serves at least all the SSs having an SIR greater than a pre-set threshold. TRS+RR throughput is greater than WFQ & WRR.

(ii) TRS + mSIR Scheduler

TRS is combined with mSIR scheduler so that all the radio resources are reserved for the subscribers having the highest values of SIR. TRS + mSIR schedulers have good performance and deliver the highest number of packets. Indeed, these schedulers favour the SSs having the highest SIR values and then using the most efficient MCSs. TRS + mSIR schedulers have good performance and deliver the highest number of packets. The freezing of traffic of SSs having a small SIR, TRS + mSIR require a large average delay to deliver a data frame.

(iii) WRR+PQ

The hybrid scheduler WRR + PQ use two types of scheduler:

• Priority Queuing (PQ): In this scheduler, each queue has a priority. A queue can be served only if all higher priority queues are empty.

• Weighted Round Robin (WRR): In this, each queue has a weight which defines the maximum number of packets that can be served during each scheduler round.

This scheduler handles the differently real time and non-real time traffic: In the first stage, each traffic class is associated to a queue. This stage guarantees a fixed bandwidth for UGS and ErtPS classes and a minimum bandwidth for rtPS while ensuring fairness between flows because the rtPS packets have variable size and this flow could monopolize the server if the traffic is composed by packets with larger size than those of Class 1 and 2. In the second stage, output of the two WRR schedulers are enquired in two queues F1 and F2, packets of these queues are managed by a priority PQ scheduler which gives higher priority to real time stream (stored in F1) which are more constringent in term of throughput and delay than the non-real time traffic (stored in F2) which are less time sensitive. It is recommended is to use TP as a selection traffic granularity method with MAXSNR as a mapping slot strategy after processing traffic by proposed hybrid scheduling block.

(iv) WDRR+ SP

In this hybrid scheduler it uses the two homogenous schedulers WDRR and SP. In the first stage the WDRR is used and then in second stage it uses SP. In the first stage use either DRR/PF/WDRR but it is analysed that WDRR shows the best result with SP at that stage.

To avoid the starvation of BE connections as in SP, it is reserved a portion of all slots exclusively for these connections. The connection admission control should take care that there are always enough slots for the real-time connections. It easily enhances the proposed scheduler and provides support for UGS and nrtPS classes. For VoIP and other real-time traffic, DRR is still the best choice. It is not acceptable to let VoIP connections starve every now and then (when the most robust MCSs are used) just because that would lead into better MAC throughput. In fact, with PF scheduling, VoIP delay could grow intolerable if the number of VoIP connections is significant.

(v) EDF+WFQ+FIFO Scheduler

The hybrid algorithm uses strict priority mechanism for overall bandwidth allocation and its complexity is O (N). The EDF scheduling algorithm is used for SSs of ertPS and rtPS classes, the WFQ algorithm is used for SSs of nrtPS class and FIFO is used for SSs of BE class. The EDF and WFQ algorithms are implemented as described in this homogenous algorithms section. FIFO is used for BE class as SSs of this class do not have any QoS requirements. This algorithm provides strict priority to ertPS and rtPS SSs; it results in a higher average throughput for the nrtPS class than the EDF algorithm. Also results in starvation of SSs of the BE class due to the strict priority nature of the algorithm and provide high priority to rtPS SSs, all the data of rtPS SSs will be flushed out in a frame. In this algorithm when the concentration of BE SSs is low, the intra-class fairness of the nrtPS class is low and is high when the concentration of ertPS and rtPS SSs is high. It provides strict priority to nrtPS SSs over BE SSs.

c. Opportunistic algorithms

(i) Cross layer scheduler

To manage the resource allocation and grants an appropriate QoS per connection, other scheduling schemes are proposed. Its complexity must be O (N). These scheduling schemes rely on different algorithms to handle different classes of services for matching their QoS requirements. There are four service types are defined in IEEE 802.16e-2005 standard which includes the UGS (Unsolicited Grant Service), rtPS (Real-time Polling Service), nrtPS (Non Real-time Polling Service), and BE (Best Effort). The guaranteed delay aspect is taken utmost care in video streaming and VoIP. In the mobile WiMAX environment, the handover procedure begins as soon as the mobile SS moves into the service range of another BS. There are three major steps involved in the Cross Layered approach. The CAC algorithm takes the proper decision to admit or reject an incoming connection request along with its required bandwidth. Cross layer adaptations are essential for guaranteeing the QoS supports in real-time multimedia traffic over wireless networks. The cross layer scheduling provides QoS Guarantee, Channel Quality. But it is Complex in implementation and all slots per frame are allocated to highest priority connection.

II. CONCLUSIONS

Today interest in the broadband wireless access has been growing due to increased user mobility and the need for data access at all times. The IEEE 802.16e based WiMAX networks commit the best available quality of experience for mobile data service users. Unlike the wireless LANs, WiMAX networks has several quality of service (QoS) methods at the Media Access Control (MAC) level for guaranteed services for data, voice and video. The Priority Control Scheme reduces the delay in the network and improves the QoS. But it has some of the drawbacks. In this paper we study the different types of Qos parameters and scheduling algorithms in WiMAX network.

III. REFERENCES

[1] Mohammed Sabri Arhaif, "Comparative Study of Scheduling Algorithms in WiMAX", International Journal of Scientific & Engineering Research, vol-2, Issue 2, ISSN 2229-5518, February-2011,.

[2] Chakchai So-In, "Scheduling in IEEE 802.16e Mobile WiMAX Networks: Key Issues and a Survey", IEEE Journal on Selected Areas in Communications, vol-27, No. 2, February 2009.

[3] Shuang Song and Biju Issac, "Analysis of WiFi and WiMAX and Wireless Network Coexistance", International Journal of Computer Networks & Communications (IJCNC), vol-6, No.6, November 2014.

[4] Bhuteswar Jena, "Fixed and Mobile WiMAX Networks based on LTE", International Journal of Computer Science and Information Technologies, vol-5, 6079-6084, 2014.

[5] Shanmugam Arumugam and Shanthi Govindaswamy, "Performance of the Modified Round Robin Scheduling Algorithm for Input Queued Switches under Self Similar Traffic", The International Arab Journal of Information Technology, vol-3, No. 2, April 2006.

[6] D. David Neels Pon Kumar and K. Murugesan, "Performance Analysis of AI Based QOS Scheduler for Mobile WiMAX", (ICTACT) Journal on Communication Technology, vol-03, Issue -03, September 2012.

[7] Dr.B.Sridevi, R.Anantha Priya, V.S.Primiya, "Proposed WFQ Based Dynamic Bandwidth Allocation for Mobile WiMAX Application", International Journal of Computational Science and Information Technology (IJCSITY), vol-.2, No.2, May 2014.

[8] K.S.S. Prasad, "An Efficient Qos Scheduling Algorithm for IEEE 802.16 Networks", Middle-East Journal of Scientific Research, ISSN 1990-9233, 2014.

[9] Ali Heidari Khoei, Ghasem Mirjaalily and Mehdi Agha Sarram, "Improving the Quality of Services by Scheduling Algorithms in WiMAX Networks", Indian J. Sci. Res., 7 (1): 1174-1184, 2014.

[10] Mohit Kumar Saini and R. K. Chauhan, "An Efficient Analysis of Resource Management in WiMAX Network", International Journal of Information & Computation Technology, ISSN 0974-2239, vol-4, Number 12, pp. 1195-1203, 2014.