A Review on Scheduling Algorithms for Multicast Services over WiMAX Networks

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Abstract— Transmission of multicast traffic (such as video, data and voice services over World Wide Interoperability for Micro Wave Access "WiMAX" aims to make multicast traffic available to users anywhere, anytime and on any device. The major challenges of transmitting wireless traffic over WiMAX network through convention multicast schemes are throughput fluctuation (Variations) among the subscribers within the network coverage, unfair distribution of network resources, delay, delay jitter and packet drop because they are placed in different locations from the Base Station. These inefficiencies are as a result of different fading and path losses in time-varying wireless channel experience by the Subscribers. Scheduling algorithms are mainly responsible for utilization of available resources that are obtained in the network in order to ensure the desire quality of service, among those scheduling algorithms are Round Robin, Max Rate, first in first out, Maximum Throughput, proportional fairness and weighted fair queuing etc. This paper surveys various scheduling algorithms for maximization of network throughput, fair distribution of resource, minimize packet loss and delay in WiMAX. Performances and limitations of some of the previous works are identified. Finally, future research directions to improve on some of the observed inefficiencies are discussed.

Keywords: IEE802.16, WiMAX, Multicast, Scheduling, throughput, Delay, Quality-of- Service

1 INTRODUCTION

Increasing demand for high speed multimedia services like Internet Protocol Television (IPTV) and mobile television has led to the introduction of broadband wireless access. One of such broadband wireless access is the Worldwide Interoperability for Microwave Access (WiMAX). It is also known as IEEE 802.16. The standard enables high-speed access to data, video and voice services [3]. Internet Protocol Television (IPTV), is expected to contribute great market value to the service providers in 4 generation (4G) wireless network [7]. It also serves as an alternative to cabled access networks, such as fiber optics, coaxial systems using cable modems and digital subscriber lines (DSLS) [1]. WiMAX theoretically provides 4-10Mps to 16km at 70Mps. WiMAX requires differing and diverse quality of service (QoS) guarantee such as optimal system throughput, maximum latency guarantees and minimal delay jitter. It is heterogeneous with unmethodical associate of real and non-real time message [16]. The concept behind traffic delivery in this paper is multicast. Multicast transmission is an efficient way to improve the network capacity by transmitting similar packets to multiples receivers simultaneously [6]. Throughput is the measure of numbers of packets sent successfully in a network and it is measured in in terms of packet per second [5]. Delay is the time taken to transfer packets to destination node from source node [5]. The IEEE 802.16 standard provides two structures for dividing the wireless medium [16]:

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(i) Point-to-Multipoint (PMP)

(ii) Mesh (Optional)

In Point-to-Multipoint (PMP) mode: Nodes are arranged in a cellular structure in such a way that the Base Station communicates a group of Subscriber Stations within the same antenna sector in a broadcast mode [16]. In this scenario all Subscriber Stations reach the same transmission from the Base Station. Where Subscriber Stations transmissions are aims to the Base Stations and operate at the same rate. While in mesh mode Nodes are arranged systematically in Ad-hoc manner and scheduling is distributed among the Subscriber Stations without transmission from the Base Station [16]. The uplink from Subscriber Station to Base Station and downlink from Base Station to Subscriber Station data transmissions in the IEEE 802.16 standard are Frame-based. Recently, Broadband Wireless Access networks have been rapidly evolving to satisfy increasing user scalability and Quality of Service (QoS) [14]. The salient features of Mobile WiMAX are [14]:

(i) The higher data rate
(ii) Mobility
(iii) Scalability
(iv) Quality of Service such as optimal system throughput

In order to support high data rate, multicast and broadcast service in WiMAX, techniques such as OFDM and OFDMA are used. Video, voice and data are all IP data services, but each has its own Quality of Service (QoS) requirements. High availability, sufficient guaranteed bandwidth, low transmission delay and jitter are the QoS requirement for video services. In order to support QoS for various types of traffic, WiMAX medium access control protocol defines bandwidth request-allocation mechanisms and five types of scheduling classes as follows [15]

(i) Unsolicited grant scheme (UGS)
(ii) Real-time polling service (rtPS)
(iii) Nonreal-time service (nrtPS)
(iv) Best effort (BE)
(v) Extended real-time service (ertPS)

The pertinent characteristic of these five scheduling service classes are presented as follows:

(i) UGS: This scheduling service is designed for periodic fixed-sized data packets. It supports constant bit rate real-time applications such as the voice over internet protocol (VOIP) without silence suppression.
(ii) ertPS: This scheduling service class generates periodic variable-sized packets. It supports a variable bit rate (VBR) real-time applications such as the VOIP with silence suppression.
(iii) rtPS: This is designed for real-time applications that generate variable bit rates (VBRs), such as audio/video (MPEG) streaming and video on demand (VoD).
(iv) nrtPS: This service class is designed for delay-tolerant nonreal-time applications such as the file transfer protocol (FTP) with guaranteed minimum throughput.
(v) BE: This service class is designed for applications that do not need QoS parameters. The hypertext transfer protocol (HTTP) and e-mail are the examples of this service application. In addition to the scheduling services, mandatory QoS parameters have been designed in the standard. The scheduling services and supported QoS parameters defined in [9] are shown in Table 1.

TABLE 1
MANDATORY QoS PARAMETERS OF THE SCHEDULING SERVICES [15]

Services / QOS Parameters	UGS T1/E1 transport	ertps VOIP	rtps streaming audio/audio	nrtps FTP	BE HTTP, Data transfer
Tolerated jitter (TJ)	✓	✓	-	-	-
Maximum latency (ML)	✓	✓	✓	-	-
Maximum sustained traffic rate (MSTR)	✓	✓	✓	✓	✓
Minimum reserved traffic rate (MRTR)	✓	✓	✓	✓	-
Traffic priority (TP)	-	✓	✓	✓	-
Packet loss	✓	✓	✓	✓	✓
Throughput	✓	✓	✓	✓	✓
Packet delivery ratio	✓	✓	✓	✓	✓

Table 1.1 depicts the essential QoS parameters and UGS service classes. Here '✓' symbol depicts that the service class has QoS defined for that particular parameter, while the '–' symbol depicts that the service class has no QoS defined for that particular parameter. For real time application like IPTV and VoIP a guaranteed QoS level is very important because these are CBR (Constant Bit Rate) applications and are delay sensitive [11].

2 REVIEW OF SCHEDULING ALGORITHMS

This section provides an overview of researches in scheduling algorithms for multicast services in WiMAX by way of optimizing WiMAX networks. This has led to much research by way of improving the system performance that ranges from maximizing throughput, fair distribution of network resources, minimize packet loss and delay. Among these scheduling algorithms are Round Robin, Max Rate, first in first out, Maximum Throughput, Proportional Fairness and Weighted fair queuing [2], [3], [12], [17]. Optimizing the performance of these models, the following presents a critical review of related research works:

Authors in [20], inspected and evaluated a frame registry tree scheduler which aimed to move forward the creation of time frame and avoid complex processing at the beginning of each frame. The authors use flexible tree structure to represent the scheduler's decision to improve packet loss and throughput of various types of traffic. The limitation with their work is that the comparison between time and space evaluation was not considered.

Authors in [21], studied the blocking probability behavior of connection oriented traffic model for multihop wireless line and grid topologies. The study focused on two areas which were: (i) the effect of transmission radius of nodes and (ii) dynamic channel assignment algorithm. They were able to show that in line topology, a large transmission radius substantially reduces blocking probability and a smaller transmission radius is suitable for a grid network with a denser node topology. They also developed a non-rearranging channel assignment algorithm that reduced blocking probability by spatially re-using the channel in an efficient manner which improved the network performance. However, the study could not establish the relationship between blocking probability and general rate of increase of interfering nodes with the transmission radius.

The authors in [7], developed a cooperative transmission model for efficiently supporting multimedia applications in WiMAX. The model comprised of two phases: First the BS multicasts data at a high rate and users in good channel conditions decode the data and secondly the users in good conditions that decode the data then assist in relaying the received data to the remaining users with poor channel conditions. The problem in their work is that the impact of mobility differentiation was not considered.

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The authors in [10], examined a multicast scheduling with multihop, multipath transmission over multiple OFDMA channels to fully exploit the effectiveness of cooperative communication and random network coding. Their work shows that cooperative communication and random network coding favours users with good channel conditions by enjoying high multicast flow rates from the source and cooperatively helped others with poor channel conditions simultaneously with little overhead. They considered channel and power allocation on relays as their performance metrics. The study was able to achieve significant throughput improvement due to its effective use of wireless spectrum. However, the limitation of the study is that the mobile stations did not make any contributions to the networks for multicasting.

Authors in [18], their work was based on the performance analysis of automatic repeat request (ARQ) mechanism for the effect of implementation of ARQ for WIMAX network, by considering the performance metrics like throughput, delay and jitter. The mechanism used a feedback channel for the confirmation of error-free packet delivery or packet retransmission. They found that the method increased the network throughput even when the radio channel conditions were getting worse. The limitation of this study is that the network delay increased because of the time spent for the retransmission of packet.

The authors in [2], their work was based on a subgroup-based resource management scheme, whereby they cluster SSs with similar channel quality in the same multicast subgroup of a WiMAX cell, Different cost functions for subgroup formation to trade off fairness and throughput requirement were used to improve the system performance. The work did not give any technique for reducing the computational cost of the subgroup creation.

In [4], the authors developed a mathematical formulation of problem to analyze the selection of optimal sub-streams from scalable video streams under bandwidth constraints to maximize the quality for mobile receivers. Their work gave a better throughput when compared to weighted round robin and similar homogeneous scheduler like Round Robin and first in first out. However, they did not consider channel conditions in their work such as fading and multi user diversity.

In [13]**,** the authors used Ad hoc on demand distance vector routing (AODV) to analyze various essential WiMAX quality of service parameters, to determine the performance of a WiMAX network. They were able to obtained optimum value of quality of service parameters as the mobile users keep on increasing in the network. The major setback of this work is that it could not handle the issue of power consumption, because the power consumption increased with an increase in the number of group members.

The authors in [11], discussed the performance and efficiency of WiMAX MAC layer that adapted with the physical layer (PHY) for point-to-multipoint topology for designing 4G networks that ensured required bandwidth, minimum latencies for different services through quality of service. The network was resilient to multipath fading channels because of the physical layer. However, the limitations of multi-input multi-output and advanced antenna systems were discarded in this work

Authors in [8], examined adaptive real-time service based distributed scheduling scheme that comprises of three components: Priority Assignment, Resource Allocation and Preserved Bandwidth Adjustment which guaranteed QoS of real-time service connections and provided fairness to every connection. They concluded that real-time distributed scheduling dynamically allocates bandwidth to different

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types of connections to meet each quality of service requirement. This work suffers a setback by not taken uplink scheduling and fairness to non-real time into consideration.

Authors in [6], developed an uplink-downlink duality framework, that is, they derived by Lagrangian duality theory for multicast max-min beamforming problem with multiple power constraints. They demonstrated that the research achieved a higher signal-to-interference-plus-noise ratio for the weakest users in the network. The limitation associated with this work is that it could not tackle the slow convergence of the network.

In [14], the authors developed a cooperative multicast scheduling scheme for wireless IPTV over mobile WiMAX based on resource assignment algorithm for quality of service optimization. The developed model increased the network throughput as the network coverage was increased. However, this work still relied on the cooperative multicast transmission developed by (Hou *et al.,* 2009). Which did not considered mobility differentiation.

The authors in [15], developed a channel delay aware scheduler for real-time applications which comprises of two modules. The wireless and the network delay monitoring tools. The wireless module included the compensation module, which was responsible for considering the throughput loss of the SS due to channel condition which improves fairness between all the SSs that were included in the same service class. The channel state monitoring module was responsible for monitoring and reporting the SSs channel state conditions to the scheduler. While the network delay monitoring tool calculated the estimated network delay of the paths and used this estimated delay to calculate the packet deadline for meeting the delayed requirement. Their work was able to meet the delayed requirements of real-time applications by taking the channel conditions and network delay into account. In addition, the work fairly distributed the network resources among the SSs and increased the network throughput. The limitation of the work is that it was not able to satisfy the short-term fairness due to the channel conditions.

The authors in [16], designed a joint routine scheduling and admission control protocol for WiMAX network, in which packets were transmitted per allotted slots from different priority of traffic classes adaptively depending on the channel condition. In the adaptive scheduling, the best route was found by means of combination of the bandwidth estimation technique with route discovery and setup. The admission control technique was based on the estimation of bandwidth utilization of each traffic class. The Work was able to achieve a better throughput and channel utilization while reducing the blocking probability and delay. However, the study did not consider that sometimes call admission control and scheduling algorithm working on different criteria in the same network can interfere.

In [17], the authors carried out survey on several bandwidth allocations and call admission control in which a scheduling algorithm was chosen based on maximum throughput and maximum delay that were based on service flow types. The various scheduling types used and their traffic class analyzed were Round Robin, Weighted Round Robin, Earliest Deadline First, Weighted fair queue, priority queue and reinforcement learning algorithm. They found out that the mean delay was increased for Best Effort (BE) and non-Real Time Pulling Service (nRTPS) when compared with Unsolicited Grant Service (UGS) and Real Time Pulling service (RTPS) flows when the system was overloaded. They discovered that priority and delay tolerant traffic were the main parameters for providing bandwidth for UGS and RTPS flows. However, the work did not take into account channel error and loss rate because channel condition was not considered due to the channel unaware scheduling that were evaluated.

The authors in [19], designed a proportional bandwidth granting schemes which consists of proportional byte based that kept the individual bandwidth request in the byte format, which was the original value extracted from the bandwidth request message. The second mechanism was the proportional physical slot before any bandwidth allocation calculation was done, which gives a better average throughput and jitter when compared to common bandwidth granting mechanism approach.

However, their designed mechanism failed to improve the delay which was one of the essential performance metrics for RTPS traffic and they did not consider different modulation and coding schemes in their work.

The efficacies of the aforementioned algorithms measured in the review literatures, the mandatory QoS parameters of the scheduling services are shown in table 1.

3 FUTURE RESEARCH DIRECTIONS

In view of the aforementioned imperfections associated with the reviewed works, and the need to overcome the inefficiencies of the conventional scheduling multicast schemes which are throughput fluctuations, unfair distribution of resources, packet loss and delay because of variation of distances due to time varying wireless channels, an improved scheduling algorithm need to be developed to immensely improve the quality of service, such as hybrid model based on sub-group formation with Optimization techniques such as, firefly, PSO, GA, Ant Cony in order to optimize the system performance.

4 CONCLUSION

Scheduling algorithms offered enormous merits such as fair distribution of network resources, maximizing the system capacity, minimizing packet loss and delay etc. However, qualities of service of these schedulers are often degraded due to increase in number of subscribers. Therefore, an improved scheduling algorithm need to be developed in order to meet the mandatory parameters of the scheduling services to catered for these inefficiencies.

REFERENCES

[1] Afolabi, R. O., Dadlani, A., & Kim, K. (2013). Multicast scheduling and resource allocation algorithms for OFDMA-based systems: A survey. Communications Surveys & Tutorials, IEEE, 15(1), 240-254.

[2] Araniti, G., Condoluci, M., Molinaro, A., & Pizzi, S. (2012). Radio-aware subgroups formation for multicast traffic delivery in wimax networks, paper presented at the 2012 IEEE 23rd International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), 477- 482.

[3] Chaari, L., Saddoud, A., Maaloul, R., & Kamoun, L. (2012). A Comprehensive Survey on WiMAX SchedulingApproaches.Retrievedfrom:www.intechopen.com/books/quality-of-service-andresource- allocation-in-wimax/a-comprehensive-survey-on-wimax-scheduling- approaches 2, 25-54.

[4] Chandra, R., and Saravanaselvi P., Key Issue on Multicast Video Streaming Over WiMAX Network. International Journal of Scientific and Research Publications, Volume 2(12): 2012 ISSN 2250-3153 1-9.

[5] Chauhan, M., Choubey, R., & Soni, R. (2013). An Advanced Scheduler for Hybrid Mbqos in wimax Network. International Journal of Computer Technology and Electronics Communication, 2(2), 10-17.

[6] Dartmann, G., Gong, X., & Ascheid, G. (2013) Low complexity cooperative multicast beamforming in heterogeneous networks. Paper presented at the 2013 IEEE 77th Vehicular Technology Conference (VTC Spring), 1-6.

[7] Hou, F., Cai, L. X., Ho, P.-H., Shen, X., & Zhang, J. (2009). A cooperative multicast scheduling scheme for multimedia services in

IEEE 802.16 networks, Wireless Communications, IEEE Transactions on, 8(3), 1508-1519.

[8] Huang, K.-F., & Wu, S.-J. (2013) Real-time-service-based Distributed Scheduling Scheme for IEEE 802.16j Networks, Journal of Networks, 8(3), 513-517.

[9] IEEE 802.16e-2009 Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems: IEEE Press, 584-864.

[10] Jin, J., & Li, B. (2009). Cooperative multicast scheduling with random network coding in WiMAX, paper presented at the 17th International Workshop on Quality of Service, 2009, (IWQoS), 1-9.

[11] Kazemi, H., & Heydarian, R. (2013) A Solution for Designing 4G Networks in Urban AreasMajlesi Journal of Telecommunication Devices, 2(2), 209- 212.

[12] Khoei, a. h., Mirjalily, g., & Garram, m. a. (2014). Improving the quality of services by scheduling algorithms in WiMAX networks. *indian j. sci. res, 7*(1), 1174-1184.

[13] Mehta, V., & Gupta, D. N. (2012), Performance Analysis of QoS Parameters for Wimax Networks. International Journal of Engineering and Innovative Technology (IJEIT) Volume, 1, 105-110.

[14] Nithyanandan, L., & Susila, J. (2013), Resource allocation algorithms for qos optimization in mobile wimax networks. International Journal of Wireless & Mobile Networks, 5(3), 77-90.

[15] Oktay, M., & MANTAR, H. A. (2013). CADA: channel and delay aware scheduler for real-time applications in WiMAX networks. turkish journal of electrical engineering and computer sciences, 21(6), 1780-1800.

[16] Prasad, R. M., & Kumar, P. S. (2013) Joint Routing, Scheduling and Admission Control Protocol for WiMAX Networks. International Arab Journal of Information Technology (IAJIT), 10(1), 85-92.

[17] Saravanaselvi, P., & Latha, P. (2013) A Survey on Call Admission Control and Bandwidth Allocation for WiMAX. International Journal of Innovative Research in Computer and Communication Engineering, 1(9), 2185-2192.

[18] Shwetha, D., Thontadharya, H., Bhat, S. M., & Devaraju, J. (2011) Performance analysis of ARQ mechanism in wimax networks. International Journal of Computer Science & Communication Networks, 1(2), 123-127.

[19] Wee, K., Liew, T. H., Ooi, S. Y., & Chong, S.-c. (2014) QoS Provisioning through Bandwidth Granting Scheme for Wireless Networks, paper presented at the CTRQ 2014, The Seventh International Conference on Communication Theory, Reliability, and Quality of Service, 1-5.

[20] Xergias, S. A., Passas, N., & Merakos, L. (2005) Flexible resource allocation in IEEE 802.16 wireless metropolitan area networks. Paper presented at the 14th IEEE Workshop on Local and Metropolitan Area Networks, LANMAN 2005, 1-6.

[21] Zafer, M., & Modiano, E. (2006) Blocking probability and channel assignment in wireless networks. *Wireless Communications, IEEE Transactions on*, *5*(4), 869- 879.