International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 5, May-2014, pp: (311-316), Impact Factor: 1.252, Available online at: www.erpublications.com.

WiMAX: A-State-of-the-Art

Gaurav Sharma[1], Rishma Chawla[2]
[1]CSE & IT Department, BBSB Engineering College, Punjab, INDIA
[2]CSE & IT Department, RIET College, Punjab, INDIA

Abstract: In this paper we will review the basic mechanisms used in WiMAX networks to support quality of service guarantees. An outline of the various approaches has been proposed and involved tradeoffs have also been discussed. The various architecture and scheduling mechanism proposed to improve quality of service in WiMAX networks have also been discussed. Then the different type of service flows in WiMAX networks have been discussed. This paper focuses on the study of QoS in WiMAX networks using different simulation environments (like NS-2, NS-3 and OMNeT ++), their different parameters and different type of data traffics being supported by them. The literature overview of the various techniques used so far in this area has been discussed in this paper.

Keywords: BE, ertPS, nrtPS, QoS, rtPS, UGS, WiMAX.

1. Introduction

In last few years there has been significant growth in the area of wireless communication. It has become an essential part of modern telecommunication system because of the user demand for the faster connection to internet services. This had eventually leaded to a demand of larger bandwidth in order to support communication. There is a desire to satisfy the emerging need for high data rate applications such as voice over IP, video conferencing, interactive gaming and multimedia streaming which has gradually led to the evolution of technologies like WiMAX (Worldwide Interoperability for Microwave Access) and WLAN (Wireless Local Area Network) [1] [2]. WiMAX is one of the most emerging technologies for Broadband Wireless Access (BWA) in metropolitan areas by providing an exciting addition to the current broadband techniques for the last-mile access. VoIP is spreading rapidly and there is need to support multiple concurrent VoIP communications and one of the limitations of WLAN is that it support only handful number of users [3][4]. Studies on VoIP over WLAN in PCF mode [5] shows that the polling overhead is high with increased number of stations in a basic service set (BSS). This results in excessive delay and poor performance of VoIP. WiMAX is a wireless cable replacement technology with unlimited coverage.

2. WiMAX Architecture

WiMAX [6] on the other hand is designed to deliver a metro area broadband wireless access (BWA) service. So, while wireless LAN supports transmission range of up to few hundred meters, WiMAX system ranges up to 30 miles [6]. Unlike a typical IEEE 802.11WLAN with 11Mbps bandwidth which supports very limited VoIP connections [4], an IEEE 802.16 WiMAX with 70Mbps bandwidth [7] can support huge number of users. These motivations led to study and comparison of the VoIP quality of service in IEEE 802.11b WLAN and IEEE 802.16 WiMAX network. IEEE 802.16 support 5 types of service classes, namely UGS (Unsolicited Grant Service), rtPS (real time Polling Service), nrtPS (non-real time Polling Service), BE (Best Effort Service), ertPS (extended rtPS service) [8]. UGS supports fixed-size data packets at a constant bit rate (CBR). It supports real time applications like VoIP but wastes bandwidth during the off periods. rtPS supports variable bit rate(VBR) real-time service such as streaming audio and streaming video. Delay-tolerant data streams such as an FTP is designed to be supported by the nrtPS. This requires variable-size data grants at a minimum guaranteed rate. Data streams, such as Web browsing, that do not require a minimum service-level guarantee is supported by BE service. BE connections are never polled but receive resources through contention. ertPS was introduced to support VBR real-time services such as VoIP with silence suppression. It has an advantage over UGS and rtPS for VoIP applications as it carries lower overhead than UGS and rtPS [9] and hence is modelled in the system. Since, WiMAX is expected to create the opportunity to successfully penetrate the commercial barrier by providing higher bandwidth; establishing wireless communication becomes an important factor. Also, bandwidth crunch and network integration are some of the major technical and social challenges regarding the future of the community-based Wi-Fi networks [10]. According to [10], the foundation of the WiMAX PTP commons is the process of hot-spot.

This the technology aimed to provide wireless data access over long distances. It is based on Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard [11] [12]. The name WiMAX was created by the WiMAX Forum, which was formed in June 2001 to promote conformance and interoperability of the standard. The WiMAX forum and IEEE 802.16 subcommittee are both involved in the development of open standards based broadband wireless networks. The

IEEE 802.16 subcommittee is purely a technical body that defines the 802.16 family of broadband wireless radio interface standards. IEEE 802.16 defines the layer 1 (physical, also referred as PHY) and layer 2 (data link or Media Access Control - MAC) of the (Open Systems Interconnection) OSI seven layer network model. It does not define standardized network architecture beyond the base station. Standardized network architecture is essential to ensure inter-working between equipment from different vendors and inter-working between networks of different operators. The WiMAX forum fills this gap and creates an end-to-end broadband wireless network interconnection and integration. Instead of global Internet connectivity, many current applications and businesses are expected to be better utilized by using the localized Wi-Fi constellation [13-15].

Table 1.1: Technology Comparison

	WLAN	WiMAX
Peak Data Rate	802.11a,g=54 Mbps	DL:70 Mbps
	802.11b=11 Mbps	UL:70 Mbps
Bandwidth	20 MHz	5–6 GHz
Multiple Access	CSMA/CA	OFDM/OFDMA
Duplex	TDD	TDD
Mobility	Low	Low
Coverage	Small	Mid
Standardization	IEEE802.11x	802.16
Target Market	Home/ Enterprise	Home/ Enterprise

While the above Table 1.1 compares WLAN and WiMax , Figure 1.1, comprising of both the WiMAX and WLAN network and using mobile nodes with dual stack is expected to provide a better performance than a similar WiMAX or WLAN network.

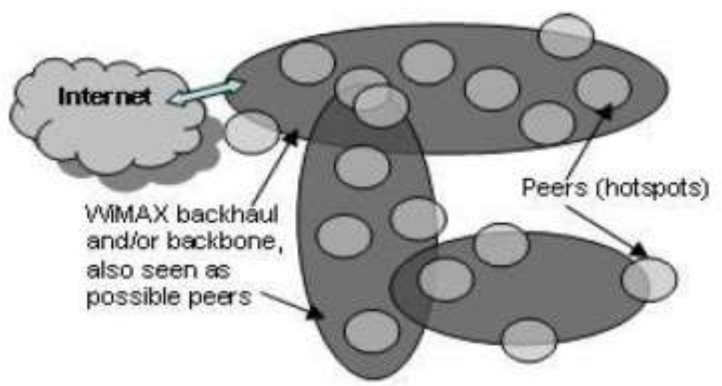

Figure:1.1: Wi-Fi integration using WiMAX [10]

3. WiMAX Mechanism

The Mobile WiMAX End-to-End Network Architecture is based on an All-IP platform, all packet technology with no legacy circuit telephony. It offers the advantage of reduced total cost of ownership during the lifecycle of a WiMAX network deployment. The use of All-IP means that a common network core can be used, without the need to maintain both packet and circuit core networks, with all the overhead that goes with it. Following are the basic requirements that have guided the WiMAX architecture development [16-18].

1. The architecture is based on a packet-switched framework, including native procedures based on the IEEE 802.16 standard, its amendments and Ethernet standards.
2. The architecture permits decoupling of access architecture and supported topologies from connectivity IP service. Network elements of the connectivity system are agnostic to the IEEE 802.16 radio specifics.
3. The architecture allows modularity and flexibility to accommodate a broad range of deployment options such as:
   a. Small-scale to large-scale (sparse to dense radio coverage and capacity) WiMAX networks
   b. Urban, suburban, and rural radio propagation environments
   c. Licensed and/or licensed-exempt frequency bands
   d. Hierarchical, flat, or mesh topologies, and their variants
   e. Co-existence of fixed, nomadic, portable and mobile usage models

4. The end-to-end architecture includes the following support for services and applications:
   a. Voice, multimedia services and other mandated regulatory services such as emergency services and lawful interception
   b. Access to a variety of independent Application Service Provider (ASP) networks in an agnostic manner
   c. Mobile telephony communications using VoIP
   d. Support interfacing with various interworking and media gateways permitting delivery of incumbent/legacy services translated over IP, e.g. SMS over IP, MMS, WAP, to WiMAX access networks
   e. Support delivery of IP Broadcast and Multicast services over WiMAX access networks

4. WiMAX Technology: A State of Art

Guerin and Peris [19] focused on QoS in packet networks. They classified the requirement to be provided by network into control path and data path. The support of different control path and data path mechanism in different environment can greatly affect the QoS in different environments. The main challenge they have discussed is interoperability of those mechanisms. These concepts have been adapted into IEEE 802.16 standard in providing the QoS support. They have torched the various tradeoffs in QoS and control path interoperability which is serving to be latest area of research in WiMAX.

Chu et al [20] proposed architecture for heterogeneous classes of traffic with different QoS requirements in Broadband Wireless Access (BWA). Performance and stability were the main area of concern for them. There is a need of implementation of various scheduling algorithms though comprehensive simulation studies of the architecture.

Nair et al [21] described the MAC protocols used in theWiMAX networks. They have discussed the various type of provisioning in WiMAX deployment to maintain Quality of Service (QoS using the features of this MAC protocol.Finally, they have reviewed the challenges inherent in implementing this MAC protocol on architectures such as the Intel® IXP network processors and embedded Intel architecture processors to support the application of MAC functionality to the wide range of potential QoS and provisioning approaches.

Chen, Jiao and Guo [22] authors proposed architecture for multilayer QoS control in WiMAX in Point to Point (PMP) and Mesh mode. They have tested the architecture on InterServ and Diffserv services which vary in traffic class, bandwidth requirements, delay, jitter, loss rate and MAC layer services. On comparison with traditional way of providing cross layer it has been observed that the proposed integrated QoS control is superior in high efficiency and fastness to guarantee the throughput requirement of source traffic.

Alavi and Mojdeh[23] introducing a novel architecture to support Quality of Service in IEEE 802.16 standards. Moreover, they proposed a design approach to implement such architecture. Simulation result shows the high performance of architecture for all types of traffic classes defined by the standard. The simulation results proved the performance of architecture.The various applications of WiMAX have also been covered in WiMAX forum. They have provided usage scenarios for real life situations.A lot of information about WiMAX network can be found[24]. Salient features of Mobile WiMAX technology and how its capabilities can be applied in enabling broadband mobile services have also been described.

Cicconetti, Lenzini, and Mingozzi [25] focused on mechanisms that are available in an 802.16 system to support quality of service (QoS) and whose effectiveness is evaluated through simulation. As far as traffic with QoS requirements, they have found that the performance of uplink connections, in terms of delay, is highly dependent on the delay introduced by the bandwidth request mechanism. Subscriber stations (SSs) might effectively exploit piggybacking and bandwidth stealing to improve the delay performance. This can only be done if there are multiple traffic sources in the same SS, either multiplexed into the same connection or carried by separate connections. It is observed that real time polling service (rtPS) outperforms non real time polling service (nrtPS) in terms of delay, at least under the considered scenarios.

Felipe and Maciel [26] proposed an alternative QOS architecture for IEEE 802.16 standard that incorporated priority bases packet scheduling and a new traffic shaping.The results obtained clearly depicts a fairness among aggregated flows by an alternative QosS architecture composed by a packet scheduling scheme, and a traffic shaping structure. Their structure can be seen as a second step to a complete QoS architecture for the IEEE 802.16 Standard.

Gakhat, Achir and Gravey [27] addressed the issue of multiservice nature in IEEE 802.16 or WiMAX networks. Their study showed that it is possible to support stringent QoS with polling based traffic classes. They have concluded that the packet scheduling can have very small impact on cost of WiMAX cards.

Ghazal, Mokdad and Otham [28] provided a performance analysis of three types of connections defined in the standard (UGS. rtPS, nrtPS)on the basis of different levels of priority and blocking probability to each class of service. This performance analysis has been done using an analysis model for evaluating admission control (AC) for the classes in WiMAX network. The analysis of the performance of the admission control of Unsolicited Grant Service (UGS), rtPS, and ntrPS is done. They noticed that the probability of blocking of a connection is higher for lower priority service class, while delay of the UGS service class in much affected by the increase of the size of a contention window.

Qu and Fang [29] focused on the features of service defined in IEEE 802.16, including UGS, ertPS, nrtPS and BE. They proposed a new admission control strategy based on the minimum reserved bandwidth and designed a scheduling algorithm to ensure the implementation of this strategy. Finally, they simulated the admission strategy and the algorithm.

Kaarthick and Yeshwenth [30] addressed the problems concerning the delivery of video packets in video conferencing and other multimedia applications over WiMAX. They modeled WiMAX point-to-multipoint topology for multiple competing traffic sources. They analyzed the traffic and studied the effect of different service flows on QoS parameters like throughput, packet loss, jitter and delay. They concluded from the results that the VOIP traffic can be best served with UGS service flow with some modifications. The UGS service flow is indeed designed for constant bit rate traffic.

Talwalkar and Iiyas (31] focused on analysis of quality of service as implemented by the WiMAX networks. First, it presents the details of the quality of service architecture in WiMAX network. In the analysis, a WiMAX module developed based on popular network simulator NS-2 is used. Various real life scenarios like voice call, video streaming are setup in the simulation environment. Parameters that indicate quality of service, such as, throughput, packet loss, average jitter and average delay, are analyzed for different types of service flows as defined in WiMAX. Results indicate that better quality of service is achieved by using service flows designed for specific applications. In the paper, the general concepts of Quality of service(QoS) in wireless networks were studied. The IEEE 802.16/WiMAX network architecture was presented and the MAC layer features that enable end-to-end QoS mechanism in the network were discussed. Various service flows that are supported in WiMAX were discussed in detail.

Farooq and Turletti [32] proposed and discussed in detail the design and implementation of an IEEE 802.16 WiMAX module for NS-3, with the Point-to-Multipoint (PMP) mode and the WirelessMAN-OFDM PHY layer. Their module implements fundamental functions of the convergence sublayer (CS) and the MAC common-part sublayer (CPS), including QoS scheduling services, bandwidth request/grant mechanism, and a simple uplink scheduler. The aim is to provide a standard-complaint and well-designed implementation of the standard.This paper presented detailed design and implementation of an IEEE 802.16 WiMAX module for the recently released NS-3 simulator. The proposed module implements the PMP mode and two different PHY layers: a basic PHY layer that simply forwards bursts received from the MAC layer and a more complete Wireless MAN-OFDMPHY that follows the standard. Module's design thoroughly follows the object-oriented Software developments methodology and utilizes Unified Modeling Language (UML) for modeling.

Weingartner, Lehn and Wehrle [33] investigated the performance requirements and the scalability of five different simulation tools namely, NS-2, OMNeT++, NS-3, SimPy and JiST/SWANS. Their results showed that three of them, NS-3, OMNeT++ and JiST are all capable of carrying out large-scale network simulations in an efficient way. JiST has proven to be the fastest simulator by far in their experiments; however the exhaustive memory consumption may limit its applicability in some simulation scenarios. In performance comparison, NS-3 demonstrated the best overall performance. Although it was surpassed by JiST in terms of simulation run-time, it still shows both low computational and less memory demands. However, at present NS-3 still is in the early stages, and just a few simulation models exists which one can use off the shelf. OMNeT++ provides a rich graphical user interface and an abstract modeling language, while JiST and NS-3 rely on pure source code for the development of the entire simulation. In conclusion, the question of which simulator to use is a difficult one and the answer is largely dependent on the specific use case. However, if scalability is the main concern, JiST, NS-3 and OMNeT++ are smart choices.

Asim and Mufti [34] presented the design of 802.16 MAC simulator which implements true frame format, with TDM/TDMA and TDDD. QoS and Admission Control are also simulated by designing Bandwidth and Service Flow Managers. Simulation topology for a typical wireless network is also presented. The MAC common part sub layer of 802.16 can be successfully simulated on NS-2, in its entirely by implementing the entire protocol specification. This provides a useful means to evolve and test the design of the MAC, and better understand the specifications. NS-2 can be an effective platform for development of bandwidth allocation algorithms and implementation of 802.16 for the purpose of QoS testing and throughput analysis.

Ismail, Piro, Grieco and Turletti [35] provided a snapshot of existing WiMAX simulators available in the public domain, while highlighting their limitations. The, they described the new features and enhancements they have integrated with the NS-3WiMAX module, and in particular: a realistic and scalable physical model, an IP packet classifier for the convergence sub-layer, efficient uplink and downlink schedulers, support for multicast traffic and pcap packet tracing functionality. The new design of the physical layer has improved the simulation time by several magnitude orders while still providing a realistic implementation of the standard. Furthermore, the IP subscriber station, while the proposed schedulers improve the management of the Qos requirements for the different service flows.

Conclusion

The paper presented the brief study of the work done by different authors in the area of WiMAX network architecture and QoS in WiMAX networks. Different simulation environments have been used to evaluate the QoS of service in WiMAX networks. Different service flows have been considered to pass different type of data traffics to evaluate the performance measures of the fast growing Broadband Wireless network. The fast growing multimedia traffic like video and audio streaming and VoIP have made it necessary to check the performance measures of networks. There are still some service flows and data traffic for which performance measures of WiMAX networks is still to be evaluated and discussed in furure.

References

[1]. B. P. Crow, I. Widjaja, J. G. Kim, “IEEE 802.11 Wireless Local Area Networks”, Proceedings of IEEE Communications, 1997
[2]. D. Malone, P. Clifford, D.J. Leith, “On Buffer Sizing for Voice in 802.11WLANs”, Proceedings of IEEE Communications Letters, 2007
[3]. http://voip.biz-news.com/news/tags/en_US/VoIP
[4]. “Smart Mobile™: Next-Generation Wlan Architecture For High Performance Networks”, A Trapeze Networks White Paper, November 2006.
[5]. D.Y. Chen, S. Garg, M. Kappes, and K. S. Trivedi, “Supporting VBR VoIPtraffic with IEEE 802.11 WLAN in PCF mode”, Proceedings of OPNETWork 2002, Washington D. C., August 2002
[6]. F.E.Retnasothie, M.K. Ozdemir , T.Y’ Cek , H. Celebi , J. Zhang, and R.Muththaiah, “Wireless IPTV over WiMAX: Challenges and Applications”,Proceedings of IEEE WAMICON, 2006
[7]. L. X. Cai, X. (Sherman) Shen, J. W. Mark, L. Cai, Y. Xiao, “Voice CapacityAnalysis of WLAN With Unbalanced Traffic”, Proceedings of IEEETransactions on Vehicular Technologies, Vol. 55, No. 3, May 2006
[8]. N.Nagarajan , Rajeev, B. Kaarthick, “Performnance analysis of VideoConferencing and Multimedia application Services over WiMAX”,Proceedings of IEEE International Advance Computing Conference (IACC2009), Patiala, India, 6-7 March 2009
[9]. G. Chu, D.Wang, S. Mei, “A QoS Architecture for the MAC protocol of IEEE 802.16 BWA System,” Proceedings of IEEE 2002 ICC, Circuits andSystems, vol. 1, July 2002, pp. 435 -439.
[10]. B.Angelov, B.Rao, “The Progression of WiMAX Toward a Peer-to- Peer Paradigm Shift”, Annual Review of Communications, Vol 59, 2007
[11]. J. G. Andrews, A. Ghosh, and R. Muhamed, “Fundamentals of WiMAX”, Prentice-Hall, 2007.
[12]. A. Ghosh et al., “Broadband Wireless Access with WiMax/802.16: Current Performance Benchmarks and Future Potential,” IEEE Comm. Mag., vol. 43, no. 2, Feb. 2005, pp. 129–36
[13]. H.Fattah and C.Leung, “An overview of scheduling algorithms in wireless multimedia networks,” IEEE Wireless Commun., vol.9, no.5, pp.76-83, Oct. 2002
[14]. H.Zhang, “Service Disciplines for Guaranteed Performance Service in packet switching Networks,” Proceedings of the IEEE, vol. 83, pp. 1374-96, Oct. 1995,
[15]. R.Guerin and V.Peris, “Quality-of-service in Packet Networks: Basic Mechanisms and Directions,” Computer Networks, vol.31, pp.169-89, Feb. 1999.
[16]. F. Wang, A. Ghosh, C. Sankaran, P. J. Flemming, F. Hsieh, and S. J.Benes, “Mobile WiMAX Systems: Performance and Evolution,” in IEEECommun. Mag., vol. 46, no. 10, pp. 41–49, Oct. 2008.
[17]. Taeshik Shon, Wook Choi: An Analysis of Mobile WiMAX Security: Vulnerabilities and Solutions, First International Conference, NBiS 2007, LNCS, Vol. 4650, pp. 88-97, 2007.
[18]. D. Gray, “Mobile WiMAX – Part II: A Comparative Analysis,” May, 2006. pp. 14 - 41.
[19]. R. Guerin and V. Peris, “Quality of Service in Packet Networks: Basic mechanisms and Directions”, Computer Networks, Vol. 31, Page(s): 169 – 189, February 1999
[20]. Guosong Chu, Deng Wang and Shunliang Mei, “A QoS architecture for the MAC protocol of IEEE 802.16 BWA System”, IEEE International Conference on Communications, Circuits and Systems and West Sino Expositions, Page(s) : 435-439, June, 2002.
[21]. G. Nair, J. Chou, T. Madejski, K. Perycz, D. Putzoly and J. Sydir, “IEEE 802.16 Medium Access Control and Service Provisioning”, Intel Technology Journal, Volume: 08, Issue: 03, Page(s): 213-28, August, 2004.
[22]. Jianfeng Chen, Wenhua Jiao and Qian Guo, “An Integrated QoS Control Architecture for IEEE 802.16 Broadband Wireless Access System”, Lucent Technologies, Bell Labs Research, China, 2005.
[23]. H.S. Alavi, M. Mojdeh, and N. YAZDABUM “a Quality of Service Architecture for IEEE 802.16 Standards”, Proceedings of 2005 Asia-Pacific Conference on Communications, Page(s): 249-253, October 2005.
[24]. “Can WiMAX addres your allocation”, Prepared on Behalf of the WiMAX Forum, October, 2005.
[25]. “Mobile WiMAX-Part I: A Technical Overview and Performance Evaluation”, Prepared on Behalf of the WiMAX Forum, February, 2006.
[26]. Cicconetti C., Lenzini L., Mingozzi E. and Eklund C, “Quality of Service Support in IEEE 802.16 Networks”, IEEE Networks, Volume 20, Issue 2, Page(s) : 50 – 55, March-April, 2006.

[27]. Luis Felipe M. de Moraes and Paulo Ditarso Maciel Jr., "An Alternative QoS Architecture for the IEEE 802.16 Standard", ACM, CoNext, 2006.

[28]. Kamal Gakhat, Mounir Achir and Annie Gravey, "How many traffic classes do we need in WiMAX?, IEEE Wireless Communications & Networking Conference, 2007.

[29]. Sahar Ghazal, Lynda Mokdad and Jalel Ben-Othman, "Performance Analysis of UGS, rtPS, nrtPS Admission Control in WiMAX Network", IEEE International Conference on Communications, Page(s): 2696-2701, May, 2008

[30]. Guannan Qu and Zhiyi Gang, "A new QoS Guarantee Strategy in IEEE802.16 MAC Layer", IEEE Third International Conference on Pervasive Computing and Applications", Page(s): 157-162, October 2008.

[31]. Kaarthick, V. J. Yeshwenth, N. Nagarajan and Rajeev, "Performance analysis of Video Conferencing and Multimedia application Services over WiMAX", IEEE International Advance Computing Conference, Page(s):1109-1123, March 2009.

[32]. Rohit A. Talwalkar and Mohammad Ilyas, "Analysis of Quality of Service (QoS) in WiMAX Networks", IEEE International Conference on Networking, 2008.

[33]. J. Farooq and T. Turletti, "An IEEE 802.16 WiMAX Module for the NS-3 Simulator" 2nd International Conference on Silumation Tools and Techniques (SIUTools'09), March, 2009.

[34]. Elias Weingartner, Hendrik vom Lehn and Klaus Wehrle, "A Performance Comparison of Recent Network Simulators". IEEE International Conference on Communications, Page(s): 1 – 5, June, 2009.

[35]. Malik Mohammad Asim and Muid Mufti. "Design and Implementation of IEEE 802.16 MAC Layer Simulator", International Journal of Computer Science and Network Security, Page(s): 53-59, August, 2009.

[36]. M.A. Ismail, G. Piro, L.A. Grieco and T. Turletti, " An Improved IEEE 802.16 WiMAX Module for the NS-3 Simulator", International Conference on Simulation Tools and Techniques (SIMUTools'10), March, 2010.