A Survey on adaptive scheduling and digital modulation schemes over IEEE 802.16 Standard

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ABSTRACT

Wireless networks are generally less efficient and unpredictable compared to wired ne`tworks, which make quality of service (QoS) provisioning a bigger challenge for wireless communications. The evergreen demand for fast delivery of large volumes of data is one of the challenging task for wireless communication technology. IEEE 802.16 standard or WiMAX is a wireless broadband solution that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offerings. But Delivering QoS is more challenging for mobile broadband than for fixed. The wireless medium has limited bandwidth, higher packet error rate, and higher packet overheads that altogether limit the capacity of the network to offer guaranteed QoS. Here we provide an overview of different scheduling and digital modulation schemes that are the key functions in the MAC common part sub layer.

Keyword : **- WiMAX, QoS, IEEE 802.16.**

I. INTRODUCTION

Broadband wireless systems could be: Fixed Broadband Wireless or Mobile Broadband Wireless. Applications using a fixed wireless solution can be classified as point-to-point or point-to-multipoint. Point-to-point applications include inter-building connectivity within a campus and microwave backhaul. Point-to-multipoint applications include broadband for residential, small office/home office (SOHO), and small- to medium-enterprise (SME) markets, T1 or fractional T1-like services to businesses, and wireless backhaul for Wi-Fi hotspots. Although initial WiMax deployments are likely to be for fixed applications, the full potential of WiMax will be realized only when used for innovative nomadic and mobile broadband applications. WiMax technology in its IEEE 802.16e-2005 incarnation will likely be deployed by fixed operators to capture part of the wireless mobility value chain in addition to plain broadband access. As end users get accustomed to high-speed broadband at home and work, they will demand similar services in a nomadic or mobile context, and many service providers could use WiMax to meet this demand. Various technical challenges associated with meeting the service requirements for broadband wireless, along with potential solutions

WiMAX is a standard that is championed by the WiMAX forum which was formed in June 2001 to promote conformance to IEEE 802.16 standard. The WiMAX forum currently has more than 470 members comprising the majority of operators, component, and equipment companies in the communications ecosystem. The WiMAX forum promotes interoperability by working closely with IEEE and other standards groups such as the European Telecommunications Standards Institute (ETSI) which have their own versions of broadband wireless. Along these lines, the WiMAX forum works closely with service providers and regulators to ensure that WiMAX forum certified systems meet customer and government requirements.

WiMAX will boost today's fragmented broadband wireless access market and mobile WiMAX promises to offer a solution to closing the existing digital divide. WiMAX can address the fixed wireless access and portable Internet market, complementing other broadband wireless technologies. Government initiatives to reduce the digital divide are making gains for broadband wireless countries such as Australia, South Korea, Taiwan, and the United States have programs in place today, and there has been a push by the European Commission for more flexible spectrum policies. WiMAX access can be easily integrated within both fixed and mobile architectures, enabling operators to integrate it within a single converged core network, thereby providing new capabilities for a user-centric broadband world. WiMAX addresses the following needs which may answer the question of closing the digital divide :

- Cost effective
- Offers high data rates

- Supports fixed, nomadic, and mobile applications thereby converging the fixed and mobile networks
- Easy to deploy and has flexible network architectures
- Supports interoperability with other networks
- Aimed at being the first truly a global wireless broadband network

In Figure 1, the overall network architecture of a WiMAX network. The network can be logically partitioned into three components, user terminals, ASN, and CSN. User terminals capture the data origination points, could be using the fixed, mobile, or portable WiMAX technology. All the three variations can be supp orted using a common air interface.

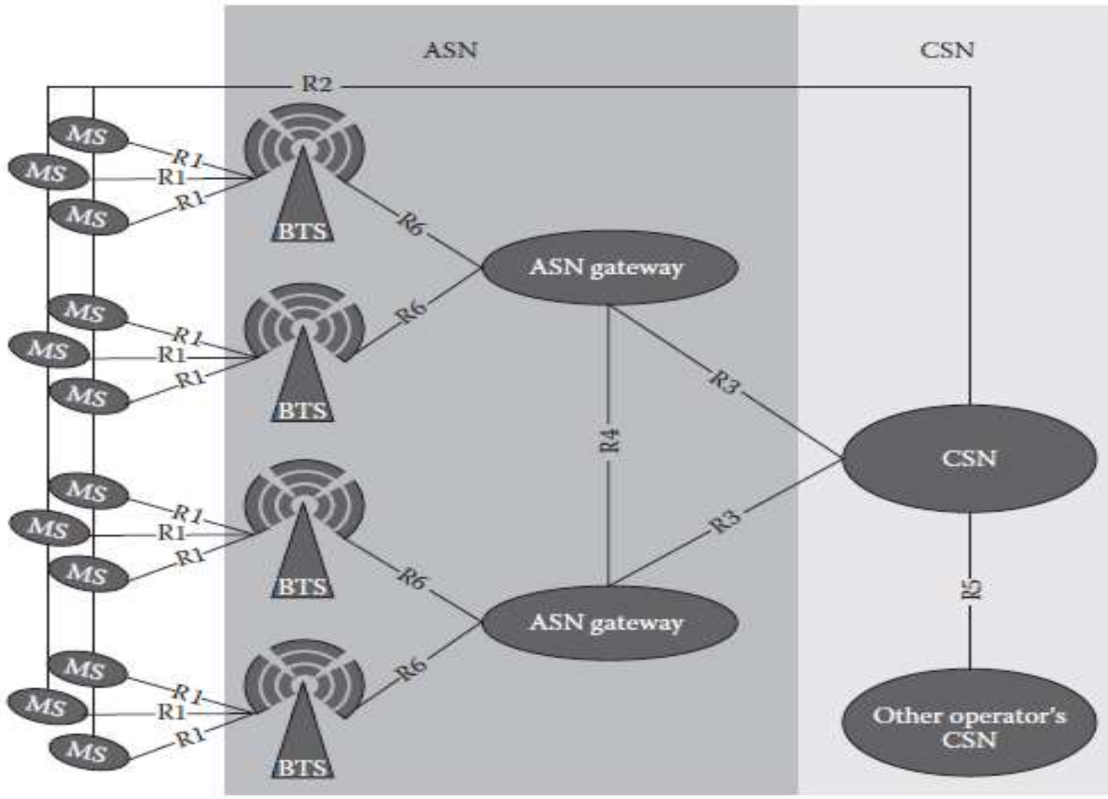

Figure 1: Logical network architecture of a WiMAX network.

ASN spans the BS and the ASN-GW. BS receives the transmitted signal, processes it, and converts into an IP packet and sends to the GWon the outgoing IP transport link. GWreceives and upon processing determines the destination on the network side and sends the packet. BS and GW are connected to each other using an IP transport. Typical implementations would have BS located in the field/cov erage area and the GW will be centrally located in the switch centers. Therefore, the IP link between BS andGW forms the transport backhaul network. CSN contains many different commercial off-the shelf (COTS) components, which provide connectivity services to the WiMAX subscribers. Addressing, authentication, and availability (AAA) servers, mobile IP home agent (MIP HA), IP multimedia services (IMS), content services, etc. provide support for seamless services to subscribers. AAA servers ensure that a user is uniquely identified and authenticated as legitimate customer. MIP HA ensures that roaming across IP networks is handled and accurate routing of data packets is ensured. Call processing related services is provided by IMS entity. Billing and operational support systems help in managing the overall network. The ASN gateway performs functions of connection and mobility management and inter service provider network boundaries through processing of subscriber control and bearer data traffic. It also serves as an Extensible Authentication Protocol (EAP) authenticator for subscriber identity and acts as a Remote Authentication Dial-In User Service (RADIUS) client to the operator's AAA servers.

A. Digital Modulations

As for all recent communication systems, WiMAX /802.16 uses digital modulation. The now well-known principle of a digital modulation is to modulate an analogue signal with a digital sequence in order to transport this digital sequence over a given medium: fibre, radio link, etc..

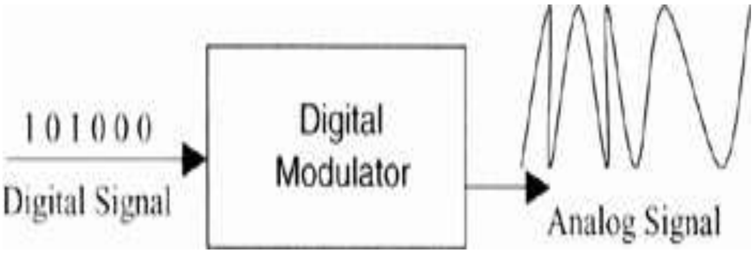

Figure 2: Digital modulation principle

Four modulations are supported by the IEEE 802.16 standard BPSK, QPSK, 16-QAM and 64-QAM. In this section the modulations used in the OFDM and OFDMA PHYsical layers are introduced with a short explanation for each of these modulations.

A. **Binary Phase Shift Keying (BPSK) :**

The BPSK is a binary digital modulation; i.e. one modulation symbol is one bit. This gives high immunity against noise and interference and a very robust modulation. A digital phase modulation, which is the case for BPSK modulation, uses phase variation to encode bits: each modulation symbol is equivalent to one phase. The phase of the BPSK modulated signal is π or -¯π according to the value of the data bit.

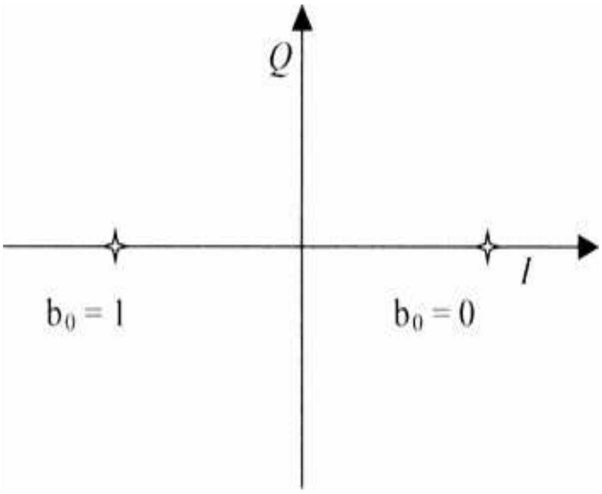

Figure 3: The BPSK constellation

B. **Quadrature Phase Shift Keying (QPSK) :**

When a higher spectral efficiency modulation is needed, i.e. more b/s/Hz, greater modulation symbols can be used. For example, QPSK considers two-bit modulation symbols.Many variants of QPSK can be used but QPSK always has a four-point constellation.

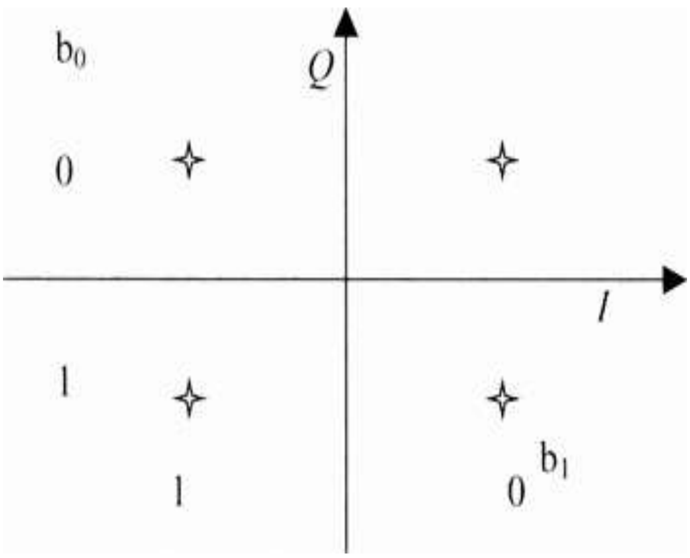

Figure 4: Example of a QPSK constellation

C. Quadrature Amplitude Modulation (QAM): 16-QAM and 64-QAM :

The QAM changes the amplitudes of two sinusoidal carriers depending on the digital sequence that must be transmitted; the two carriers being out of phase of $+\pi/2$, this amplitude modulation is called quadrature. It should be mentioned that according to digital communication theory, QAM-4 and QPSK are the same modulation (considering complex data symbols). Both 16-QAM (4 bits/modulation symbol) and 64-QAM (6 bits/modulation symbol) modulations are included in the IEEE 802.16 standard.

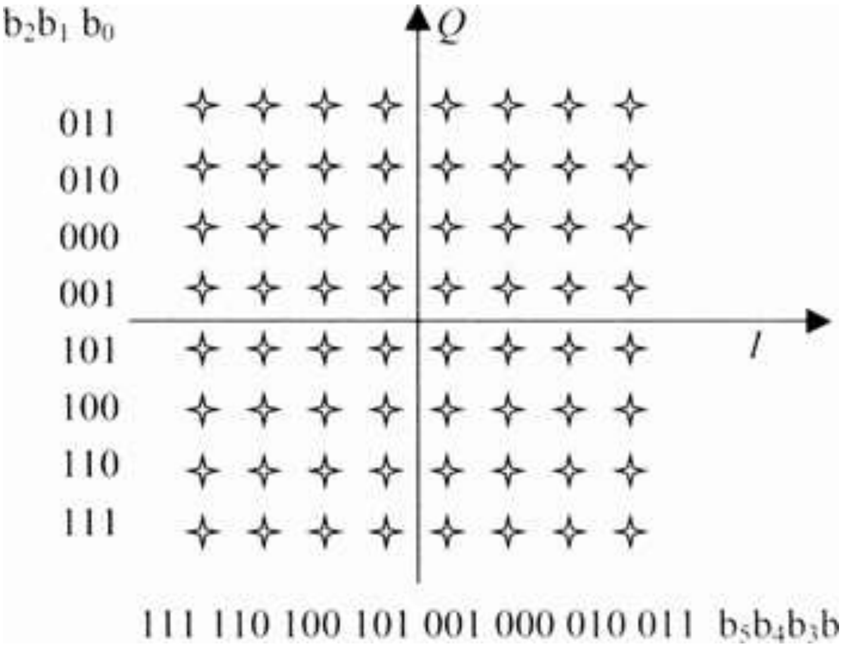

Figure 5: A 64-QAM constellation

2. WIMAX- SCHEDULING SERVICES

The IEEE 802.16 standard provides powerful tools in order to achieve different QoS constraints. The 802.16 standard MAC Layer provides QoS differentiation for the different types of applications that might operate over 802.16 networks, through five defined scheduling service types, also called QoS classes. Four scheduling services were defined in 802.16e:

a) Unsolicited Grant Service (UGS);
b) real-time Polling Service (rtPS);
c) non-real-time Polling Service (nrtPS);
d) Best Effort (BE).
e) Extended Real-time Polling Service (ertPS);

a) Unsolicited Grant Service (UGS)

The UGS scheduling service type is designed to support real-time data streams consisting of fixed-size data packets issued at periodic intervals. This would be the case, for example, for TI/EI classical PCM (Pulse Coded Modulation) phone signal transmission and Voice over IP without silence suppression.

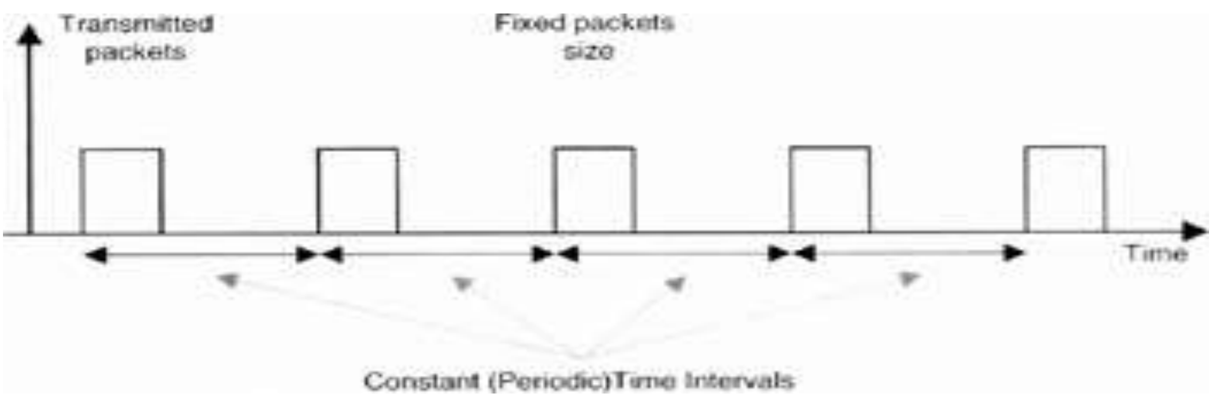

Figure 7: UGS scheduling service uplink grants allocation mechanism

In a UGS service, the BS provides fixed-size data grants at periodic intervals. This eliminates the overhead and latency of SS requests. Figure 7 illustrates the UGS mechanism. The BS provides Data Grant Burst IEs to the SS at periodic intervals based upon the maximum sustained traffic rate of the service flow. The size of these grants is sufficient to hold the fixed-length data associated with the service flow, taking into account the associated generic MAC header and grant management subheader.

b) Real-Time Polling Service (rtPS)

The rtPS scheduling service type is designed to support real-time data streams consisting of variable-sized data packets that are issued at periodic intervals. This would be the case, for example, for MPEG (Moving Pictures Experts Group) video transmission.

In this service, the BS provides periodic unicast (uplink) request opportunities, which meet the flow's real-time needs and allow the SS to specify the size of the desired grant. This service requires more request overheads than UGS, but supports variable grant sizes for optimum real-time data transport efficiency. Figure 8 shows the rtPS mechanism.

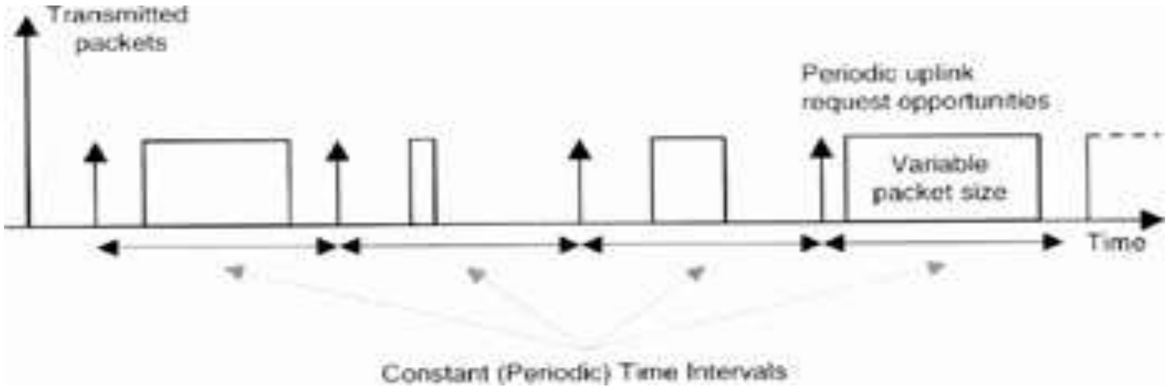

Figure 8: rtPS scheduling service uplink grants allocation and request mechanism

c) Non-Real-Time Polling Service (nrtPS)

The nrtPS is designed to support delay-tolerant data streams consisting of variable-size data packets for which a minimum data rate is required. The standard considers that this would be the case, for example, for an FTP transmission. In the nrtPS scheduling service, the BS provides unicast uplink request polls on a ‘regular’ basis, which guarantees that the service flow receives request opportunities even during network congestion. The standard states that the BS typically polls nrtPS CIDs on an interval on the order of one second or less. In addition, the SS is allowed to use contention request opportunities, i.e. the SS may use contention request opportunities as well as unicast request opportunities. Figure 9 shows the nrtPS mechanism.

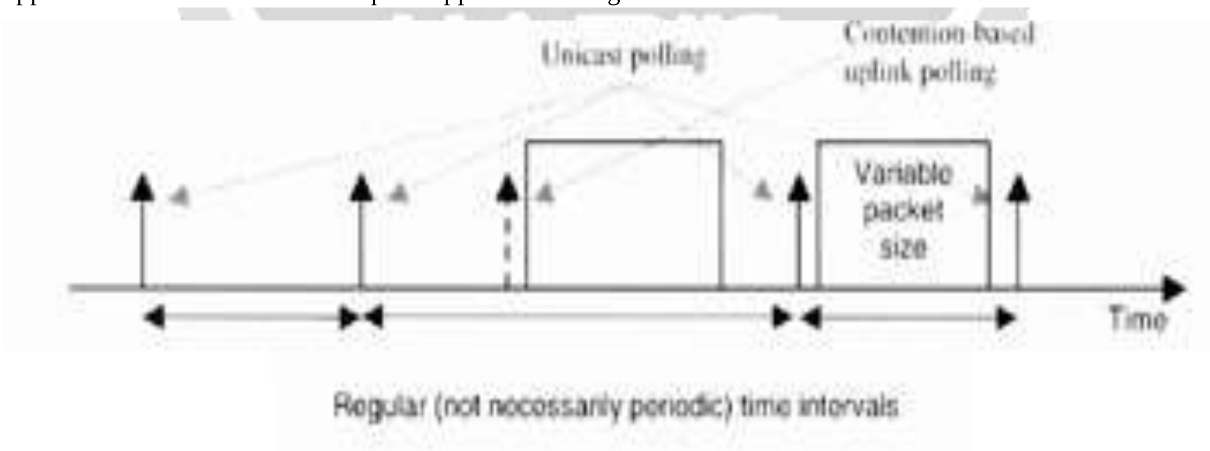

Figure 9: Illustration of the nrtPS scheduling service uplink grants allocation and request mechanism.

d) Best Effort (BE)

The BE service is designed to support data streams for which no minimum service guarantees are required and therefore may be handled on a best available basis. The SS may use contention request opportunities as well as unicast request opportunities when the BS sends any.

The BS do not have any unicast uplink request polling obligation for BE SSs. Therefore, a long period can run without transmitting any BE packets, typically when the network is in the congestion state. Figure 10 shows the BE mechanism.

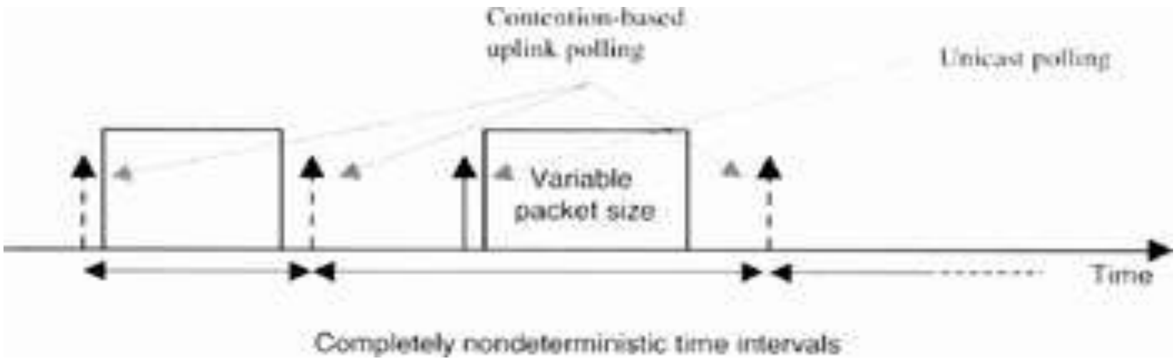

Figure 10: Illustration of the BE scheduling service uplink grants allocation and request mechanism.

II. RELATED WORK

Tarik Anouari et al. [1] analyzed throughput for different number of mobile nodes using different codecs and different service classes. It was found that up to six mobile nodes throughput increases then it decreases. rtPS service class drops steeper than others in all the codec techniques used. Jitter is highest for BE where it increases steeply after number of mobile nodes pass six. rtPS shows some increase after six nodes but decreases after eight nodes. UGS is better among all, it increases with small values after six mobile nodes. Delay is not observed till number of mobile nodes is four. After six nodes, BE and rtPS increase steeply for delay while UGS increases with some small values. Till six nodes, rtPS work better than BE but UGS performed the best of all in all codec techniques used. UGS has fixed sized packets as needed by the real-time applications. QoS is an inherit property of the telecommunication network wherein the degree of the meeting the requisite contract by it in the adverse conditions is measured. The improvement in the performance of WiMax id measured by the improvement in the QoS factors like throughput, jitter, and delay and packet loss. IEEE 802.16 has included five different QoS classes to WiMax which spans over a wide range of the applications like video and voice streaming, real-time conversation, web-based applications and so on. These service classes include Best Effort (BE), Extended real-time Polling service (ertPS), Real-time Polling service (rtPS), Non real-time Polling service (nrtPS) and Unsolicited Grant service (UGS). Voice over IP is the transport of voice data over the IP network parallel to PSTN for clearer and efficient voice service. SIP and H.323 are the protocols used. Real-time protocol (RTP) and User Datagram Protocol work together for VoIP.

R.A. Talawalker et.al [2] worked QoS parameters underline the performance of the WiMax network. They worked on QoS parameters like throughput, packet loss, average jitter and average delay on VoIP and video traffic and found lesser values for QoS parameters using UGS for about 50 mobile nodes. This work used regression analysis on QoS parameters on higher number of mobile nodes in real-time environment. QoS service classes in WiMax type of application decides the services needed and thereby decide QoS. 802.16 have decided four service classes and fifth one ertPS is included in 802.16e. These are in order of the decreasing priority UGS, rtPS, ertPS, nrtPS, BE. Delay could decide the type of application. **UGS:** Unsolicited Grant Service has the highest priority where bit rate is constant and delay dependent applications are involved like VoIP. **rtPS:** real-time Polling Service has second priority where variable bit rates and delay dependent applications are included like streaming video and streaming audio. **ertPS:** extended real-time Polling service was included in 802.16e has third priority where bit rate was kept variable and delay dependent applications were included like VoIP and silence suppression. **nrtPS:** non real-time Polling service has fourth priority where bit rate was variable and delay-dependent applications included like FTP. **BE:** Best Effort has least priority among the service classes where best efforts are included in applications like emails and web traffic.

J. B. Othman et.al. [3] presented a new admission control (AC) for IEEE 802.16. The AC aims to accept new connections according to the negotiated service class (UGS, rtPS, nrTPS, and BE). The authors propose to use the token bucket concept that provide QoS for real time traffics without degrading the QoS of non real time traffic. With the diversity of service and in order to avoid any degradation of the active connection, and Admission Control (AC) is defined to limit the number of connections in the network. This mechanism is not specified in the standard and it is let to the operators. The major AC defined in the literature are based on merging real time traffics in one service class and the others in another class or on the strict priority. The advantage of this method is that we reduce lightly the number of high priority but increase considerably the number of low priority traffic. To show the benefit of the proposed AC, authors have developed an analytical model based on Markov Chains that compare strict priority with our AC and numerical results show that the proposed solution decrease the overall QoS of UGS traffic of 05% while we increase it of more than 75% for the other traffics.

Laxmi Shrivastava et. al. [4], a new algorithm named as load balanced congestion adaptive routing (LBCAR) algorithm has been proposed for randomly distributed networks in which two metrics - traffic load density and life time associated with a routing path, have been used to determine the congestion status and weakest node of the route and the route with low traffic load density and maximum life time is selected for packet transmission. This algorithm combines the idea of load balancing and congestion adaptions effectively in AODV and limits the idealized maximum number of packets transmittable through the route having weakest node with minimum life time. It can adaptively adjust the forwarding probability of RREQ messages according to the distribution and load status of nodes and link cost in route discovery phase. Simulation results indicate that, compared with original AODV and DSR, LBCAR can significantly reduce the packet loss balancing the load in the network and increasing the network life time with varying pause time.

J. B. Othman et.al. [5] presented a new admission control (AC) for IEEE 802.16. The AC aims to accept new connections according to the negotiated service class (UGS, rtPS, nrtPS, and BE).

Jintana Nakasuwan et al. [6] studied performance of the protocol is defined by average throughput. An announcement is done by the nodes to show their presence to the neighbors. This learns for route discovery. Nodes have routing tables which are constantly updating for efficient routing. A best routing algorithm chooses the best path in terms of no. of hops, reliability and throughput. Routing protocols are classified on routing strategy, network structure and how quickly link failure is detected and new route is restored to minimize packet loss. In proactive routing protocols, nodes have routing updated tables present at the configuration of the network. Routing tables are constantly updating through frequent information exchange with the nodes of the network, which is an overhead. Proactive protocols are maximally based on the Link State Routing as Optimized LSR. Reactive protocols discover route when the need arise. There is latency between route request and route discovery. Efficiency of the routing protocol is defined by the performance and reliability of the protocol. AODV and OLSR are compared in terms of average throughput using ns-2 simulation. AODV outshines OLSR because periodic control traffic in OLSR creates overheads. OLSR tries to push some flows beyond their saturation against degradation of other flows to increase the throughput.

Rakesh Kumar Jha et al. [7] presented a concept of our WiMAX (Worldwide Interoperability for Microwave Access) network performance for QoS monitoring and optimization solution for BS (Base Station) with multimedia application. In the communication sector, the optimal objective is to equate quality and cost. Due to its large coverage area, low cost of deployment and high speed data rates. WiMAX is a promising technology for providing wireless last-mile connectivity. Physical and MAC layer of this technology refer to the IEEE 802.16e standard, which defines 5 different data delivery service classes that can be used in order to satisfy Quality of Service (QoS) requirements of different applications, such as VoIP, videoconference, FTP, Web, etc. In this paper we have made six scenarios. Here two types of MAC layer QoS are used and they are UGS and rtPS having application of Voice over IP (VoIP) and MPEG respectively. Also the traffic priority for UGS is high as compared to rtPS. In each scenario the number of fixed nodes (Fixed Subscriber Stations) and Mobile nodes (Mobile Subscriber Stations) are different. To cover more nodes or if nodes are outside the coverage area more than one BS are required.

L.D.Malviya et.al [8] presented an Adaptive modulation enables a WiMAX system to optimize the throughput based on propagation conditions. IEEE802.16 (WiMAX) system support BPSK, QPSK, 16-QAM and 64-QAM and the access scheme is OFDM. This paper presents the performance of different variants of transmission control protocols with different modulation schemes when density of mobile nodes changes.

In [9], J. B. Othman et.al. present a new admission control (AC) for IEEE 802.16. The AC aims to accept new connections according to the negotiated service class (UGS, rtPS, nrTPS, and BE).

In [10] M. Rehan Rasheed et.al. investigates different routing protocols and their performances on 802.16 WiMAX networks. Using simulation, different routing protocols have been tested with various network parameters. Results show that DSDV in general outperforms other routing protocols.

In [11], L.D.Malviya et.al present an Adaptive modulation enables a WiMAX system to optimize the throughput based on propagation conditions. IEEE802.16 (WiMAX) system support BPSK, QPSK, 16-QAM and 64-QAM and the access scheme is OFDM. This paper presents the performance of different variants of transmission control protocols with different modulation schemes when density of mobile nodes changes.

III. CONCLUSION AND FUTURE WORK

These are specific implementations, selections of options within the 802.16e standard, to suit particular ensembles of service offerings and subscriber populations. Although the routing and resource allocation for OFDM-based networks has been well studied in the literature, different routing and modulation schemes have been specifically designed for WiMAX. These schemes should be modified or new schemes should be defined for OFDM-based WiMAX to effectively utilize the network resources and improve the network performance for integrated voice, video, and data services over fixed, nomadic, portable, and fully mobile users. WiMax or IEEE 802.16 standard is definitely a hot topic and has a fair list of industry supporters. An appropriate digital and bandwidth allocation scheme for OFDM based WiMAX should consider diverse QoS requirement of heterogeneous traffic and mobility issues simultaneously, because a scheme that guarantees QoS for one type of traffic in a fixed network may not perform well for a different type of traffic in a fully mobile network. Moreover, the routing schemes should balance between users requirements and service providers revenue.

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