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Review of Qos Parameters for Wimax Environment

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Abstract: Broadband wireless access (BWA) has emerged as a promising solution for last mile access technology to provide high speed internet access. At this moment, cable and digital subscriber line (DSL) technologies are providing broadband services. But the practical difficulties in deployment have prevented them from reaching many potential broadband internet customers. Many areas throughout the world currently are not under broadband access facilities. Especially a developing country like India even many urban and suburban locations may not be served by DSL connectivity. WiMax is one of the next generation wireless networking standard provides a cost effective solution for wireless network ensuring QoS. All difficulties those have been faced while using wired DSL network can be overcome by WiMax, which is faster to deploy , easier to scale and more flexible because of its wireless nature. Use of OFDM modulation makes it a true BWA technology. There are several environmental factors affect the performance, stability and accuracy. These factors can be listed as Degree of Connectivity among Nodes, Degree of Mobility, Number and Duration of Data Flows. Understanding the performance of routing protocols in dynamic networks is a key feature to determine which routing protocol is best suited for which type of network scenario. This paper presents a thorough overview of some of the QoS parameters and routing protocols along with their strengths and weaknesses. A comparative study of the QoS parameters and routing protocols is done and in addition, the current issues and future challenges that are involved in this exciting area of research are also included.

Keywords- WiMAX, OFDM, rtPS, nrtPS, UGS, BE

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 as summarized in Table I and Table II:

TABLE I
SERVICE REQUIREMENTS, CHALLENGES AND SOLUTIONS

Service Requirements	Technical Challenge	Potential Solution
Non-line-of-sight coverage	Mitigation of multipath fading and interference	Diversity, channel coding, etc.
High data rate and capacity	Achieving high spectral efficiency	Cellular architecture, adaptive modulation and coding, spatial multiplexing, etc.
	Overcoming intersymbol interference	OFDM, equalization, etc.
	Interference mitigation	Adaptive antennas, sectorization, dynamic channel allocation, CDMA, etc.
Quality of service	Supporting voice, data, video, etc. on a single access network	Complex MAC layer
	Radio resource management	Efficient scheduling algorithms
	End-to-end quality of service	IP QoS: DiffServ, IntServ, MPLS, etc.
Mobility	Ability to be reached regardless of location	Roaming database, location update, paging
	Session continuity while moving from the coverage area of one base station to another	Seamless handover
	Session continuity across diverse networks	IP-based mobility: mobile IP

TABLE II
SERVICE REQUIREMENTS AND THEIR CHALLENGES AND SOLUTIONS

Service Requirements	Technical Challenge	Potential Solution
Portability	Reduce battery power consumption on portable subscriber terminals	Power-efficient modulation; sleep, idle modes and fast switching between modes; low-power circuit; efficient signal-processing algorithms
Security	Protect privacy and integrity of user data	Encryption
	Prevent unauthorized access to network	Authentication and access control
Low cost	Provide efficient and reliable communication using IP architecture and protocols	Adaptation of IP-based protocols for wireless; adapt layer 2 protocols for IP

II. NETWORK ARCHITECTURE

The WiMax Forum's Network Working Group [3], is responsible for developing the end-to-end network requirements, architecture, and protocols for WiMax, using IEEE 802.16e-2005 as the air interface. The network reference model envisions unified network architecture for supporting fixed, nomadic, and mobile deployments and is based on an IP service model. Fig.1 shows a simplified illustration of IP-based WiMax network architecture. [2] The overall network may be logically divided into three parts:

[a] Mobile Station (MS)

It is for the end user to access the mobile network. It is a portable station able to move to wide areas and perform data and voice communication. It has all the necessary user equipments such as an antenna, amplifier, transmitter, receiver and software needed to perform the wireless communication. GSM, FDMA, TDMA, CDMA and W-CDMA devices etc are the examples of Mobile station. Mobile stations used by the end user to access the network.

[b] Access Service Network (ASN)

It is owned by NAP, formed with one or several base stations and ASN gateways (ASN-GW) which creates radio access network. It provides all the access services with full mobility and efficient scalability. Its ASN-GW controls the access in the network and coordinates between data and networking elements. ASN comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge.

[c] Connectivity Service Network (CSN)

Provides IP connectivity to the Internet or other public or corporate networks. It also applies per user policy management, address management, location management between ASN, ensures QoS, roaming and security. CSN provides IP connectivity and all the IP core network functions.

The architecture allows for three separate business entities:

1. Network access provider (NAP)

NAP owns and operates the ASN;

2. Network services provider (NSP)

NSP provides IP connectivity and WiMax services to subscribers using the ASN infrastructure provided by one or more NAPs;

3. Application service provider (ASP)

ASP can provide value-added services such as multimedia applications using IMS (IP multimedia subsystem) and corporate (virtual private networks) that run on top of IP.

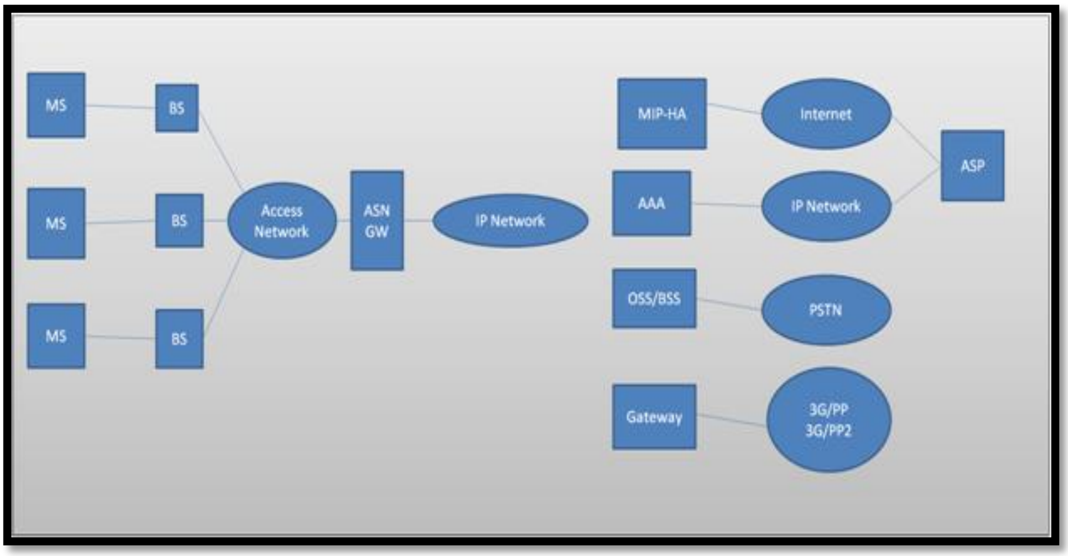

Fig.1. WiMax architecture based on IP

III. WIMAX PHYSICAL LAYER

The WiMax physical layer is based on orthogonal frequency division multiplexing. OFDM is the transmission scheme of choice to enable high-speed data, video, and multimedia communications and is used by a variety of commercial broadband systems, including DSL, Wi-Fi, Digital Video Broadcast-Handheld (DVB-H), and Medial, besides WiMax. [3], [5] the physical of WiMax is named as OFDM belong to multicarrier modulation family. Higher data rate streams are divided to several lower rate streams called tones or subcarriers. The symbols sent across are orthogonal to one another to avoid ISI. Guard intervals are also provided. OFDM is implemented through FFT. Fixed WiMax use 256 OFDM-based physical layer while mobile WiMax use FFT-based OFDMA physical layer varying between 128 and 2048 subcarriers. WiMax physical layer have slots and frames over air interface as shown in Fig 2.

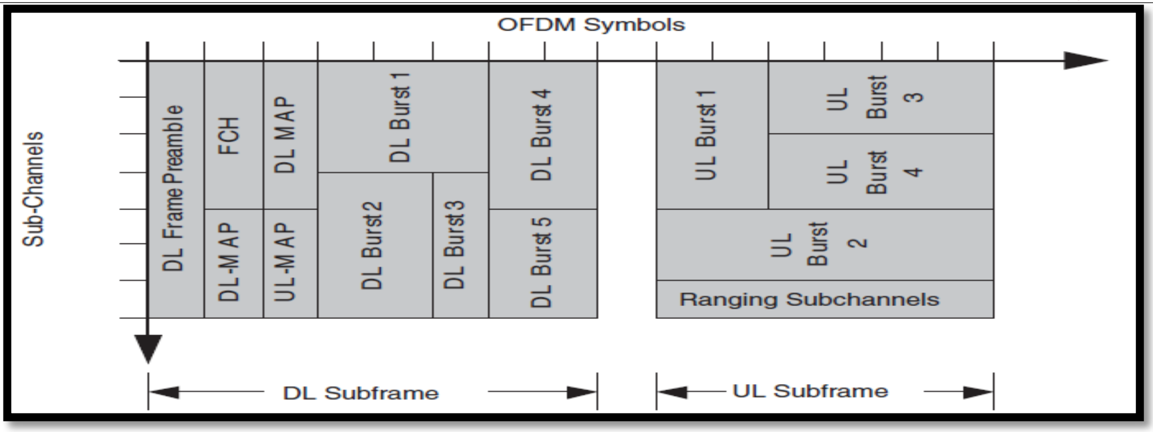

Fig.2. OFDM frame

[a] Orthogonal Frequency Division Method

Brief review the key steps in an OFDM communication system (Fig.3). In OFDM, the encoding and decoding are done in the frequency domain, where X, Y, and contain the L transmitted, received, and estimated data symbols. A group of L data symbols form a block called OFDM block has duration of T seconds are separated by guard time show delay on reception. Formation of data blocks and guard time avoids ISI. Frequency domain conversion using Discrete Fourier Transformation and Circular convolution is done. Cyclic Prefix is the main player of the show where DFT and circular convolution is used. If the maximum channel delay spread has a duration of v +1 samples, adding a guard band of at least v samples between OFDM symbols makes each OFDM symbol independent of those coming before and after it, and so only a single OFDM symbol can be considered. Transmitted signal is appended with some tailing segment of the same signal. Upon reception, circular convolution of signal with length of the v +1 samples evaluate the samples back. The cyclic prefix comes with both bandwidth and power penalty. Cyclic Prefix is important to avoid multipath delay. [1]Some practical issues are neglected, for example, assume that the transmitter and the receiver are perfectly synchronized and that the receiver perfectly knows the channel, in order to perform the FEQ.

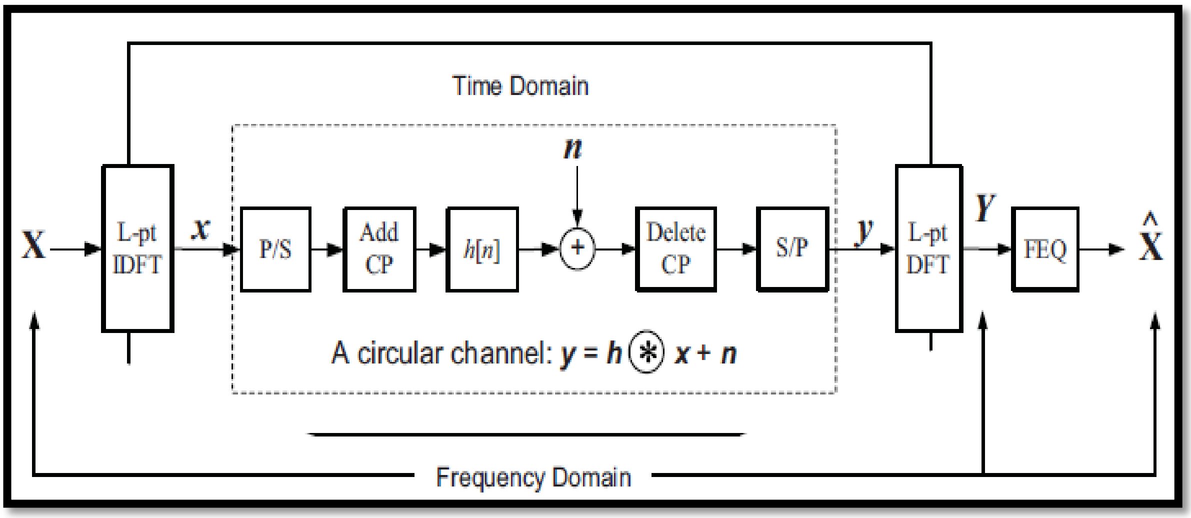

Fig.3. Functional stages of a WiMax PHY layer

IV. SCHEDULING SERVICES OR QOS CLASSES

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.

There are five scheduling services were defined in 802.16e [11]:

TABLE III
QOS SERVICE CLASSES IN WIMAX

Service	Description	QoS parameters
UGS (Unsolicited Grant Service)	Support of real-time service flows that generate fiixed-size data packets on a periodic basis, such as VoIP without silence suppression	Maximum sustained rate Maximum latency tolerance Jitter tolerance
rtPS (Real-Time Polling Service)	Support of real-time service flows that generate transport variable size data packets on a periodic basis, such as streaming video or audio	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Traffic priority
ertPS (Extended real-time Polling Service)	Extension of rtPS to support traffic flows such as variable rate VoIP with Voice Activity Detection (VAD)	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Jitter tolerance Traffic priority
nrtPS (Non- real time Polling Service)	Support for non-real-time services that require variable size data grants on a regular basis	Minimum reserved rate Maximum sustained rate Traffic priority
BE (Best Effort)	Support for best-effort traffic	Maximum sustained rate Traffic priority

V. SURVEY OF QOS ROUTING PROTOCOLS

A number of routing algorithms have been developed to operate efficiently in mobile networking context. These algorithms can be classified into different categories based on the following qualitative and quantitative properties:

Demand Based Routing

Distributed Routing

Position based Routing

Flat Routing

Hierarchical Routing

[a] Demand Based Routing

In demand based routing, routes are discovered when they are needed. In other words, routes are not pre-computed; rather they are searched on demand. However, in other approaches routes are continuously evaluated independent of the demand. Based on the time when the routes are discovered routing protocols can be classified as proactive, reactive and hybrid.

1. Proactive (Table Driven): Protocols are based on distance vector/ link state algorithms. These algorithms attempt to monitor the current status of network topology by maintaining routing tables. The information in tables may be updated periodically at regular time intervals. Alternatively, the information in table may be updated when an event occur independent of traffic demand. An event may be a predefined distance traveled by a node, or a predefined number of links formed or broken by the movement of a node.

The advantage of such protocols is that route information for each destination is available whenever required. On the other hand these protocols waste network capacity to keep routing information current, even though most of information becomes stale even before it is used, due to node mobility. The communication overhead involved in maintaining global information about the networks is not acceptable for networks whose bandwidth and battery power are severely limited. These protocols work well for small size of networks with low mobility rate of nodes.

2. Reactive (On Demand)**:** Protocols discover the routes when they are required. These algorithms minimize the communication overheads and are adaptive to sleep period operation since inactive nodes do not participate at the time when route is established. On-demand protocols typically have the following components:

Route discovery (destination search)

When the source node S needs to send a message to destination D, it issues a destination search request if route to destination D is not available. Flooding a short message performs the destination search, so that each node in the network is reached. Path to destination is memorized in the process.

Route reply

When the destination node D receives the first short search message, D will send a route reply message to the source through the path obtained by reversing the path followed by the route request received by D. The route reply message may contain exact location, time, mobility rate, etc of destination.

Routing data message

After receiving route reply, the source node S then sends a data message (long message) towards the exact location of destination through the route obtained from the route reply message. The efficiency of destination search depends on the corresponding location update scheme.

Route maintenance

The routes discovered are stored in the route table temporarily while it is in use or for some limited time to avoid frequent route discovery. A source restarts a route discovery procedure whenever it detects that a previously discovered route is obsolete.

Route erasure

Obsolete route information or non-active routes are removed from routing tables to check the table size. These protocols reduce redundant routing information in the network, do not waste network capacity on updates, and allow nodes to save power by going into sleep modes. On the other side, these protocols may suffer from high route latency. Also, the routes discovered using flooding, may cause large overheads, nullify the savings on updates.

3. Hybrid Protocols: Some protocols attempt to get the best of both worlds by limiting proactive routing to the local neighborhood of a node and using efficient reactive routing beyond it. Such protocols are known as hybrid protocols.

[b] Distributed Routing

In distributed routing, routing decisions are made independently by each node that participates in forwarding a massage. Distributed routing algorithms may further be divided into localized and non-localized routing.

1. ***Localized Algorithms:*** In a localized routing algorithm each node decides to forward the message based on the location of itself, its neighboring nodes, and destination. The neighboring nodes may update each other's location whenever an edge is broken or created. Localized routing algorithms that guarantee delivery show that they can nearly match the performance of shortest path algorithms.

2. ***Non-localized Algorithms:*** Non-localized algorithms can be classified as global or zone ones. In a global routing algorithm, each node is assumed to know the position of every other node in the network. In addition, since nodes change between active and sleep periods, the activity status for each node is also required. When such global knowledge is available, the routing task becomes equivalent to the shortest path problem, if hop count is used as main performance metrics. Between the two extremes is the zone approach, where network is divided into zones, with localized algorithm applied within each zone, and shortest path or other scheme applied for routing between zones.

[c] Position based Routing

The routing algorithms that use the position of nodes (that is their coordinates in two or three-dimensional space) in routing a message from source to destination are called position based routing. The position of nodes may be available directly by communicating with a satellite, using GPS (Global Positioning System), if nodes are equipped with a small low power GPS receiver. The advantages of using location information outweigh the cost of additional hardware. Such algorithms have been proved to be more effective in comparison to non-position based in terms of overhead cost and flooding ratio. The distance information, for instance, allows nodes to adjust their transmission powers and thus save the energy. This enables to maximize the number of routing tasks that a network can perform.

Following are the advantages of position based routing:

1. In wireless networks, the presence of geographically nearby nodes determines the existence of links .A node can save battery power by adjusting the transmission power based on the availability of distance information of the destination. By saving battery power a node can increase the routing tasks in a network. These algorithms do not require knowledge of the entire network topology.

2. Transmission of message from source can be restricted into a selected region based on the direction of the destination.

[d] Flat Routing

A flat routing scheme treats all nodes as equal. Routing between nodes is only constrained by their connectivity, which in turn depends only on the state of the radio link between them. The main advantage of flat routing is that no connections being preferred, the probability of any link being congested while other possible links exist is minimized. Also, the same algorithm can run on all nodes. However, flat routing protocols do not scale well.

[e] Hierarchical Routing

In hierarchical routing network is partitioned into two or more layers. At bottom layer nodes are grouped into a small unit called clusters based on some criteria. A cluster head (group leader or gateway node) is elected from each cluster. These cluster heads together form a next higher layer in the network. Routing between clusters is always done through cluster heads. The main advantage of hierarchical routing is drastic reduction in routing table storage space and processing overhead. Thus routing scales well to large networks. However in a mobile environment, hierarchical routing requires complex clustering and location management algorithms. This is because nodes and even cluster heads migrate in and out of clusters. In such environment re-election of cluster heads, splitting and reforming of clusters is common and thus involves overheads.

Both proactive and reactive routing has certain advantages and disadvantages. The advantage of the proactive schemes is that, once a route is needed, there is little delay until the route is determined. In reactive protocols, because route information may not be available at the time a datagram is received, the delay to determine a route can be quite significant. Furthermore, the global flood-search procedure of the reactive protocols requires significant control traffic. Because of this long delay and excessive control traffic, pure reactive routing protocols may not be applicable to real-time communication. However, pure proactive schemes are likewise not appropriate for the Ad hoc networking environment, as they continuously use a large portion of the network capacity to keep the nodes in an Ad hoc networks move quite fast, and as the changes may be more frequent than the route requests, most of this routing information is never even used! This results in a further waste of the wireless network capacity. What is needed is a protocol that, on one hand, initiates the route determination procedure on-demand, but at limited search cost.

VI. CONCLUSION

The combination of both advanced radio features and flexible end-to-end architecture makes WiMAX attractive solution for diverse operators. It provides many different services on one network, services which required different networks in the past. It also provides convergence of fixed and mobile networks. It provides high speed access to the subscriber at a reasonable cost, thereby enabling the service provider to make a profit from the technology, using economies of scale. It offers the advantage of reduced total cost of ownership during the lifetime of a network deployment. Standalone WiMAX networks are certainly feasible, but in most cases WiMAX access technology will be adopted by operators as an extension to their existing networks. The biggest challenges to deploying WiMAX-based services do not seem very much from the spectrum, but from business case issues. Some of the most prominent issues are bandwidth constraints and limited power of the mobile stations. Therefore there is definitely need of a routing solution that can not only offer a better routing solution but also address some of the other routing related issues.

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