Comparative Performance Analysis of WiMAX Networks with CBR traffic on various Routing Protocols

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Abstract: The IEEE 802.16 standard, also known as worldwide interoperability for microwave access (WiMAX), has emerged as the strongest contender for broadband wireless technology with promises to offer guaranteed Quality of Service (QoS). WiMAX (IEEE 802.16) networks support high mobility. This paper presents a comparative performance analysis for WiMAX networks with CBR traffic on AODV, DSR and OLSR routing protocols.

Keywords: WiMAX, OFDMA, Routing protocols

1. INTRODUCTION

WiMAX networks are the most important broadband wireless technologies and is anticipated to be a viable alternative to traditional wired broadband techniques due to its cost efficiency. WiMAX networks support multimedia applications such as voice over IP (VoIP), voice conference and online gaming. WiMAX networks [3] have been increasingly called the technology of the future. Belonging to the IEEE 802.16 series, WiMAX networks will support data transfer rates up to 70 Mbps over link distances up to 30 miles. Supporters of this standard promote it for a wide range of applications in fixed, portable, mobile and nomadic environments, including wireless backhaul for WiFi hot spots and cell sites, hot spots with wide area coverage, broadband data services at pedestrian and vehicular speeds last-mile broadband access, etc. So WiMAX networks systems are expected to deliver broadband access services to residential and enterprise customers in an economical way. It is necessary to provide Quality of Service (QoS) guaranteed with different characteristics. Therefore, an effective scheduling is critical for the WiMAX system. Many traffic scheduling algorithms are available for wireless networks, e.g. Round Robin, Proportional Fairness (PF) scheme and Integrated Cross layer scheme (ICL).

The rest of this paper is organized as follows: In section II brief introductions to salient features of WiMAX networks is discussed. In section III three routing techniques which are used for the research work is presented. Simulation platforms and results are discussed in section IV and Conclusion is given in section V.

2. SALIENT FEATURES OF WiMAX NETWORKS

WiMAX [1] networks are a wireless network that has a high class set of features with a lot of flexibility in terms differentiates it from other metropolitan area wireless access technologies are: a) Orthogonal Frequency Division Multiplexing (OFDM) based physical layer, b) Very high peak data rates, c) Scalable bandwidth and data rate support, d) Adaptive modulation and coding (AMC), e) Link-layer retransmissions, f) Support for Time Division Duplex (TDD) and Frequency Division Duplex (FDD) g) Orthogonal Frequency Division Multiple Access (OFDMA), g) Flexible and dynamic per user resource allocation, h) support for advanced antenna techniques, x. Quality-of-service support, i) Robust security, j) Support for mobility, k) IP-based architecture.

Unlike [2] voice services, which make symmetric use of uplink (subscriber to base station) and downlink (base station to subscriber), data and video services make a very asymmetric use of link capacities and are, therefore, better served by Time Division Duplexing (TDD) than Frequency Division Duplexing (FDD). This is because TDD allows the service provider to decide the ratio of uplink and downlink transmission times and match it to the expected usage as shown in Fig. 1. The WiMAX networks physical layer (PHY) is based on orthogonal frequency division multiplexing, a scheme that offers good resistance to multipath, and allows WiMAX networks to operate in Non Line of Sight (NLOS) conditions. OFDM [3] is now widely recognized as the method of choice for mitigating multipath for broadband wireless. WiMAX networks are capable of supporting very high peak data rates. In fact, the peak PHY data rate

can be as high as 74Mbps when operating using a 20MHz wide spectrum. More typically, using a 10MHz spectrum operating using TDD scheme with a 3:1 downlink-to-uplink ratio, the peak physical data rate is about 25Mbps and 6.7Mbps for the down-link and the uplink, respectively. WiMAX networks [4] have a scalable the available channel bandwidth. Mobile WiMAX networks use OFDM as a multiple-access technique, whereby different users can be allocated different subsets of the OFDM tones.

The WiMAX network MAC layer has a connection-oriented architecture that is designed to support a variety

physical-layer architecture that allows for the data rate to scale easily with available channel bandwidth. This scalability is supported in the OFDMA mode, where the FFT (Fast Fourier Transform) size may be scaled based on

of applications, including voice and multimedia services. The system offers support for constant bit rate, variable bit rate, real-time, and non-real-time traffic flows, in addition to best-effort data traffic. WiMAX network MAC [5] is designed to support a large number of users, with multiple connections per terminal, each with QoS requirement.
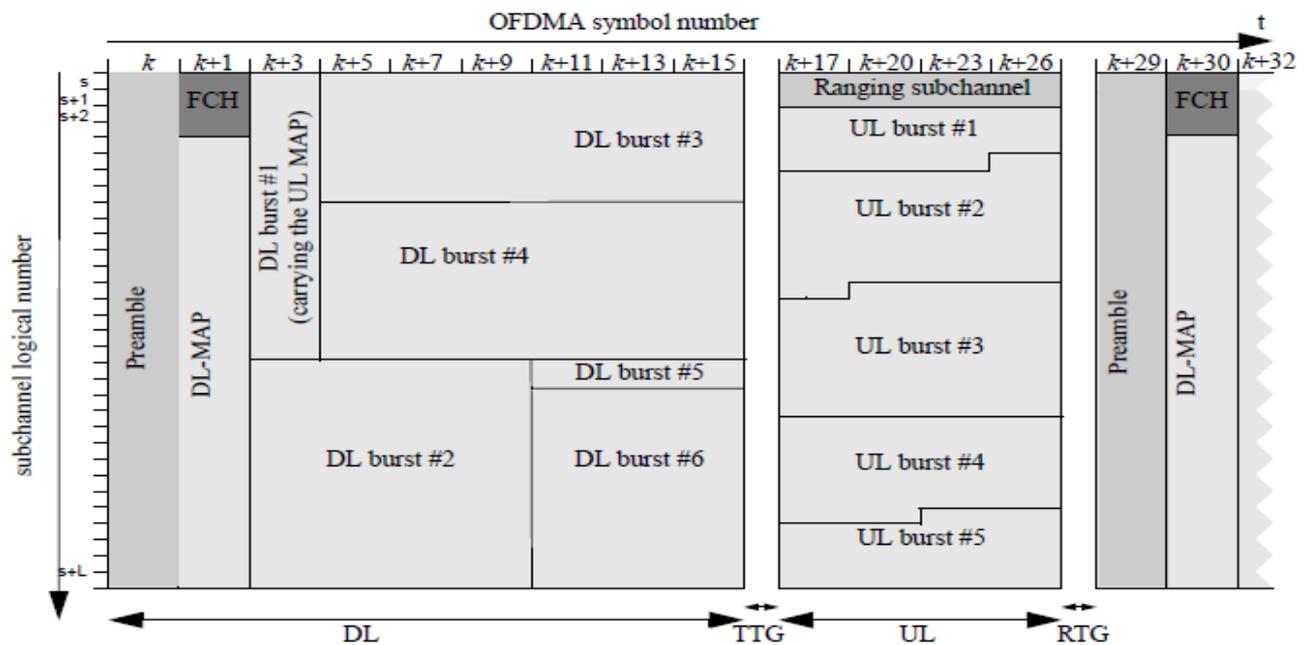

Figure 1. OFDMA TDD frame structure

3. ROUTING PROTOCOLS IN WIMAX NETWORKS

Many routing protocols are designed to provide communication in wireless networks such as AODV, DSR, [6- 13] etc. However, we have carried out present work on AODV, DSR &OLSR. A brief description of these routing protocols is presented below:

A. Ad-hoc On-demand Distance Vector Routing Protocol (AODV)

AODV [13, 15, 16] is a reactive routing protocol. That is, AODV requests a route only when needed and does not require nodes to maintain routes to destinations that are not communicating. The process of finding routes is referred to as the route acquisition. AODV uses sequence numbers in a way similar to DSDV to avoid routing loops and to indicate the freshness of a route. Whenever a node needs to find a route to another node it broadcasts a Route Request (RREQ) message to all its neighbors. The RREQ message is flooded through the network until it reaches the destination or a node with a fresh route to the destination. On its way through the network, the

RREQ message initiates creation of temporary route table entries for the reverse route in the nodes it passes. If the destination, or a route to it, is found, the route is made available by unicasting a Route Reply (RREP) message back to the source along the temporary reverse path of the received RREQ message. On its way back to the source, the RREP message initiates creation of routing table entries for the destination in intermediate nodes. Routing table entries expire after a certain time-out period. Neighbors are detected by periodic HELLO messages (a special RREP message).

B. Dynamic Source Routing (DSR)

Dynamic Source Routing [17,18,19] is a reactive routing protocol which uses source routing to deliver data packets. Headers of data packets carry the sequence of nodes through which the packet must pass. This means that intermediate nodes only need to keep track of their immediate neighbours in order to forward data packets. The source, on the other hand, needs to know the complete hop sequence to the destination. As in AODV, the route acquisition procedure in DSR requests a route by

flooding a Route Request packet. A node receiving a Route Request packet searches its route cache, where all its known routes are stored, for a route to the requested destination. If no route is found, it forwards the Route through the network until it reaches either the destination or a node with a route to the destination. If a route is found, a Route Reply packet containing the proper hop sequence for reaching the destination is unicasted back to the source node. DSR does not rely on bi-directional links since the Route Reply packet is sent to the source node either according to a route already stored in the route cache of the replying node, or by being piggybacked on a Route Request packet for the source node. However, bi-directional links are assumed throughout this study. Then the reverse path in the Route Request packet can be used by the Route Reply message. The DSR protocol has the advantage of being able to learn routes from the source routes in received packets. To avoid unnecessarily flooding the network with Route Request messages, the route acquisition procedure first queries the neighboring nodes to see if a route is available in the immediate neighborhood. This is done by sending a first Route Request message with the hop limit set to zero, thus it will not be forwarded by the neighbors. If no response is obtained by this initial request, a new Route Request message is flooded over the entire network.

C. Optimized Link State Routing (OLSR)

Optimized Link State Protocol (OLSR) [21] is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes. [21, 22, 23, 24, 25] OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbors. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbors has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. the Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages. [20, 21, 22, 23, 24, 25] There is also Multiple Interface Declaration (MID) messages which are used for informing other host that the announcing host can have multiple OLSR interface addresses. The MID message is broadcasted throughout the entire network only by MPRs. There is also a "Hostand Network Association"

Request packet further on after having added its own address to the hop sequence stored in the Route Request packet. The Route Request packet propagate

(HNA) message which provides the external routing information by giving the possibility for routing to the external addresses. The HNA message provides information about the network- and the net mask addresses, so that OLSR host can consider that the announcing host can act as a gateway to the announcing set of addresses. The HNA is considered as a generalized version of the TC message with only difference that the TC message can inform about route cancelling while HNA message information is removed only after expiration time. The MID and HNA messages are not explained in more details in this chapter, the further information concerning these messages can be found in [20].

4. SIMULATION RESULTS AND ANALYSIS

WiMAX Simulation environment was created in Qualnet 5.0 simulator. The simulation was carried with an area of $1500*1500m^2$ with no. of nodes vary from 5 to 40 (Fig.2.) for AODV, DSR OLSR routing protocols with CBR traffic with 1800 sec. simulation time. The other parameters are listed in Table 1 below:

1. TABLE1. SIMULATION OTHER PARAMETERS

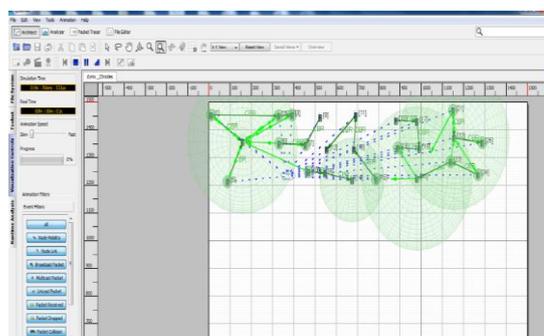| Serial No.	Parameters	Value
1	Channel Bandwidth	20 MHz
2	FFT Size	2048
3	Packets Rate	4 Packets/s
4	Noise factor	10.0
5	Network protocol	IPv4
6	No of Buffered Packets	100
7	Channel Frequency	2.4GHz
8	Temperature	290 k

Figure 2. Qualnet Scenario for WiMAX Networks

A. Average End-to-End Delay

The average end –to-end delay v/s no. of nodes for WiMAX networks is shown in Fig.3. With AODV, DSR and OLSR routing protocols the average delay was found 0.89657 sec, 094170925 sec and 0.162965375 sec.

respectively. The best performance is shown by OLSR having lowest end to end delay of 0.110226 sec. with a maximum delay of 0.233145 sec as shown.
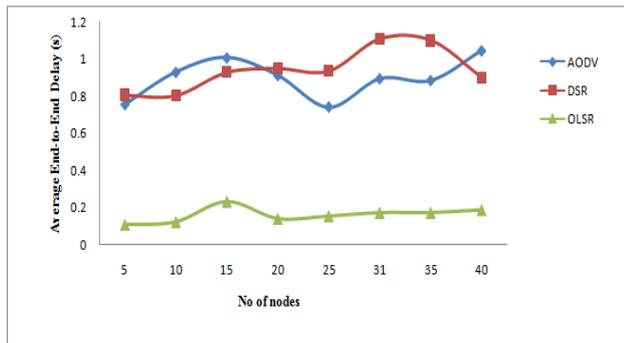

Figure 3. Average End –to-End Delay comparison of WiMAX networks

B. Average Jitter

The average jitter v/s no of nodes for WiMAX networks is shown in Fig.4. It should be less for a routing protocol to perform better. The average jitter was found 0.0207802 sec, 0.20898225 sec. and 0.046266975 sec. respectively for AODV, DSR and OLSR routing protocols. OLSR has less average jittering than AODV and DSR routing protocols in the variation of no of nodes.
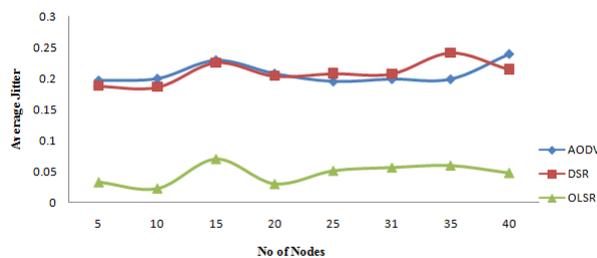

Figure 4. Average Jitter comparison of WiMAX networks

C. Throughput

The throughput comparison is shown in Fig. 5. The average value of throughput was 5344 bits/s, 5102 bits/s and 4275 bits/s respectively for AODV, DSR and OLSR results (Fig.5.), in best performance was found   by AODV as it delivers data packets at higher rate in comparison to DSR and OLSR.
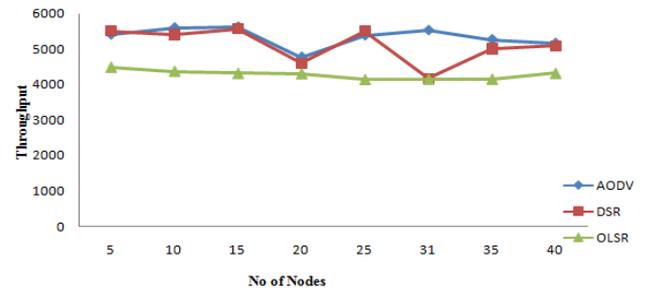

Figure 5. Throughput comparison of WiMAX networks

1. CONCLUSION

In this paper, authors have provided a comparative performance analysis of various routing protocols for WiMAX networks. From the result of our studies, it can be concluded   that, on an average OLSR and AODV perform better than DSR in respect to end to end delay. In case of DSR, throughput is higher than OLSR, but average end to end delay is higher. However in case of AODV throughput is the highest ,but average end to end delay is more than OLSR and DSR .So we can say that for CBR application OLSR routing protocol is better than the other two protocols.

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