VARIOUS ROUTING PROTOCOLS PERFORMANCE ANALYSIS FOR WIMAX NETWORK

Brajesh Patel*

Priyanka Dubey**

Abstract

Worldwide Interoperability for Microwave Access (WiMAX) is a useful technology provides fixed and mobile access and offer the same subscriber experience for fixed and mobile user. WiMAX Provides other significant facilities to increasing amounts of bandwidth, using a variety of mobile and roaming devices. The earliest version of WiMAX is based on IEEE 802.16 and is optimized for fixed and roaming access, which is further extended to support portability and mobility based on IEEE 802.16e, also known as Mobile WiMAX. However, whenever topology changes caused by node movements make routing in Mobile WiMAX networks a problem. In this Paper we are analyzing routing protocols especially for wireless networks. An assumption of each subscriber station has its routing capabilities within its own network is prepared. The performance matrix includes Packet Delivery fraction (PDF), Throughput, End to End Delay, and number of packet dropped were identified.

Keywords— Worldwide Interoperability for Microwave Access,routing protocol. Ad-hoc On-demand distance vector, Dynamic Source Routing, Destination-Sequenced Distance-Vector Routing.

* Deptt of Computer Science. HoD (Com. Sci.), SRIT, Jabalpur(m.p), R.G.P.V Bhopal. India.

** Deptt of Computer Science, Student of M.E. (4th SEM), SRIT, Jabalpur(m.p), R.G.P.V Bhopal. India.

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates. Broadband Internet connections are restricted to wire line infrastructure. Wire line infrastructures are considerably more costly and time consuming than a wireless one. Broadband Wireless Access (BWA) provide uspromising solution for "last mile" access technology to provide high speed connections. IEEE 802.16 standard for BWA and its associated industry consortium, Worldwide Interoperability for Microwave Access (WiMAX) forum promise to offer high data rate over large areas to a large number of users where broadband is unavailable. This is the first industry wide standard that can be used for fixed wireless access with substantially higher bandwidth than most cellular networks. This paper presented an analysis of the performance for wireless routing protocols in Mobile WiMAX environment. A study and comparison on network performance of AODV, DSR, DSDV routing protocols are evaluated and presented. A simulation has been setup and assumed of each of the subscriber station maintain routing table for its own network is made. This setup is made due to make sure the traffic flow is sending the data directly to the destination without the help of base station. However, if one subscriber station has to send data to a station located in another network, it must send data through the base station and vice versa.

II. WIRELESS ROUTING PROTOCOLS

Three type of routing protocols has been analysed in this research as detailed.

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

Ad-hoc On-demand distance vector (AODV) [2, 3] is another variant of classical distance vector routing algorithm, a confluence of both DSDV and DSR. It shares DSR's on-demand characteristics hence discovers routes whenever it is needed via a similar route discovery process. However, AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR that maintains multiple route cache entries for each destination. The initial design of AODV is undertaken after the experience with DSDV routing algorithm.Like DSDV, AODV provides loop free routes while repairing link breakages but unlike DSDV, it doesn't require global periodic routing advertisements. AODV also has other significant features. Whenever a route is available from source to destination, it does not add any overhead to the packets.However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage.

B. Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [4] is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is designed especially for

use in multihop ad hoc networks of mobile nodes. It allows the network to be completely self organizing and self-configuring and does not need any existing network infrastructure or administration. DSR uses no periodic routing messages like AODV, thereby reduces network bandwidth overhead, conserves battery power and avoids large routing updates. Instead DSR needs support from the MAC layer to identify link failure. DSR is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short – lived or long – lived, cannot be formed as they can be immediately detected and eliminated. This property opens up the protocol to a variety of useful optimizations. Neither AODV nor DSR guarantees shortest path. If the destination alone can respond to route requests and the source node is always the initiator of the route request, the initial route may the shortest.

C. Destination-Sequenced Distance Vector routing (DSDV)

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. The improvement made to the Bellman-Ford algorithm includes freedom from loops in routing tables by using sequence numbers [2]. The DSDV protocol can be used in mobile ad hoc networking environments by assuming that each participating node acts as a router. Each node must maintain a table that consists of all the possible destinations. In this routing protocol has an entry of the table contains the address identifier of a destination, the shortest known distance metric to that destination measured in hop counts and the address identifier of the node that is the first hop on the shortest path to the destination. Each mobile node in the system maintains a routing table in which all the possible destinations and the number of hops to them in the network are recorded. A sequence number is also associated with each route or path to the destination. The route labeled with the highest sequence number is always used. This also helps in identifying the old routes from the new ones. This function would avoid the formation of loops. In order to minimize the traffic generated, there are two types of packets used that known as "full dump", which is a packet that carries all the information about a change. The second type of packet called "incremental" is used which carried just the changes of the loops. The second type benefits that increased the overall efficiency of the system. DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle.Whenever the topology of the network changes, a new sequence number needed before the network re-converges.

Thus, DSDV is not suitable for highly dynamic networks.

Table 1: A comparison of the characteristics of the above three routing protocols DSDV, DSR, and AODV

Protocol Property	DSDV	DSR	AODV
Multicast Routes	No	Yes	No
Distributed	Yes	Yes	Yes
Unidirectional Link Support	No	Yes	No
Multicast	No	No	Yes
Periodic Broadcast	Yes	No	Yes
QoS Support	No	No	No
Reactive	No	Yes	Yes

III. ANALYSIS METHOD

There are three techniques for performance evaluation which are analytical modeling, simulation and measurement. The reason for choosing simulation as a technique for performance evaluation in this research is explained below. A. Selection Techniques for Network Performance Evaluation Performance is a key criterion in the design, procurement, and use of computer systems. Computer systems professionals such as computer systems engineers, scientist, analysts and users need the basic knowledge of performance evaluation techniques as the goal to get the highest performance for a given cost. There are three techniques for performance evaluation, which are analytical modeling, simulation and measurement. Simulation had being chosen because it is the

most suitable technique to get more details that can be incorporate and less assumption is required compared to analytical modeling. Accuracy, times available for evaluation and cost allocated are also another reason why simulation is chosen.

III. NETWORK SCENARIO AND TRAFFIC GENERATING

A third party tools is used identify the nodes placement and then the network traffic is generated automatically. This method helps on demanded the scalable performance test for a specific network configuration. A file with the statements which set nodes positions and nodes movement using CMU generator is done. The reference directory is $NS2_HOME/indep-utils/cmu-scen-gen/setdest. An executable “setdest” program also s created to support this. This is a third party tools that has a CMU's version auxiliary scenario creation tool. A system dependent /dev/random and made calls to library functions initstate() for generating random numbers is derived. Some commands are implementer for executable usage for example as the command shown below.

./setdest -n 500 -p 2.0 -s 100.0 -t 200 -x 500 -y 500 > scene-500-2-100-500-500

This means, the topology boundary is 500m X 500m, the scenario has 500 nodes with nodes’ max moving speed of 100.0m/s and the pause between movements is 2s, and simulation will stop in 200s, and output the generate tcl statements into file whose name is scene-500-2-100-500-500. A. Network traffic generating This project also generates network traffic such as the statements on sources, connections, and other. This task is done by running the command $NS2_HOME/indep-utils/cmu-scen-gen/cbrgen.tcl as a tcl file. Generated scenarios are modified within the tools. Random traffic connections of TCP and CBR are setup between nodes. It is used to create CBR and TCP traffics connections between wireless nodes. In order to create a traffic-connection file, the type of traffic connection (CBR or TCP), the number of nodes and maximum number of connections to be setup between them, a random seed and incase of CBR connections, a rate whose inverse value is used to compute the interval time between the CBR packets is set. So the command line generated is as shown below: ns cbrgen.tcl [-type cbr/tcp] [-nn nodes] [-seed seed] [-mc connections] [-rate rate]

Here, "-type cbr/tcp" means define the type of traffic connection, "-nn nodes" means the number of nodes could be used, "-mc connections" means maximum number of connections to be setup between those nodes, "-seed seed" means a random seed, if it not equal to 0, the traffic pattern will reappear if all the other parameters are the same. "-rate rate" means a rate whose inverse value is used to compute the interval time, which easily to say is packets sending rate. For an example:

ns cbrgen.tcl -type cbr -nn 500 -seed 1.0 –mc 10 -rate 2.0 > cbr-20-test means create a CBR connection pattern between 500 nodes, having maximum of 10 connections, with a seed value of 1.0 and a rate of 2.0 pkts/second.

B. Performance Metrics

The project focuses on 3 performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running in NS-2 simulation as derived:

• Packet delivery fractions (PDF)

PDF also known as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. The PDF in figure 2 shows how successful a protocol performs delivering packets from source to estination. The higher for the value give use the better results. This metric characterizes both the completeness and correctness of the routing protocol also reliability of routing protocol by giving its effectiveness

$$P = \frac{1}{c}\sum_{f=1}^{e}\frac{R_f}{N_f}$$

Figure 2: Packet Delivery Fractions Expression

where P is the fraction of successfully delivered packets, C is the total number of flow or connections, f is the unique,flow id serving as index, Rf is the count of packets received from flow f and Nf is the count of packets transmitted to f.

• Average end-to-end delay of data packets

There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. The project use Average end-to-end delay as in figure 3 expression. Average end-to-end delay is an average end-to-end delay of data packets. It also caused by queuing for transmission at the node and buffering data for detouring. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

$$D = \frac{1}{N}\sum_{i=1}^{s}(r_i - s_i)$$

Figure 3: Average End-To-End Delay Expression

where N is the number of successfully received packets, i is unique packet identifier, r i is time at which a packet with unique id i is received, s i is time at which a packet with unique id i is sent and D is measured in ms. It should be less for high performance.

• Data Packet Loss (Packet Loss)

Mobility-related packet loss may occur at both the network layer and the MAC layer. In the project packet loss concentrate or network layer. The routing protocol forwards the packet if a valid route to the destination is known. Otherwise, the packet is buffered until a route is available. A packet is dropped in two cases: the buffer is full when the packet needs to be buffered and the time that the packet has been buffered exceeds the limit.

• Throughput

Throughput is defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput [6]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Some factors affect the throughput as; if there are many topology changes in the network, unreliable communication between nodes, limited bandwidth available and limited energy [7]. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation below.

$$Throughput = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{total duration of simulation}}$$

Figure 4: Throughput Expression

IV. RESULT AND DISCUSSION

Details of analysis are focusing on packet-delivery fraction, packet loss, and average end to end delay and send/received ratio in term mobility. This simulation chooses 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 nodes. The standard parameters as shown in table 2.

Table 2: The Standard Parameters For Simulation

Parameter	Value
Simulator	ns-2
Protocols studied	AODV, DSR. DSDV
Simulation time	100 sec
Simulation area	500 x 500
Traffic type	CBR (UDP)

A. Packet Delivery Fraction (PDF) Result and Analysis

Figure 5 shows a comparison between the routing protocols on the basis of packet delivery fraction as a function of nodes and using different number of traffic sources.

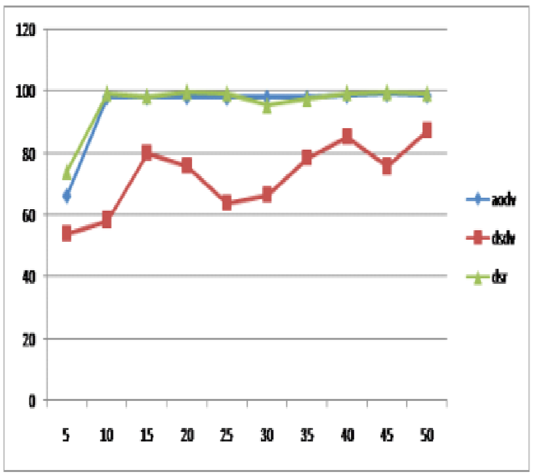

Figure 5: A Comparison between the Routing Protocols

AODV shows the best overall performance. AODV & DSR have PDF of 100% at nodes 10. DSDV deliver less data packet compare to DSDV because DSDV is a proactive or table-driven routing protocols, each node continuously maintains up-to-date routes to every other node in the network. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency.

B. Average End to End Delay Result and Analysis

Figure 6 shows the graphs for end-to-end delay vs number of nodes. We see that the average packet delay decrease for increase in number of nodes waiting in the interface queue while routing protocols try to find valid route to the destination. Besides the actual delivery of data packets, the delay time is also affected by route discovery, which is the first step to begin a communication session. The source routing protocols have a longer delay because their route discovery takes more time as every intermediate node tries to extract information before forwarding the reply. The same thing happens when a data packet is forwarded hop by hop. Hence, while source routing makes route discovery more profitable, it slows down the transmission of packets.

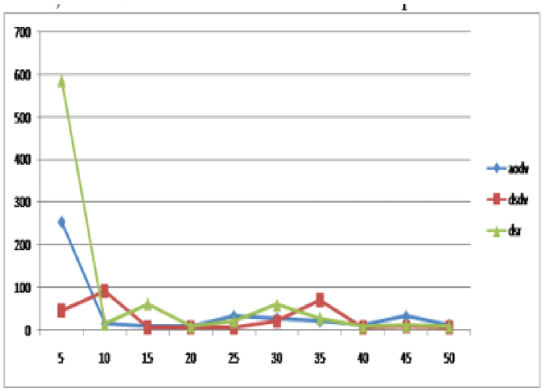

Figure 6: Graphs for End-To-End Delay Vs Number of Nodes.

AODV and DSR show poor delay characteristics as their routes are typically not the shortest. Even if the initial route discovery phase finds the shortest route (it typically will), the route may not remain the shortest over a period of time due to node mobility. However, AODV performs a little better delay-wise and can possibly do even better with some fine-tuning of this timeout period by making it a function of node mobility. DSDV too has the worst delay characteristics because of the loss of distance information with progress. Also in TORA route construction may not occur quickly. This leads to potential lengthy delays while waiting for new routes to be determined. In DSR Route Discovery is fast, therefore shows a better delay performance than the other reactive protocols at low pause time (high mobility). But in case of congestion (high traffic) DSR control messages get loss thus eliminating its advantage of fast establishing new route. Under such situations DSR has a relatively high delay that AODV, but however the delay decreases with increase in number of nodes [7].

C. Packet Loss Result and Analysis

Refer to the graph in figure 7 show not much packet loss on AODV side. This is because when a link fails, a routing error is passed back to a transmitting node and the process repeats. Meanwhile for DSR, this routing protocol shows it is as good as AODV if packet loss be as indicator. For DSDV, show the packet loss higher than DSR and AODV because the route maintenance mechanism does not locally repair a broken link.

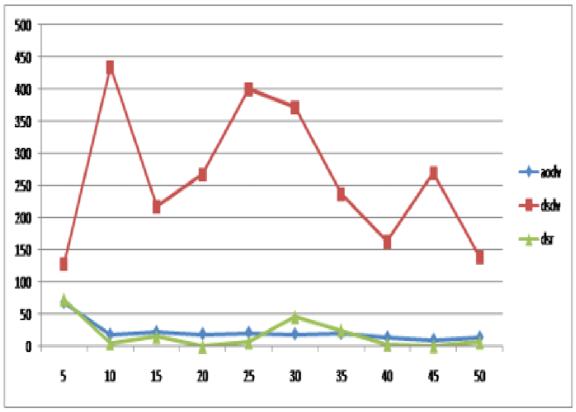

FIGURE 7: Packet Loss on AODV

V. CONCLUSION

This paper presented the realistic comparison of three routing protocols DSDV, AODV and DSR. The significant observation shows the simulation results agree with expected results based on theoretical analysis. As expected, reactive routing protocol AODV performance is the best considering its ability to maintain connection by periodic exchange of information. AODV performs predictably. Delivered virtually all packets at low node mobility, and failing to converge as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs the worst, but still requires the transmission of many routing overhead packets. At higher rates of node mobility it's actually more expensive than DSR. For the future work, this area will investigate not only the comparison between AODV, DSDV and DSR routing protocols in WiMAX network but more on the vast areas. Security issue on routing protocol in WiMAX environment also can be studied for computer communications. Exploration on the measurement with other fields of the trace file could be done in the future.

REFERENCES

[1] M. Azizul Hasan, "Performance Evaluation of WiMAX/IEEE 802.16 OFDM Physical Layer," Masters Thesis, Dept. of electrical and Communications Engineering, Communications Laboratory, Helsinki University of Technology, Finland, June 2007.

[2] C.E. Perkins and P. Bhagwat, "Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers," IGCOMM, London, UK, August 1994.

[3] E. M. Royer and C.K. Toh, "A Review of Current Routing Protocols for Ad-Hoc Mobile Ad hocNetworks," IEEE Personal Communications, April 1999

[4] A. Boukerche, "Performance Evaluation of Routing Protocols for Ad Hoc Networks," Mobile Networks and Applications, Kluwer Academic Publishers, 2004.

[5] URL with http://www.isi.edu/nsnam/ns/

[6] U. T. Nguyen and X. Xiong, "Rate-adaptive Multicast in Mobile Ad-hoc Networks", Department of Computer Science and Engineering York University Toronto, Canada , 2007.

[7] R.Samir Das, Charles E. Perkins, Elizabeth E. Royer, "Performance Comparison of Two On-demand Routing Protocols for Ad Hoc Networks".2000