ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 6, June 2015

QoS Analysis of the Routing Protocols for Scaling RF-MANET

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Abstract— **MANET is a self organized and self configurable wireless network, where the nodes are mobile and can move arbitrarily. These mobile nodes work as router for the transmission of information packets to the distant nodes. Routing is a critical issue in MANET. We focus on performance analysis of different reactive, proactive and hybrid routing protocols in terms of throughput and end-to-end delay. In order to investigate best routing protocol for scaling number of nodes, we need to analyze QoS parameters in terms of throughput and end-to-end delay.**

In this paper, we have taken six different routing protocols such as AODV, AOMDV, DSR, DSDV, OLSR and ZRP. We have analyzed the average throughput and end-to-end delay of these protocols for scaling number of nodes up to 200. The simulation work has done by using NS-2 and data analysis with graphical representation by using MATLAB(R).

***Index Terms*— MANET (Mobile Ad hoc Network), QoS (Quality of Service), AODV (Ad hoc On-demand Distance Vector), AOMDV (Ad Hoc On-demand Multiple path Distance Vector) DSDV (Destination Sequenced Distance Vector), DSR (Dynamic Source Routing), OLSR (Optimized Link State Routing Protocol), ZRP (Zone Routing Protocol) and, NS-2 (Network Simulator 2) tool.**

I. INTRODUCTION

Mobile ad hoc network (MANET) is made up of mobile devices or nodes that use wireless transmission medium for communication. It is an infrastructure less network because it does not require any central administration [1].When number of nodes in the networks increases, the complexity of the network also increases means network becomes more congested [2].

There are number of routing protocols that are available for MANET, it comprises of proactive (table driven routing protocols), reactive (on demand routing protocols) and hybrid routing protocols. Proactive protocols are Destination-Sequenced Distance Vector (DSDV) and Optimized Link State Routing protocol (OLSR) while reactive routing protocols are Ad hoc on demand Distance Vector (AODV), Ad hoc on demand Multipath Distance Vector (AOMDV) and Dynamic Source Routing (DSR). And a hybrid routing protocol is Zone Routing Protocol (ZRP). The protocols in the networks must be power efficient, adaptive and to be anticipated to any change inside the network. It must be distributed in manner in order to enhance its reliability. The main objective of the routing protocols is to establish a path from a source to the destination that satisfies the needs of the desired QoS [3]. Every node discovers its own routing path by using control packets. Route maintenance is also required as the node changes its position [4].

Scalable routing is one of the major key challenges for MANET, in large scale networks. In order to ensure effective operation of MANET as the total number of nodes becomes very large, the overhead of the employed routing algorithms should be low and it should be independent of the total number of nodes in MANET [5]. Another challenge in MANET is mobility. As we know that all the nodes are mobile so there is an issue of the consumption of energy and reliability of routing nodes. Energy consumption is main performance measure to compare these protocol performances [4].

Here Research paper is organized as follows. In section II, review a brief description of the different routing protocols. Section III describes simulation environment and metrics. Results are analyzed in section IV. Finally, the conclusion is presented in section V.

Tuneja and Gujral analyzed the performance of AODV, DSDV and DSR in terms of Throughput, PDR, Delay, Routing load, sent and received packets, when the nodes are 25 and packet size kept is 1000 bytes [4]. Kushwaha and Tomar have investigated AODV, DSDV, and DSR for varying node mobility in terms of packet delivery fraction (PDF) [6]. Gauda and Mandal compared ERAODV (Energy AODV), AODV and DSDV in terms of remaining and consumed energy, NRL and PDR by varying number of nodes up to 95 [7]. Modi and Dubey compared AODV,DSDV, DSR and OLSR by scaling nodes up to 150 using metrics Average throughput, Average End-to-end delay, NRL and PDR [8].

The research work has been done by the authors regarding performance analysis of routing protocols. Our aim in this paper is to carry out detailed simulation analysis of six routing protocols with varying number of nodes by keeping the fixed number of connection. Here, we are analyzing the behavior of routing protocols at large network and to find most efficient and adaptive protocol in terms of QoS parameters.

II. DESCRIPTION OF THE ROUTING PROTOCOLS

A. AODV (Ad Hoc On Demand Distance Vector)

AODV is a reactive protocol [9]. It provides Unicast and multicast routing. This Protocol maintains the routes of communicating node and send routing table at each particular node. The routing table contains the routing information regarding the particular node. When a source wants to send the data to the destination the routing table is checked for the

Manuscript received June, 2015.

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availability of the required path. If a route to the destination is present, it will transmit the packet. If the routing table does not have any valid route, then it uses the route request (RREQ) packets to initiate the route discovery mechanism [7].

A RREQ message is broadcasted when a node need to discover a route to a destination [10]. It also contains the most recent sequence number for the destination. A valid destination route must have a sequence number at least as greater as that contained in RREQ. When a RREQ reaches the destination node, the destination route is made available by unicasting a RREP back to the source route [11]. A node generates a RREP if, it is itself the destination or it has an active route to the destination. As the RREP propagates back to the source node, intermediate nodes update their routing table (In the direction of the destination node). RERR (Route Error) packets are also used mainly when nodes get moved around and connections are lost. If a node receives a RERR, it deletes all routes associated with the error. Error message are sent when a route becomes invalid or if it cannot communicate with one of its neighbor. AODV requires more time to establish the communication but it does not create any extra traffic and does not require much memory and calculation [7].

B. DSDV (Destination Sequence Distance Vector)

It is based on classical distributed Bellman-Ford routing mechanism [12]. DSDV is basically a proactive routing protocol. Main advantage of this protocol is that it avoids the routing loops in a mobile network [6]. It uses sequence numbers for the destination nodes to determine "freshness" of a particular route [13]. A sequence numbering system is used in order to distinguish the stale routes from the new once. The sequence number is incremented when an update is sent by the host nodes. Each node maintains a routing table of the possible destinations and numbers of routing hops to each destination are recorded. Messages are shared between the mobile nodes which are in the same transmission range. The updates of routing table are sent periodically throughout the network thus the consistency of the table is maintained. But, it generates the unnecessary traffic in the network. To minimize the routing updates, variable size packets are used depending on the number of topological changes. The routing table is maintained by each node participating in the network.

C. DSR (Dynamic Source Routing)

Dynamic Source Routing protocol is a reactive routing protocol, it is basically an on demand protocol, where the nodes request routing information only when needed [13]. DSR is an efficient routing protocol used in multi-hop mobile Ad hoc networks. Route Discovery and Route Maintenance are the two phases which are used in DSR. These phases help nodes to discover and maintain the best routes from source to destinations [14]. DSR protocol does not require periodic "HELLO" packet transmissions, which are used by a node to inform its neighbors of its presence. When a sender wants to communicate with next node or its destination, it checks its route cache to see any routing information related to that destination. If the route cache does not contain such information, then the sender will initiate a process that is route discovery by broadcasting a route request packet. In DSR the intermediate nodes need not to maintain up to date routing information in order to route the packets to the destination.

D. OLSR (Optimized Link State Routing Protocol)

Optimized Link State Routing protocol is basically a proactive routing protocol. It is based on hop-by-hop routing. Here each node uses its most recent routing information to route packets [15]. Classical link state routing algorithm is optimized by the OLSR routing protocol. In this algorithm each node declares all links with neighboring nodes and floods the entire network with routing messages. The key concept used in the OLSR protocol is the multipoint relays (MPRs) [16]. So each node maintains a table of selected MPR and rebroadcast packets received from the originating source node (MPR). Periodically, each node broadcasts a "HELLO" messages and selects minimal subset MPR among one hop neighbors to cover all nodes which are two hops away [17].

Each node in the network selects a set of nodes from its one hop neighbors to act as Multipoint Relays "MPR's". The selection is made in a way that it covers all nodes that are two hops away (i.e. neighbors of the neighbors) [15].This set of nodes retransmits the OLSR control messages; hence it reduces the number of messages forwarded by all its neighbors. A node senses and selects its MPRs by the control messages called 'HELLO' messages that are used to ensure a bidirectional link with the neighbor. HELLO messages are transmitted at a certain time interval. Control messages which are broadcasted by the nodes are called Topology control "*TC*", it is used to declare its *MPR* selection. These are also transmitted at a certain time intervals.

E. ZRP (Zone Routing Protocol)

A hybrid wireless networking routing protocol, zone routing protocol uses both proactive and reactive mechanism of routing protocols, while sending information over a network. For communication with the interior nodes of a zone, ZRP protocol is used. The node continuously needs to update the routing information to determine the peripheral node as well as it maintains a map in which nodes can be reached locally [18].

In ZRP, a routing zone is considered in which a node proactively maintains routes to destinations within a local neighborhood. A node's routing zone is defined as a collection of nodes whose minimum distance in hops from the node is greater or equal to the zone radius. Each node maintains its own routing zone [19]. For the construction of a routing zone a node requires to know about its neighbors and the identification of a node's neighbors may be provided directly by the media access control (MAC) protocols [19]. There are two subset of ZRP, which are IARP and IERP [20]. A proactive routing protocol, Intra-zone Routing Protocol (IARP), is used inside routing zones, and a reactive routing protocol, Inter-zone Routing Protocol (IERP), is used between routing zones.

F. AOMDV (Ad Hoc on Demand Multipath Distance Vector)

The Ad-hoc On-demand Multi-path Distance Vector (AOMDV) routing protocol [21] is a multi-path extension of the Ad-hoc On-demand Distance Vector (AODV) routing protocol. The basic concept of AOMDV is to find the multiple paths between a source and a destination. It is an On-demand routing protocols means it discover a route when a source needs to communicate with another node or the

destination. During the single route discovery process the multi-path routing protocol discovers multiple paths. These multiple paths can be used as backup routes when the primary route fails [22]. There are some aspects of AOMDV compared to other on-demand multi-path routing protocols. First, it does not have inter-modal coordination overheads. Secondly, by distributed computation it ensures disjointness of alternate routes without the use of source routing. Thirdly, alternate paths are computed by AOMDV with minimal additional overhead over AODV [23].

III. Simulation Environment and Performance Metrics

The simulation works are conducted using a discrete event simulator ns-2.35 on the Linux platform Ubuntu 12.04 to analyze the protocols on the basis of throughput and end to end delay with scaling number of nodes up to 200. It is most widely used network simulator and easily available. We have generated 16 traffic pattern files and 16 node movement files by considering different scales of network and traffic load. The protocols used in simulation are AODV, AOMDV, DSDV, DSR, OLSR and ZRP. The different scales of network include 25, 50, 75, 100, 125, 150, 175 and 200 nodes are distributed randomly as shown in Table 1.

No. of Nodes	25,50,75,100,125,150,175,200
Antenna Type	Omni-directional (RF)
Propagation Model	Two Ray Ground
Packet Size	512 bytes
Traffic Source	CBR(UDP)
Routing Protocols	AODV,AOMDV,DSDV,OLSR, DSR,ZRP
Simulation Time	200s
Initial energy of nodes	1000 joules
Area Size	1 km
Number of connections	20
RF node radius	20 cm
Traffic Pattern files	16
Node movement file	16
Pause Time	20 sec
Mobility model	Random way point

TABLE 1. Simulation Environment of RF-MANET

To analyze the performance of different routing protocols, simulation area is taken of 1000m x 1000m. Omni-directional antenna is used under IEEE 802.11 (MAC) Protocol. Two ray ground propagation and random waypoint mobility model is used in the simulation. The constant bit rate (CBR) UDP is used to analyze the performance of different routing protocol in terms of Throughput and End to end delay. Here we have used the packet size of 512 bytes, 200sec simulation time and 20 sec pause time. The initial energy is taken in simulation is 1000 joules.

Performance Metrics

Performance metrics are used for the improvement of performance, effectiveness and efficiency of any network [3]. As for the experiments the matrices which had been carried out for the simulation are throughput and end to end delay as the performance metrics.

A. Throughput (messages/second)

Throughput indicates the information whether data packets are successfully delivered or not [24]. It means the total number of packets successfully received by the destination node over a communication channel. This data delivery process can be done over a physical or logical link [25]. The Throughput is measured in bits per second (bps).

B. Average End-to-End delay (seconds)

It is the average time which a data packet takes to reach the destination. This average delay is calculated by subtracting "the time at which first packet was transmitted by source" from "the time at which first data packet arrived to destination" [26].

SIMULATION MODEL

CBR traffic under UDP connections are used to compare the different protocols. The tcl scripts are used to describe the simulation parameters such as number of nodes, number of flows etc. The tool setdest was used to produce mobility scenarios, where nodes are moving at different uniform speeds ranging between 0 to 20 m/s with a margin of ±1 and a uniform pause time of 20s.

A. The traffic model

In this paper we focus on Constant Bit Rate (CBR) sources [26]. The packet size is limited to 512 bytes. The source-destination pairs are chosen randomly over the network. The source-destination numbers are fixed (called connection number). Each connection pair begins packet sending at a chosen time and it keeps sending at the specified rate.

B. The mobility model

Random way point mobility model is a random model which is designed to describe the movement pattern of mobile users and it shows how their location, velocity and acceleration change over time [27]. In RWP, a node randomly chooses its destination, called waypoint and moves with constant velocity towards it in a straight line. Velocity is selected randomly from 0 to certain maximum range. After reaching the destination, the node pauses for some time and then repeats the same procedure for another node [28].

IV. Simulation Results

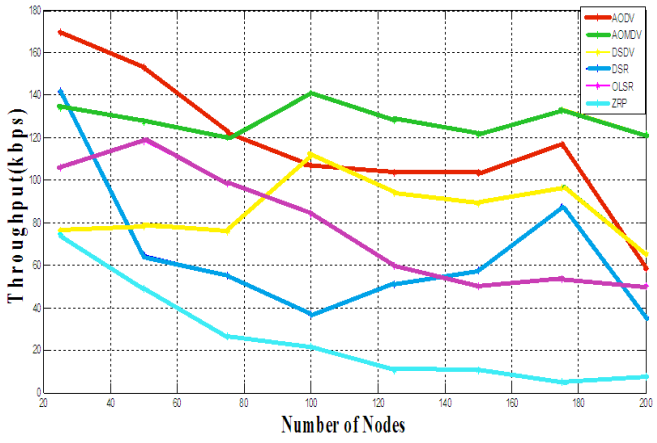

Fig. 1 Plot of throughput vs. number of nodes

Fig. 1 is showing throughput analysis of different routing protocols with respect to increasing number of nodes up to 200. In graph, initially AODV is producing the highest throughput values up to 70 nodes with compared to other used protocols. The AOMDV protocol produces highest throughput throughout after 75 nodes. ZRP is showing the worst performance in terms of throughput for all size networks. AODV has better performance than OLSR, DSR, and ZRP for different size networks but DSDV performs better then AODV for 100 node only. OLSR is performing better than DSDV for smaller number of nodes. But as the size of network increases, the DSDV protocol is showing higher values of throughput.

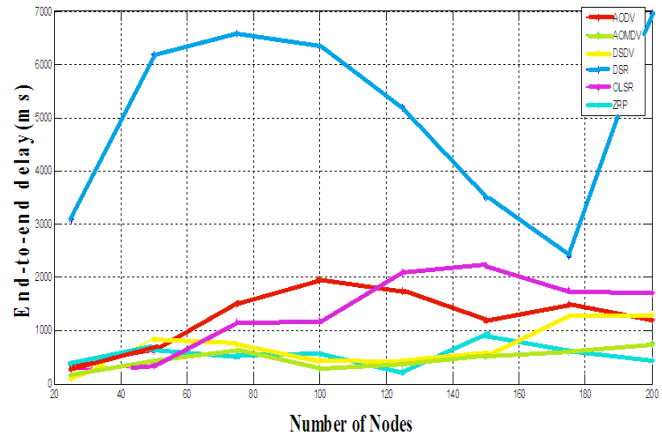

Fig. 2 Plot of end to end delay vs. number of nodes

Fig. 2 is showing end to end delay of different routing protocols with respect to increasing number of nodes up to 200. On an average, the AOMDV and ZRP protocol is showing the best performance in terms of end-to-end delay. OLSR protocol is better than AODV for small size network up to 120 nodes, then AODV performs better for large size network. The performance of DSDV protocol is better than AODV, OLSR and DSR. The DSR protocol is producing worst performance in terms of end to end delay for all size networks.

V. Conclusion

The various parameters are analyzed for 802.11 mobile Ad hoc network environment using NS-2.35 for different reactive, proactive and hybrid routing protocols. The AODV, AOMDV, DSDV, DSR, OLSR, and ZRP protocols are evaluated by increasing the number of nodes. Two performance metrics such as throughput and average end-to-end delay are used in order to analyse the protocols.
In this analysis, reactive protocols such as AOMDV and AODV have shown better performance in terms of throughput. ZRP and AOMDV are the protocols which have lowest end to end delay But AOMDV protocol has shown superior performance, in terms of throughput and end to end delay. Here we can observe that reactive protocol AOMDV gives the best performance for all size networks on different traffic conditions.

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