

# Study of Network Characteristics Incorporating Different Routing Protocols

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**Abstract**— Wireless mesh networks (WMNs) offer much promise for communication. The routing protocols are designed basically to establish correct and efficient paths between users. In the recent years several routing protocols have been proposed and many of them studied through extensive simulation at different network characteristics. In this paper various protocols like Bellman-Ford, Ad-Hoc on-Demand Routing (AODV), Dynamic Source Routing (DSR), and Ad hoc On Demand Distance Vector (DYMO) have been discussed and compare their Average End-to-End Delay (sec.), Throughput (bits/sec.) and Jitter (sec.).

**Keywords**— Wireless mesh network, Routing Protocols, EXata GUI link 5.1.

## I. INTRODUCTION

As various wireless networks evolve into the next generation to provide better services, a key technology, wireless mesh networks (WMNs), has emerged recently. In WMN nodes are comprise of mesh routers and mesh clients. Each node operates not only as a host but also as a router, forwarding packets on behalf of other nodes that may not be within direct wireless transmission range of their destinations. A WMN is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves. This feature brings many advantages to WMNs such as low up-front cost, easy network maintenance, robustness and reliable service coverage [1].

A wireless mesh network (WMN) is composed of a large number of nodes that are densely deployed in communicating over radio. It is specifically designed for discrete data sent occasionally [2]. Routing protocols play an important role in wireless network to managing the configuration, formation, and maintenance of the network topology [3].



The goal of routing protocol is to determine paths with reduced overhead and also faster reconfiguration when a broken link is identified [2]. Every node has the responsibility to determine the best route to its destination. A lot of research study is performed on various routing protocols but this paper represents a comparison of Bellman-Ford, AODV, DSR and DYMO. The performance analysis is based on different network metrics such as End-to-End delay(s), Average Jitter(s), and Throughput.

## II. THEORY

### A. Ad-hoc routing protocols:

An ad hoc routing protocol is a convention, or standard, that controls how nodes decides which way to route packets between computing devices in a mobile ad hoc network. In ad hoc networks, nodes are not familiar with the topology of their networks. Instead, they have to discover it: typically, a new node announces its presence and listens for announcements broadcast by its neighbors. Each node learns about others nearby and how to reach them, and may announce that it too can reach them [1]. Mobile ad hoc network does not have any fixed infrastructure. In ad hoc network node move arbitrarily so topology changes in ad hoc network is rapid and unpredictable therefore routing is very important in ad hoc network [4].

Routing protocols can be classified in three parts: (i) Table driven (Proactive) routing protocols (ii) Reactive routing protocols (iii) Hybrid routing protocols. [4].

#### 1) Proactive (Table driven) routing protocol [4]

In table driven routing protocols, every nodes maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node requires a path to a destination, it runs an appropriate path-finding algorithm on the topology information it maintains.

#### 2) Reactive (On demand) routing protocol

Protocols that fall under this category do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically [4]. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery occurs by flooding the

route request packets throughout the network. Examples of reactive routing protocols are the Ad-hoc On-demand Distance Vector routing (AODV), and Dynamic Source Routing (DSR) [5].

### 3) Hybrid routing protocol

Protocols belonging to this category combine the best features of the above two categories. Nodes within a certain distances from the node concerned, or within a particular geographical region, are said to be within the routing zone of the given node. For routing within this zone, a table-driven approach is used. For nodes that are located beyond this zone, an on-demand approach is used [4].

## III. STUDIED PROTOCOLS

### A. *Bellman-Ford Routing Protocol*

Bellman-Ford Routing Algorithm, also known as Ford-Fulkerson Algorithm, is used as a distance vector routing protocol. Routers that use this algorithm have to maintain the distance tables, which tell the distances and shortest path to sending packets to each node in the network. The information in the distance table is always updated by exchanging information with the neighboring nodes [4].

Advantages [4]:

- Easy to implement

Disadvantages [4]:

- It does not scale well.
- Changes in network topology are not reflected quickly since updates are spread node-by-node.
- Count to infinity (if link or node failures render a node unreachable from some set of other nodes, those nodes may spend forever gradually increasing their estimates of the distance to it, and in the meantime there may be routing loops).

### B. *Adhoc On-demand Distance Vector (AODV):*

This protocol performs route discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. When source node receives the route error (RERR) message, it can reinitiate route. Neighborhood information is obtained from broadcasted hello packets. It is a flat routing protocol which does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV protocol is a loop free and uses sequence numbers to avoid the infinity counting problem which is typical to the classical distance vector routing protocols [7].

AODV uses a broadcast route discovery mechanism as it also use(with modifications) in DSR algorithm . instead of source routing, however, AODV relies on dynamically establishing route table entries at intermediate nodes. This difference pays off in networks with many nodes, where a large overhead is incurred by carrying source routes in each data packet [6].

Advantages [7]:

- Routes are established on demand and destination sequence numbers are used to find the latest route to the destination.

- Lower delay for connection setup. Disadvantages [7]:
- AODV doesn't allow handling unidirectional links.
- Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead.
- Periodic beaconing leads to unnecessary bandwidth consumption [4].

### C. *Dynamic Source Routing (DSR):*

DSR is a reactive uniform routing protocol that uses a concept called source routing [8]. Each node maintains a route cache where it lists the complete routes to all destinations for which the routes are known. In dynamic source routing, source node sends a route request to all nodes which are in the wireless transmission range. Source routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks. To commence the route discovery mechanism, wireless node floods a route request to all nodes which are in the wireless transmission range. The initiator (source) and target (destination) of the route discovery is identified by each route request packet. The source node also provides a unique request identification number in its route request packet. For responding to the route request, the target node generally scans its own route cache for a route before sending the route reply toward the initiator node. However, if no suitable route is found, target will execute its own route discovery mechanism in order to reach toward the initiator [9].

The route maintenance mechanism is used when the source node is unable to use its current route to the destination due to changes in the network topology. In such case, the source has to use any other route to the destination. However, it may invoke the route discovery mechanism again to discover a new route. A routing entry in DSR contains all the intermediate nodes of the route rather than just the next hop information. A source puts the entire routing path in the data packet and the packet is sent through the intermediate nodes specified in the path. If the source does not have a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a path to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet [9].

Advantages [9]:

- Provide multiple routes and avoid loop formation.

Disadvantages [9]:

- Large end-to-end delay,
- Scalability problems caused by flooding and source routing mechanisms.

### D. *Dynamic MANET On-demand Protocol (DYMO):*

The Dynamic MANET On demand (DYMO) is a reactive or on demand, multihop, unicast routing protocol that not update route information periodically. The DYMO is a small memory stores routing information and generated Control Packets when a node receives the data packet from route path. The basic operations of Dynamic MANET On

demand source router generates Route Request (RREQ) messages and floods them for Destination routers for whom it doesn't have route information. Intermediate nodes store a route to the originating router by adding it into its routing table during this dissemination Process [4]. The target node after receiving the RREQ responds by sending Route Reply (RREP) Message. RREP is sent by unicast technique towards the source. An intermediate node that receives the RREP creates a route to the target and so finally it reaches to originator. Then Routes have been established between source and destination in both directions. The DYMO nodes monitors link over which traffic is flowing in order to cope up with dynamic network topology. A Route Error (RERR) message is generated when a node receives a data packet for the destination for which route is not known or the route is broken. Is RERR notifies other nodes about the link failure. The source node reinitiate route discovery quickly as it receives this RERR .Hello messages are used by all nodes to maintain routes to its neighbor nodes The sequence numbers are used in DYMO to make it loop free. These sequence numbers are used by nodes to determine the order of route discovery messages and so avoid propagating stale route information [4].

Type of Cast:

- Unicast [4]: Unicast forwarding means one to one communication. i.e., one source transmits data packets to a single destination.
- Multicast [4]: Multicast means one to many i.e. when a node needs to send same data to multiple destinations.

**IV. SIMULATION SETUP**

The four routing protocols (Bellman-ford, AODV, DSR and DYMO) are used to evaluate and compare the effectiveness of Mobile Ad-Hoc network; by performing extensive simulations in EXata 5.2[10] each simulation is carried out under a linear mobility. The simulation parameters are listed in Table 1.

**V. NETWORK SIMULATION**

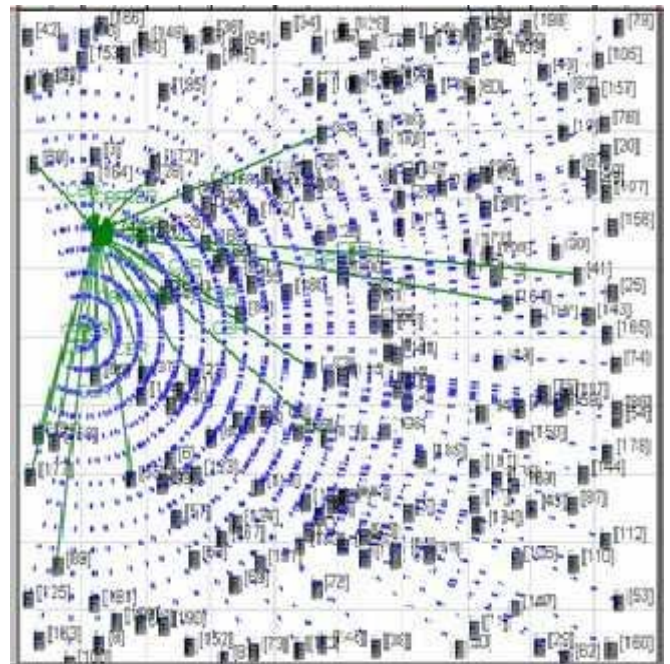
This Section enables to analyze temporal assessment of different routing protocol under the specified terrain conditions in wireless mesh networks.

**A. Simulation Scenario**

The scenario under consideration is constructed in EXata version 5.1 over Windows platform for simulation and emulation studies. EXata is a discrete event simulator [10].It is equally capable of simulating various wired or wireless scenarios from simple to complex conditions. In the simulation model, there are 200 nodes and all of these are connected to one wireless station. The terrain condition we have set as 1000m × 1000m as flat area. The entire area is further divided into 100 square shaped cells. Simulation time used is 90s. All the nodes are assumed as dynamic one. The type of wireless propagation model is Two Ray ground propagation. The numbers of constant bit rate (CBR) connections are 20.The entire connection set up has been done randomly.

Parameter	Value
Area size (flat area)	1500×1500
Attitude Range Above & Below Sea Level	1500m
Simulation Time	90sec
Energy Model	MicaZ
Traffic Type	CBR
Mobility Model	Random Waypoint
MAC Protocol	MAC802.15.4
Network protocol	IPV4
Routing protocol	Bellman-Ford, AODV,DSR,DYMO
No of Nodes	200
Node Placement	Random
Number of CBR	20
Data rate	2Mbps
Path Loss Model	Two Ray Model
No. of Channels	1
Channel Frequency	2.4GHz
Packet Size (bytes)	512
No. of times Experiment simulated	Single
MAC Protocol	IEEE 802.11
Battery Model	Linear
Antenna Model	Omni directional

**Table 1.Simulation Parameters**



**Fig. 1 Simulation Scenario**

## VI. SIMULATION PARAMETERS

The following three performance metrics are used to compare Bellman-ford, AODV, DSR and DYMO protocols.

### A. Throughput [4]:

Throughput is defined as total number of packets received by the destination. It is a measure of effectiveness of a routing protocol (Reddy and Reddy 2006). Throughput is determined as the ratio of the total data received to required propagation time. The throughput (messages/second) is the total number of delivered data packets divided by the total duration of simulation time (Al-Maashri and Ould-Khaoua, 2006).

### B. Average End-to-End Delay [4]:

Average end-to-end delay is the average time it takes a data packet to reach to destination in seconds. It is calculated by subtracting "time at which first packet was transmitted by source" from "time at which first data packet arrived to destination".

### C. Jitter [4]:

Jitter is the variation in the time between packets arriving, caused by network congestion, and route changes.

## VII. SIMULATION RESULTS

The simulation is done for the performance analysis of different routing protocols using the EXata 5.1 which is developed by Scalable Network Technology [9]. EXata 5.1 provides a comprehensive environment for designing protocols, creating and animating network scenarios, and analyzing their performance. On the basis of the above mentioned simulation scenario and parameters, have obtained the following results. The results are shown as under in the form of various analyses from Fig.1 to Fig.12.

### A. Results and Discussions

Bellman-Ford has throughput of 550066 bits/sec which is less than AODV and DYMO because the changes in network topology are not reflected quickly since updates are spread node-by-node and in the meantime there may be routing loops.

AODV protocol has highest throughput of 751447bits/sec because it establishes routes on demand and the destination sequence numbers are applied to find the latest route to the destination. So the connection setup delay is lower. Hence has higher throughput.

DSR has lowest throughput 217457 bits/sec because the performance degrades rapidly with increasing mobility as route cache information could also result in inconsistencies during the route reconstruction phase. The connection setup delay is higher than in table-driven protocols. But the protocol performs well in static and low-mobility environments.

DYMO is an advancement of existing AODV protocol. DYMO operates similar to the AODV but operation is moreover quite simpler. In DYMO routes are computed on demand. Unlike AODV, DYMO does not support unnecessary HELLO messages; operation is purely based upon the sequence number assigned to all the packets. As DYMO is the advanced version of AODV but still it has low throughput than later. The throughput of DYMO is 719922bits/sec and of AODV is 751447bits/sec. This is because DYMO does not perform well with low mobility as for the low mobile networks the control messages overhead is high and unnecessary. So the throughput get reduced.

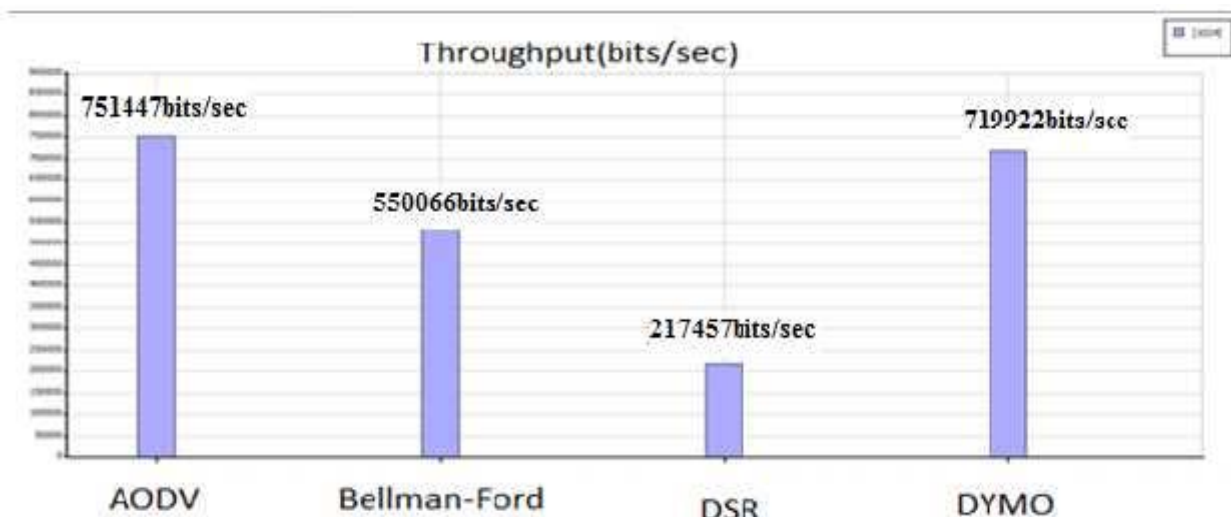


Fig.2. Throughput



Fig.3.Average End to End Delay

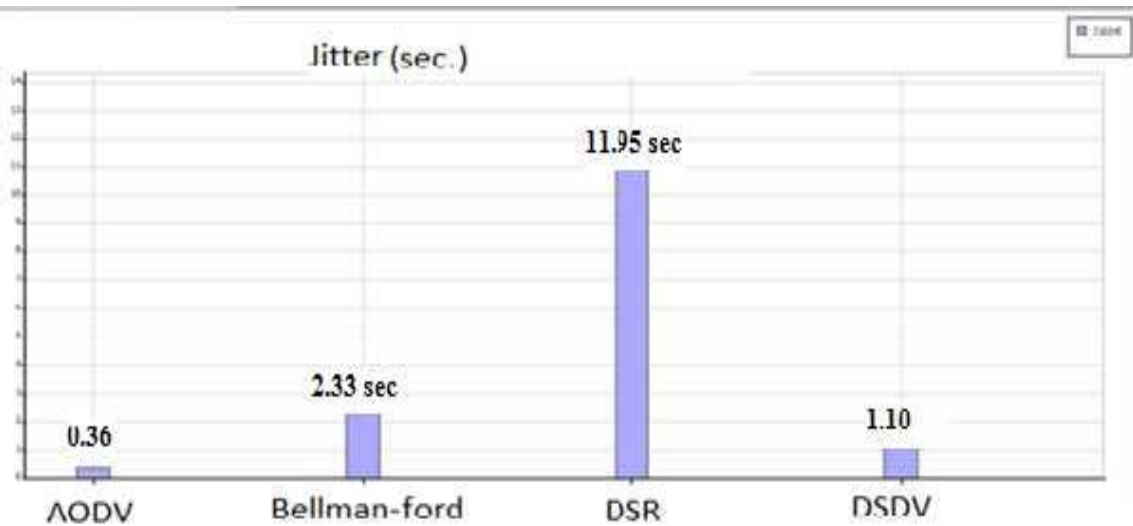


Fig.4. Jitter

VIII. CONCLUSION

Throughput should be higher for better performance in a network whereas average end to end delay and jitter both should be minimum. Here Jitter and Average end to end delays are minimum for AODV therefore it has better performance than rest all of the protocols. But DSR has maximum values for both jitter and average end to end delay hence have least throughput.

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