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Throughput and Delay Comparison of MANET Routing Protocols

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Abstract

Mobile wireless ad hoc networks are infrastructureless and often used to operate under unattended mode. So, it is significant in bringing out a comparison of the various routing protocols for better understanding and implementation of them. In this paper, we studied and compared the performance of various routing protocols like Ad hoc On-Demand Vector routing (AODV), Fisheye, Dynamic MANET On-demand (DYMO), Source Tree Adaptive Routing (STAR) protocol, Routing Information Protocol (RIP), Bellman Ford, LANd Mark Ad hoc Routing protocol (LANMAR) and Location Aided Routing protocol (LAR). The comparison results were graphically depicted and explained.

Keywords: *MANET, Wireless networks, routing, AODV, Scalability, Fault tolerance*

1 Introduction

Scalable routing is one of the key challenges in designing and operating large scale Mobile Ad hoc NETworks (MANET). In order to ensure effective operation as the total number of nodes in the MANET becomes very large, the overhead of the employed routing algorithms should be low and independent of the total number of nodes in MANET [1]. An important consideration in the development of scalable routing algorithms in large scale MANET is that the overhead properties of the scalable routing formally studied and analysed. In order for the ad hoc networks to operate as efficiently as possible, appropriate on-demand routing protocols have to be incorporated, to find efficient routes from a source to a destination, taking node mobility into consideration. The Mobility influences ongoing transmissions, since a mobile node that receives and forwards packets may move out of range. As a result, links fail over time. In such cases a new route must be established. Thus, a quick route recovery procedure should be one of the main characteristics of a routing protocol. It is also important to study the various performance metrics for better understanding and utilization of the routing protocols. In this paper, we presented the results for various proactive and reactive routing protocols like Ad Hoc On-Demand Vector routing (AODV), Fisheye, Dynamic MANET On-demand (DYMO), Source Tree Adaptive Routing (STAR) protocol, Routing Information Protocol (RIP), Bellman Ford, LANd Mark Ad hoc Routing protocol (LANMAR) and Location Aided Routing protocol (LAR). The performance analysis of our study is restricted to throughput and delay metrics with and without concern of mobility.

2 Problem Formulations

2.1 AODV

The Ad Hoc On-Demand Distance Vector routing protocol (AODV) is an improvement of the Destination-Sequenced Distance Vector routing protocol (DSDV). It is based on distance vector and also uses the destination sequence numbers to determine the freshness of the routes. It operates on the On-demand fashion. AODV requires hosts to maintain only active routes. The advantage of AODV is that it tries to minimize the number of required broadcasts. It creates the routes on an on-demand basis, as opposed to maintain a complete list of routes for each destination. Therefore, the literature on AODV [2], classifies it as a *pure on-demand route acquisition system*. The usage of the AODV protocol for mobile ad hoc networking applications provided consistent results for large scale scenarios [3].

2.2 Fisheye

Fisheye technique proposed by Kleinrock and Stevens [4] to reduce the size of information required to represent graphical data. The eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from the focal point increases. In routing, the fisheye approach translates to maintaining accurate distance and path quality information about the immediate neighborhood of a node, with progressively less detail as the distance increases.

2.3 Dymo

The DYnamic MANET On-demand (DYMO) protocol is a reactive routing protocol being developed within IETF's MANET working group. Typically, all reactive routing protocols rely on the quick propagation of route request packets throughout the MANET to find routes between source and destination. While this process typically relies on broadcasting, route reply messages that are returned to the source rely on unicasting. DYMO is basically an improvement over the AODV protocol as for AODV every node records the next hop to send a packet to a specific destination [5].

2.4 STAR

STAR [6] is a table-driven routing protocol. Each node discovers and maintains topology information of the network, and builds a shortest path tree (source tree) to store preferred paths to destinations. The basic mechanisms in STAR include the detection of neighbors and exchange of topology information (update message) among nodes. For STAR, there are importantly two alternative mechanisms to discover neighbours. When a node receives a hello message from another node that it does not know previously, it discovers a new neighbor. If a node does not receive any message (update or hello) from a neighbor for a certain period of time, it determines that this neighbour is broken or out of its range.

2.5 RIP

Routing Information Protocol (RIP) is an Interior Gateway Protocol used to exchange routing information within a domain or autonomous system. RIP lets routers exchange information about destinations for the purpose of computing routes throughout the network. Destinations may be individual hosts, networks, or special destinations used to convey a default route. RIP is based on the Bellman-Ford or the distance-vector algorithm. This means RIP makes routing decisions based on the hop count between a router and a destination. RIP does not alter IP packets; it routes them based on destination address only.

2.6 Bellman Ford

Bellman-Ford Routing Algorithm, also known as Ford-Fulkerson Algorithm, is used as an algorithm by distance vector routing protocols such as RIP, BGP, ISO IDRP, NOVELL IPX. Routers that use this algorithm will 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. The number of data in the table equals to that of all nodes in networks (excluded itself). The columns of table represent the directly attached neighbors whereas the rows represent all destinations in the network. Each data contains the path for sending packets to each destination in the network and distance/or time to transmit on that path. The measurements in this algorithm are the number of hops, latency, the number of outgoing packets, etc.

2.7 LANMAR

LANMAR is an efficient routing protocol in a “flat” ad hoc wireless network [7, 8]. LANMAR assumes that the large scale ad hoc network is grouped into logical subnets in which the members have a commonality of interests and are likely to move as a “group” LANMAR uses the notion of landmarks to keep track of such logical subnets. It uses an approach similar to the landmark hierarchical routing proposed in [9] for wired networks. Each logical group has one node serving as landmark. The route to a landmark is propagated throughout the network using a Distance Vector mechanism [7]. The routing update exchange of LANMAR routing can be explained as follows. Each node periodically exchanges topology information with its immediate neighbours. In each update, the node sends entries within its Fisheye scope [3]. Updates from each source are sequentially numbered. To the update, the source also piggybacks a distance vector of all landmarks. Through this exchange process, the table entries with larger sequence numbers replace the ones with smaller sequence numbers. As a result, each node has detailed topology information about nodes within its Fisheye scope and has a distance and routing vector to all landmarks. LANMAR outperform AODV protocol.

2.8 LAR

The Location - Aided Routing Protocol uses location information to reduce routing overhead of the ad-hoc network. Normally the LAR protocol uses the GPS (Global Positioning System) to get this location information. With the availability of GPS, the mobile hosts knows there physical location. To reduce the complexity of the protocol, we assume that every host knows his position exactly; the difference between the exact position and the calculated position of GPS will not be considered.

3 Design of the Experiment & Simulation Setup

The method for analyzing the routing protocols traffic is to begin with a carefully designed base configuration and network scenario for the experiment, and to vary the node density and mobility at a time to stress the network in different directions. Careful selection of these control parameters enables us to assess and isolate the effect of network size, with fixed application traffic CBR. In addition, design of the base condition, network topology, and routing are to be taken into account the real networks for which the results should be applicable.

In this experiment, we noted down the throughput and delay values for various few node and a multimode scenarios for assessing the scalability issue for the routing protocols under consideration. In the beginning of the experiment, the initial settings of the node and simulation times were thoroughly checked out. Care also is taken in selection of the terrain dimension, disabling the unnecessary filter components in the simulator settings. The experiment is continued for different node densities of 2, 10, 50 and 100 nodes respectively. In all these cases, we noted down the throughput, delay and real times of the simulator. We selected the terrain dimensions as 1500m x1500m cm, and nodes in the terrain are mobile. We fixed the simulation time for all the node densities and also varied according to the increments in node densities. The experiment used a static utilization of IPv4 networking protocol. QualNet, is a scalable network simulation library that was designed with the primary goal of simulating large, high-fidelity models of wired, wireless, and mixed networks in an efficient manner. It was designed to achieve modular design for easy comparison of protocols under uniform conditions, detailed and accurate models, efficient execution, and transparent parallel execution for further scalability and runtime efficiency [10, 11]. These significant features encouraged us to use QualNet (Evaluation version) for our study.

3.1 Mobility model

Nodes in the simulation set up move according to a model that is well known as the "random waypoint" model. The movement scenario files we used for each simulation are characterized by a pause time. Each node begins the simulation by remaining stationary for *pause time* seconds. It then selects a random destination in the 1500m x 1500m space and moves to that destination at a speed distributed uniformly between 0mps and a maximum speed of 10mps. Upon reaching the destination, the node pauses again for *pause time* seconds, selects another destination, and proceeds there as previously described, repeating this behavior for the duration of the simulation. Each simulation ran for 200 seconds of simulated time. We ran our simulations with movement patterns generated for a fixed pause time of 30 Seconds.

3.2 Application Traffic

As the goal of our simulation was to compare the performance of each routing protocol, we chose our application traffic sources to be constant bit rate (CBR) sources**.** When defining the parameters of the communication model, we experimented with sending rates of 1.2 packets per second and packet sizes of 512 bytes to observe the consistency.

4 Results and Discussion

4.1 Throughput

It is one of the dimensional parameters of the network which gives the fraction of the channel capacity used for useful transmission selects a destination at the beginning of the simulation i.e., information whether or not data packets correctly delivered to the destinations.

4.2 Average end to end delay

The average end-to-end delay of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination.

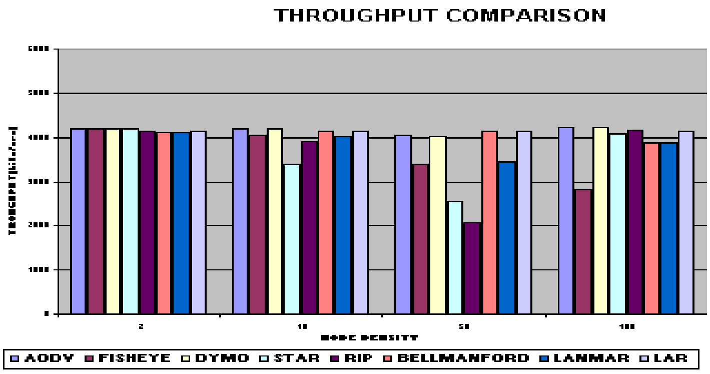

Figure 1. Throughput comparison

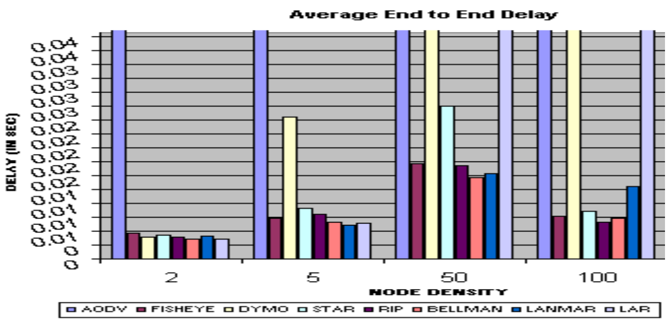

Figure 2. Average End to end delay comparison

4.3 Throughput analysis

In the above experiment we found that at node densities of 2, 10, 50 and 100 Star and RIP routing protocols showed lower throughput values whereas other routing protocols others are consistent. It is further observed that, as the node density is increased further, the Bellman- Ford routing protocol has a higher throughput. This shows the throughput is this protocol may be useful at higher node densities. It is also found that RIP, STAR, Fisheye and LANMAR protocols showed a dip at a node density of 50. This indicates that when network scaled up the average results of several interactive runs (10 interactive runs in our experiment and converted them into consistent results as shown in Figure: 1) are to be taken into account, but not the individual results. The results are compared with the extended results of already existing work [3] and found very much suitable for selecting routing protocols.

4.4 End to end delay analysis

As shown in Figure: 2**,** this simulation experiment showed us that AODV, Dymo and Bellmanford protocols are having higher end to end delays than others, indicating that the speed of simulation in large scale networks will be affected by this. Whereas LANMAR and RIP shows the considerable amount of delay in scaled up environment. This analysis exclusively deals with the network speed and communication effectiveness. Higher the delay, lower is the speed and possibility of packet drop and so needs the fault tolerance approach of selecting these protocols.

5 Conclusion

In this paper, we compared the routing protocols based on significant performance metrics like throughput and delay. In this experiment we gone through some problems like communication stoppage for short durations, difference in simulation times for same scenario conditions (of course was solved by running the simulator for more than 10 times). We also faced the problem of switching off of the scenario for higher node densities. It might be due to the processor capability (RAM usage). We obtained the consistent results as compared with the literature [12, 13]. We believe that our work could be more intuitive for researchers for protocol selection and their suitability of application in real time scenario analysis in ad hoc networks.

6 Open Problem

Our work focussed only on the network throughput and delay. It would be significant to consider other metrics like power consumption, the number of hops to route the packet, fault tolerance, minimizing the number of control packets etc., The work can be extended by nitty-gritty study of routing protocols in a fault tolerant approach with proper simulation set up with parallel real time environment for mobile and wireless ad hoc networks.

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