Performance Analysis of DSR, AODV, FSR and ZRP Routing Protocols in MANET

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Abstract - Mobile Ad hoc NETwork (MANET) is a collection of mobile nodes that are arbitrarily located so that the interconnections between nodes are dynamically changing. MANET mobile nodes forms a temporary network without the use of any existing network infrastructure or centralized administration. A routing protocol is used to find routes between mobile nodes to facilitate communication within the network. The main goal of such an ad hoc network routing protocol is to establish correct and efficient route between a pair of mobile nodes so that messages delivered within the active route timeout interval. Route should be discovered and maintained with a minimum of overhead and bandwidth consumption. This paper presents performance evaluation of three different routing protocols i.e. Dynamic Source Routing Protocol (DSR), Ad hoc On-demand Distance Vector (AODV), FishEye State Routing (FSR) and Zone Routing Protocol (ZRP) with respect to variable pause times. Performance of DSR, FSR and ZRP is evaluated based on Average end-to-end delay, Packet delivery ratio, Throughput and Average Jitter.

Keywords- MANET, DSR, AODV, FSR, ZRP, Jitter, Throughput, Average end-to-end delay, Packet delivery ratio, Pause time.

1. INTRODUCTION

A mobile ad hoc network is a collection of wireless mobile nodes that dynamically establishes the network in the absence of fixed infrastructure [1]. One of the distinctive features of MANET is, each node must be able to act as a router to find out the optimal path to forward a packet. As nodes may be mobile, entering and leaving the network, the topology of the network will change continuously. MANETs provide an emerging technology for civilian and military applications. One of the important research areas in MANET is establishing and maintaining the ad hoc network through the use of routing protocols. Though there are so many routing protocols available, this paper considers FSR, ZRP, AODV and DSR for performance comparisons due to pause time. These protocols are analyzed based on the important metrics such as throughput, packet delivery ratio, jitter and average end-to-end delay.

Most of the research study shows that DSR and AODV are performing well depend upon the environment, among the reactive protocols. In the case of proactive, FSR, TORA and OLSR protocols are performing well. The performance of different proactive, reactive and hybrid protocols have been analyzed by different researchers. The comparative analysis of DSR [2], AODV [3], FSR [4] and ZRP [5] is proposed in this paper since no such analysis is available in the literature.

In particular, Section 2 presents the related works with a focus on the evaluation of the routing protocols. Section 3 briefly discusses the MANET routing protocols classification and the functionality of these routing protocols FSR, ZRP, AODV and DSR. The simulation results and comparative analysis of the above said routing protocols are discussed in Section 4. Finally, Section 5 concludes with the comparisons of the overall performance of these protocols.

2. RELATED WORK

Most recently, Ashish K. et al [6] evaluated AODV, FSR and ZRP for Scalable Networks. They performed simulations with the following two different scenarios for the performance evaluation of AODV, FSR and ZRP routing protocol.

(i). Network designed using random waypoint mobility model with different pause time.
(ii). Network designed using random waypoint mobility model with variable number of nodes.

Performance of AODV, FSR and ZRP routing protocol is evaluated with respect to four performance metrics such as average end to end delay, packet delivery ratio, throughput and average jitter. AODV shows best performance when compared with FSR and ZRP in terms of packet delivery ratio and throughput. AODV delivers more than 60 percent of all CBR packets when network is presented as a function of pause time and delivers more than 80 percent of all CBR packets when network is presented as a number of nodes.

Sree Ranga Raju, et al [7] compared the performance of DSR, AODV and ZRP, especially focusing on ZRP and the impact of some of its most important attributes to the network performance. They found that the performance of ZRP was not up to the task and it performed poorly throughout all the simulation sequences.

Ayyaswamy Kathirvel, et al [8] compared the performance of DSR, AODV, FSR and ZRP with respect to propagation model. Reactive routing protocols (AODV and DSR) have got good packet delivery ratio. When compared with proactive and hybrid routing protocols, hybrid routing protocol have got next higher packet delivery ratio. Similarly reactive routing protocols have got less delay and jitter.
3. OVERVIEW OF MANET ROUTING PROTOCOLS

a. Dynamic Source Routing

The Dynamic Source Routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks. Route Discovery: Is the mechanism by which a source node to send a packet to a destination node, obtains a source route to the destination. Route discovery is used only when the source node attempts to send a packet to a destination and does not already know a route to that destination. Route Maintenance: Is the mechanism by which a node to send a packet to a destination is able to detect, while using a source route to the destination, if the network topology has changed. If this is the case then it must no longer use this route to the destination because a link along the route broken. Route maintenance for this route is used only when the source node is actually sending packets to the destination. 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.

The responsibility for assessing the status of a route falls to each node in the route. Each must insure that packets successfully cross the link to the next node. If it doesn’t receive an acknowledgement, it reports the error back to the source, and leaves it to the source to establish a new route. While this process could use up a lot of bandwidth, DSR gives each node a route cache for them to use aggressively to reduce the number of control messages sent. If it has a cache entry for any destination request received, it uses the cached copy rather than forward the request. In addition, it promiscuously listens to other control messages for additional routing data to add to the cache.

b. Fisheye State Routing

Fisheye State Routing (FSR) [4] protocol is a proactive (table driven) ad hoc routing protocol and its mechanisms are based on the Link State Routing protocol used in wired networks. FSR is an implicit hierarchical routing protocol. It reduces the routing update overhead in large networks by using a fisheye technique. Fisheye has the ability to see objects the better when they are nearer to its focal point that means each node maintains accurate information about near nodes and not so accurate about far-away nodes. The scope of fisheye is defined as the set of nodes that can be reached within a given number of hops. The number of levels and the radius of each scope will depend on the size of the network. Entries corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency and the exchanges in smaller scopes are more frequent than in larger. That makes the topology information about near nodes more precise than the information about far away nodes. FSR minimized the consumed bandwidth as the link state update packets that are exchanged only among neighboring nodes and it manages to reduce the message size of the topology information due to removal of topology information concerned far-away nodes. Even if a node doesn’t have accurate information about far away nodes, the packets will be routed correctly because the route information becomes more and more accurate as the packet gets closer to the destination. This means that FSR scales well to large mobile ad hoc networks as the overhead is controlled and supports high rates of mobility.

Fig. 1 illustrates how the fisheye technique is applied to a MANET. When the size of a network increases, sending update messages may potentially consume the bandwidth. FSR uses the fisheye technique to reduce the size of the update message without affecting routing. In the figure, three fisheye scopes are defined with respect to the focal point, node 11.

c. Zone Routing Protocol

Zone Routing Protocol or ZRP was the first hybrid routing protocol with both a proactive and a reactive routing component. ZRP was first introduced by Haas in 1997. ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols. ZRP defines a zone around each node consisting of its k-neighborhood (e. g. k=3). In ZRP, the distance and a node, all nodes within hop distance from node belongs to the routing zone of node. ZRP is formed by two sub-protocols, 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, respectively. A route to a destination within the local zone can be established from the proactively cached routing table of the
source by IARP, therefore, if the source and destination is in
the same zone, the packet can be delivered immediately.
Most of the existing proactive routing algorithms can be used
as the IARP for ZRP. For routes beyond the local zone, route
discovery happens reactively. The source node sends a route
requests to its border nodes, containing its own address, the
destination address and a unique sequence number. Border
nodes are nodes which are exactly the maximum number of
hops to the defined local zone away from the source. The
border nodes check their local zone for the destination. If the
requested node is not a member of this local zone, the node
adds its own address to the route request packet and forwards
the packet to its border nodes. If the destination is a member
of the local zone of the node, it sends a route reply on the
reverse path back to the source. The source node uses the
path saved in the route reply packet to send data packets to
the destination.

Consider the network in Fig 2. The node S has a
packet to send to node X. The zone radius is \( r = 2 \). The node
uses the routing table provided by IARP to check whether
the destination is within its zone. Since it is not found, a
route request is issued using IERP. The request is broadcast
to the peripheral nodes (gray in the picture). Each of these
searches their routing table for the destination.

\[ d. \text{ Ad hoc On-demand Distance Vector} \]

The Ad-hoc On-Demand Distance Vector (AODV)
routing protocol is designed for use in ad-hoc mobile
networks. AODV is a reactive protocol: the routes are
created only when they are needed. It uses traditional routing
tables, one entry per destination, and sequence numbers to
determine whether routing information is up-to-date and to
prevent routing loops. An important feature of AODV is the
maintenance of time-based states in each node: a routing
entry not recently used is expired. In case of a route is broken
the neighbors can be notified. Route discovery is based on
query and reply cycles, and route information is stored in all
intermediate nodes along the route in the form of route table
entries.

The following control packets are used: routing
request message (RREQ) is broadcasted by a node requiring
a route to another node, routing reply message (RREP) is
back to the source of RREQ, and route error message
(RERR) is sent to notify other nodes of the loss of the link.
HELLO messages are used for detecting and monitoring
links to neighbors.

4. SIMULATION RESULTS AND ANALYSIS

a. Average End-to-End Delay

End-to-end delay indicates how long it a packet
takes to travel from the CBR source to the application layer
of the destination. [9]. This includes all possible delays
caused by buffering during route discovery latency, queuing
at the interface queue, retransmission delays at the MAC,
propagation and transfer times. The average delay from the
source to the destination’s application layer is shown in fig 3.
According to our simulation results, best performance is
shown by FSR having lowest end to end delay. With the
increase in pause time average end to end delay is constant
from pause time up to 60 sec, and then decreases for DSR, ,
initially FSR and AODV increases up to 60 sec then
decreases and ZRP increases up to 40 sec, decreases up to
60 sec and constant from pause time 60sec to 100sec.

b. Packet Delivery Ratio

Packet delivery ratio is the fraction of packets sent
by the application that are received by the receivers and is
calculated by dividing the number of packets received by the
destination through the number of packets originated by the application layer of the source. For better performance of a routing protocol, it should be better [10]. The packet delivery ratio is shown in fig 4, DSR perform much better than AODV, FSR and ZRP of all CBR packets.

![Figure 4: Packet Delivery Ratio](image)

**c. Throughput**

The throughput is defined as the total amount of data a receiver receives from the sender divided by the time it takes for the receiver to get the last packet. The throughput is measured in bits per second (bit/s or bps) [11]. The throughput is shown in fig 5. According to our simulation results, best performance is shown by DSR as it delivers data packets at higher rate in comparison to AODV, FSR and ZRP.

![Figure 5: Throughput](image)

**d. Average Jitter**

Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. It should be less for a routing protocol to perform better. The average jitter is shown in fig 6. In DSR, there is more chance for jitter as source node initiate route discovery mechanism by broadcasting a route request packet to its neighbors. According to our simulation results, ZRP has less average jittering than DSR, AODV and FSR routing protocols.

![Figure 6: Average Jitter](image)

5. **CONCLUSIONS**

In this paper, a performance comparison of DSR, AODV, FSR and ZRP routing protocols for mobile Ad-hoc networks is presented as a function of pause time. Performance of these routing protocols is evaluated with respect to four performance metrics such as average end to end delay, packet delivery ratio, throughput and average jitter. According to our simulation results, DSR shows best performance than AODV, FSR and ZRP in terms of packet delivery ratio and throughput as a function of pause time. FSR show lowest end-to-end delay and ZRP has less average jittering than DSR, AODV and FSR. DSR and AODV performed the worst in case of average jitter and ZRP performed the worst in case of throughput. In future, number of nodes, more sources, additional metrics such as average hop count, routing overhead may be used.
REFERENCES


