Simulation study of Mobile Ad-hoc Networks routing protocols

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***Abstract*— A mobile ad hoc network (MANET) consists of mobile wireless nodes. The communication between these mobile nodes is carried out without any centralized control. MANET is a self organized and self configurable network where the mobile nodes move arbitrarily. The mobile nodes can receive and forward packets as a router. Routing is a critical issue in MANET and hence the focus of this paper along with the performance analysis of routing protocols. We compared four routing protocols i.e. AODV, DSR ,OLSR and ZRP. Our simulation tool will be Network Simulator (NS-2.34). The performance of these routing protocols is analyzed by two metrics: packet delivery fraction and End to end delay. All the four routing protocols are explained in a deep way with metrics. The comparison analysis will be carrying out about these protocols and in the last the conclusion will be presented, that which routing protocol is the best one for mobile ad hoc networks.**

Keywords*— *MANET, NS-2, AODV, OSLR, DSR, ZRP.

I. Introduction

Wireless networks have continued to play prominent roles in day to day communication. It is widely used in military applications, industrial applications and even in personal area networks. It has been very popular in different applications in view of its different valuable attributes which includes simplicity of installation, reliability, cost, bandwidth, total required power, security and performance of the network. But similar to wired networks, it also make use of fixed infrastructures[7] such as cordless telephone, cellular networks, Wi-Fi, microwave communication and satellite communication etc.

Nowadays, next generation wireless ad-hoc networks are widely used because of user base of independent mobile users, need for efficient and dynamic communication in emergency/rescue operations, disaster relief efforts, and military networks and also for different applications [3], [9].

The network covers a large geographical area without fixed topology which may change dynamically and unpredictably. These networks improve the scalability of the network compared to the infrastructure-based wireless networks because of its decentralized nature. In any critical scenarios such as natural disasters, military conflicts etc, ad-hoc network provides better performance due to the minimum configuration and quick operations [10], [14].

The design of an optimum routing protocol for MANET is highly complex. The need to design an efficient algorithm, which will help to determine the connectivity of network organizations, link scheduling, and routing in such dynamic scenarios, becomes very important [6]. The efficiency of a routing algorithm depends on the efficient and successful route computation. Usually the shortest path algorithm is an effective approach to calculate the optimal route in static networks but this simple idea is not always true in a MANET framework [13]. Many factors: such as extended power [2], quality of wireless links, path losses, fading, interference, and topological changes have to be considered for determining a new route.

Networks should adaptively change their routing paths depending on scenarios at any instance to improve any of these affects [11].

There are three categories of MANET routing protocols: table driven, on-demand and hybrid. In a table driven(proactive) protocol

A. Proactive Routing protocols:

Proactive routing protocols are also called table driven routing protocols because each node maintains a dynamic routing table. It is efficient if the network is static and routes are often used. The updates are shared periodically between the nodes. Each node than recalculates the shortest path on the basic of minimum hop count. Thus each node contains a complete picture of the network topology. Various proactive routing protocols are OLSR ,DSDV, FSR, and WRP etc.

B. Reactive Routing protocols:

Reactive routing protocols first listen to the communication request. It is also called as on-demand routing as route discovery is initiated only when there is a demand of communication between any two nodes. This paradigm is more efficient and prevents routing overhead up to a certain limit. The examples are DSR, AODV and TORA.

C. Hybrid Routing protocol:

A Hybrid protocol combines the advantages of proactive and reactive routing protocols. It uses reactive protocol for reducing routing overhead and proactive protocols to reduce latency. It presents a trade-off between latency and overhead. The Zone Routing Protocol (ZRP) [4] is the most popular hybrid routing protocol. ZRP takes advantage of this fact and divides the entire network into overlapping zones of variable size. It uses proactive protocols for finding zone neighbors (instantly sending *hello* messages) as well as reactive protocols for routing purposes between different zones [5].

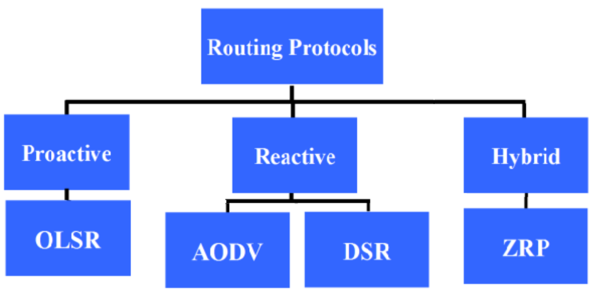

Fig.1. categories of MANET routing protocols

II. AD HOC NETWORK ROUTING PROTOCOLS

There are several kinds of routing protocols for wireless ad hoc networks. We will discuss four of these protocols :

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

AODV is an on-demand routing protocol. The AODV algorithm gives an easy way to get change in the link situation. For example if a link fails notifications are sent only to the affected nodes in the network. This notification cancels all the routes through this affected node. It builds unicast routes from source to destination and that's why the network usage is least. Since the routes are build on demand so the network traffic is minimum. AODV does not allow keeping extra routing which is not in use . If two nodes wish to establish a connection in an ad hoc network then AODV is responsible to enable them to build a multi-hop route. AODV uses Destination Sequence Numbers (DSN) to avoid counting to infinity that is why it is loop free. This is the characteristic of this algorithm. When a node send request to a destination, it sends its DSNs together with all routing information. It also selects the most favorable route based on the sequence number [4].

There are three AODV messages i.e. Route Request (RREQs), Route Replies (RREPs), and Route Errors (RERRs) [1]. By using UDP (user datagram protocol) packets, the source to destination route is discovered and maintain by these messages. For example the node which request, will use its IP address as Originator IP address for the message for broadcast. It simply means that the AODV not blindly forwarded every message. The number of hops of routing messages in ad hoc network is determined by Time-To-Live (TTL) in the IP header.

When the source node wants to create a new route to the destination, the requesting node broadcast an RREQ message in the network .

B. DSR (Dynamic Source Routing)

Dynamic Source Routing Protocol is a reactive routing protocol and is called on demand routing protocol. It is a source routing protocol that is why it is a simple and an efficient protocol. It can be used in multi hop wireless ad hoc networks [5]. The DSR network is totally self organizing and self configuring. The protocols is just compose of two mechanisms i.e. route discovery and route maintenance. The DSR regularly updates its route cache for the sake of new available easy routes. If some new available routes were found the node will directs the packet to that route. The packet has to know about the route direction. So the information about the route was set in the packet to reach its destination from its sender. This information was kept in the packet to avoid periodic findings it has the capability to find out its route by this way. DSR has two basic mechanisms for its operation i.e. route discovery and route maintenance. In route discovery, it has two messages i.e. route request (RREQ) and route reply (RREP). When a node wishes to send a message to a specific destination, it broadcast the RREQ packet in the network. The neighbor nodes in the broadcast range receive this RREQ message and add their own address and again rebroadcast it in the network. This RREQ message if reached to the destination, so that is the route to the specific destination. In the case if the message did not reached to the destination then the node which received the RREQ packet will look that previously a route used for the specific destination or not.

Each node maintains its route cache which is kept in the memory for the discovered route. The node will check its route cache for the desired destination before rebroadcasting the RREQ message. By maintaining the route cache at every node in the network, it reduces the memory overhead which is generated by the route discovery procedure. If a route is found in that node route cache then it will not rebroadcast the RREQ in the whole network. So it will forward the RREQ message to the destination node. The first message reached to the destination has full information about the route. That node will send a RREP packet to the sender having complete route information.

C. OLSR (Optimized Link State Routing)

It is a proactive routing protocol and is also called as table driven protocol because it permanently stores and updates its routing table.

OLSR keeps track of routing table in order to provide a route if needed. OLSR can be implemented in any ad hoc network. Due to its nature OLSR is called as proactive routing protocol. Multipoint relay (MPR) nodes are shown in the given figure 2. All the nodes in the network do not broadcast the route packets. Just Multipoint Relay (MPR) nodes broadcast route packets. These MPR nodes can be selected in the neighbor of source node. Each node in the network keeps a list of MPR nodes[12].

This MPR selector is obtained from HELLO packets sending between in neighbor nodes. These routes are built before any source node intends to send a message to a specified destination. Each and every node in the network keeps a routing table. This is the reason the routing overhead for OLSR is minimum than other reactive routing protocols and it provide a shortest route to the destination in the network. There is no need to build the new routes, as the existing in use route does not increase enough routing overhead. It reduces the route discovery delay.

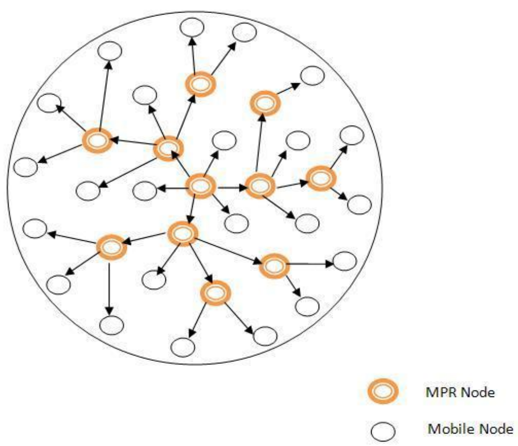

Fig. 2. MPR node sends the TC message

D. Zone Routing hybrid protocol

Haas and Pearlman first introduced Zone Routing hybrid protocol (ZRP) whereby whole network area is divided into several small zones to perform its operation. Zone size or radius does not depend on distance or radius; it depends on the number of hops. It is applicable in a wide variety of mobile Ad-hoc network with diverse mobility across a large span. It uses separate strategy to find out a new route between nodes, which are lying within or outside the zone.

There are four elements available in ZRP: MAC level function, IARP, IERP and BRP. IARP, proactive approach is used to discover a new route within the zone and in this case, links are considered as unidirectional.

But in order to communicate with the nodes, which sometimes may be located outside the zone, it uses IERP, on-demand routing approach. These different strategies, such as routing zone topology and proactive maintenance which improve the routing efficiency and the globally reactive routing using query/reply mechanism improves the quality of discovering in ZRP [6].

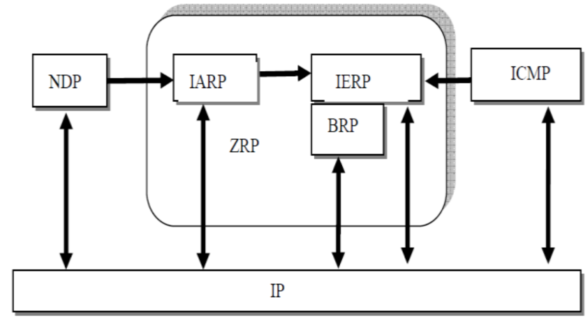

Fig.3. A complete block diagram of ZRP with different components.

III. PERFORMANCE EVALUATION OF ROUTING PROTOCOLS

In this section we will present different metrics considered in the performance evaluation of routing protocols. First we will briefly discuss the performance parameters considered in the comparison. The simulation design will also be discussed.

A. Performance evaluating metrics :

In order to evaluate the performance of the concerned routing protocols, the following two metrics are considered:

1.Packet Delivery Fraction (PDF):

This is the ratio of the number of data packets successfully delivered to the destinations to those generated by sources.

Packet Delivery Fraction (pdf %) =
(received packets/ sent packets) * 100

2.Average End-to-End Delay (AED):

It is defined as the average time taken by data packets to propagate from source to destination across the network. This includes all possible delays under Pause time and number of nodes.

For each packet sent, calculate the send time and receive time, then average it.

B. Software Environment

We used standard simulator tool NS2 for simulation [8] Network simulator (NS2) is an event driven simulator tool and designed specifically to study the dynamic nature of wireless communication networks.

At the physical and data link layer, we used the IEEE 802.1 with Two Ray Ground radio propagation model. We have considered the traffic of Constant Bit Rate (CBR) data packets over UDP.

The next Table summarizes the complete setup for the simulation :

TABLE I
SIMULATION SETUP

Parameter	Value
Simulation tool	NS-2 (2.34)
Operating system	Ubuntu Linux 18.04.2 desktop
Area Size	1000 m * 1000 m
Maximum Speed	20 m/s
Maximum Connection	25
Packets Rate	12 Packets / Second
Traffic Type	CBR over UDP
Simulation Time	600 (sec)
Packet Size	512 bytes
Pause Time	0,100,200,300,400,500,600
Number of node	50,100,150,200,250

C. Simulation of first Scenario (Mobility) :

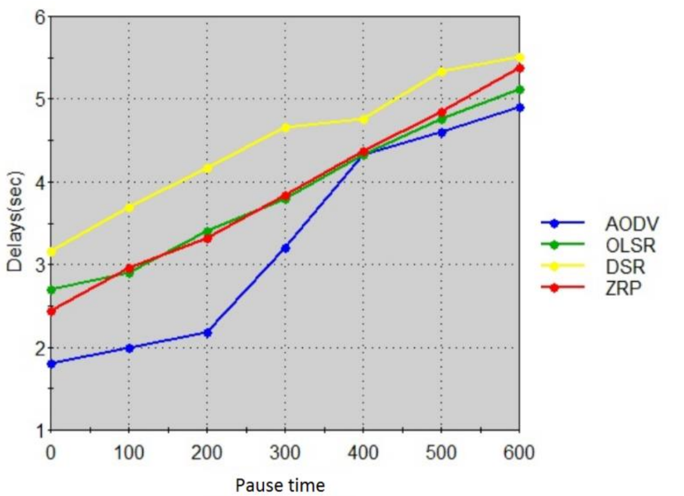

Fig. 4 End to End Delay vs Pause time

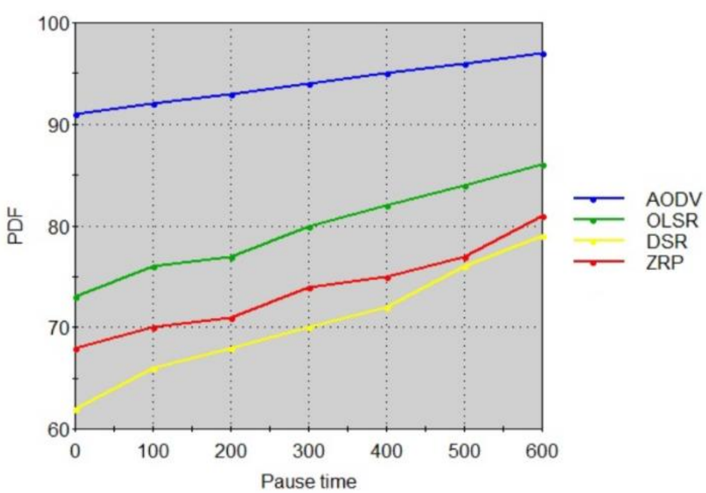

Fig. 5 Packet Delivery Fraction (%) vs Pause Time

D. Simulation of second Scenario (Network size)

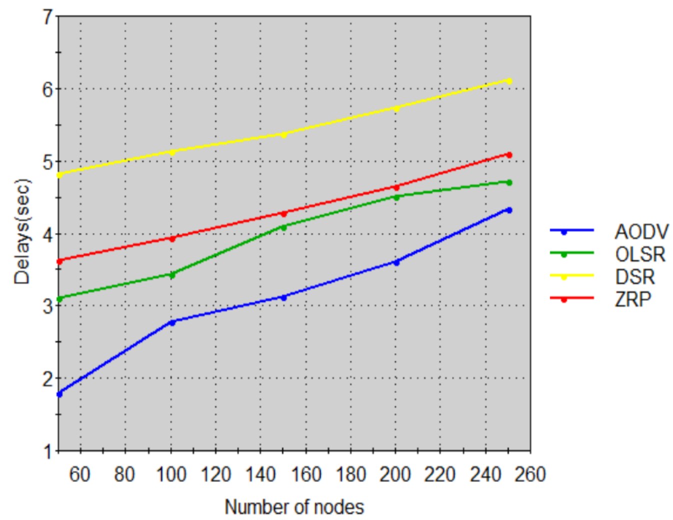

Fig. 6 End to End Delay vs Number of nodes

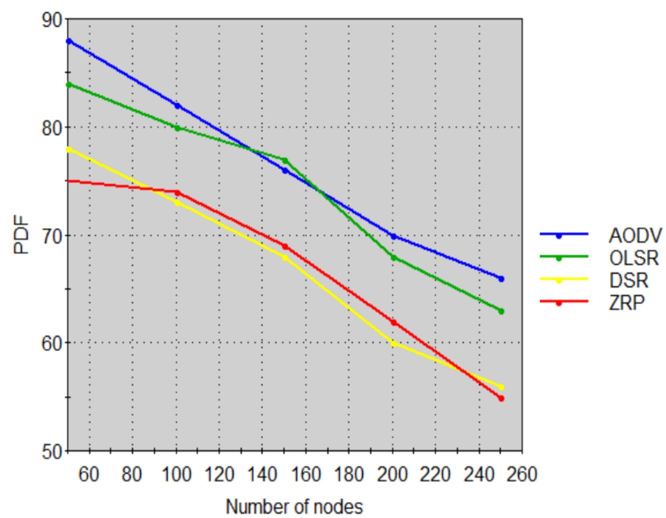

Fig. 7. Packet Delivery Fraction (%) vs Number of nodes

IV. SIMULATION RESULT AND DICUSSION

AODV has a very low delay and that is because it doesn't produce much routing data when the network is stable. OLSR provide high reliability and low latency in new route decision, the protocols do not perform well in high mobile node scenarios because of the necessity of maintaining big routing tables for the mobile nodes.

As a result, routing information cannot update new routing tables and this causes more traffic overheads and decreases the total bandwidth efficiency .

But DSR also face some limitations as the source node needs to wait for the response of the sending route request. This culminates into significant delay and reduces the performance in real time traffics .

To summarize our analysis of routing protocol performance, we focus on the protocols' ability to adapt to rapid topology changes, and scalability to larger and denser networks. Additionally, our analysis reveals the fundamental performance trade of between adaptation to rapid topology changes. Improving the ability to adapt to topology changes can lead to higher routing overhead when designing and optimizing protocols.

AODV delivers good performance throughout our simulation studies. It has better PDF performance than all other protocols in dynamic scenarios because of the ability to adapt to topology changes. This ability comes from its frequent initialization of route discovery. However, the problem with AODV comes from frequent flooding of RREQ packets, which results in linearly increasing routing overhead with increasing degree of connectivity.

This significantly limits AODV scalability to denser and larger networks. It also causes AODV to generate high overhead in extremely dynamic scenarios in which many extra route discovery processes are triggered. For DSR, the distinctive features are the aggressive use of route cache and the use of source routing. However, the performance of DSR suffers from both features in many of the scenarios. Aggressive use of cache causes stale routes, which hurts DSR performance on PDF and delay.

Even though route caching effectively helps reduce flooding of control packets, injecting source route header in data packets results in high total overhead and will cause extra processing burden in real implementations. ZRP does show reasonable scalability in high density scenarios. However, ZRP has higher delay and the overall performance does not stand out in any of the scenarios.

OLSR, which is also a proactive protocol, delivers better delay and overhead performance in most cases. OLSR optimization schemes are very effective in limiting routing overhead, making it a good choice for low and medium dynamicity scenarios.

V. COCLOUSION

In this paper, the performance of the four MANET Routing protocols such as AODV, OLSR,DSR and ZRP was analyzed using NS-2 Simulator.

We have done comprehensive simulation results of Average End-to-End delay and packet delivery fraction over the routing protocols by varying network size, simulation time. OLSR is a proactive routing protocol and suitable for limited number of nodes with low mobility due to the storage of routing information in the routing table at each node. Comparing DSR with OLSR and AODV protocol, byte overhead in each packet will increase whenever network topology changes since DSR protocol uses source routing and route cache. Hence, DSR is preferable for moderate traffic with moderate mobility. As DSR routing protocol needs to find route by on demand, End-to-End delay will be higher than other protocols and DSR performs worst when the number of nodes increases.

AODV produces low end-to-end delay compared to other protocols. it is ideal for large networks. Results show that ZRP has very fluctuating PDR values, meaning that its architecture is highly volatile and not suitable for installations or applications of high reliability.

AODV appears to be the best choice in most of the scenarios. AODV has the best performance in the whole series. Need to improve the performance of DSR and ZRP. For large mobile networks, OLSR is fine. The main advantage is enormous multi-route and multi-casting support.

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