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Comparison of Manet Routing Protocols

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ABSTRACT: Ad-hoc network are autonomous network that do not rely on a pre-defined infrastructure and can be set up anywhere at any time. In ad hoc network each node individually acts as a mobile router and communicates to each other to send and receive packets. Wireless ad-hoc network is group of mobile nodes that communicates over a common wireless channel. Each node follows a routing algorithm to route the packets from a source to desired destination. Mobile Ad-Hoc Network (MANET) is infrastructure less collection of mobile nodes that is connected through a wireless medium forming speedily changing topologies. Due to rapid deployment, the MANET has attracted the researchers. The researchers have proposed various routing protocols for MANET. This paper discusses these broad ranges of MANET routing protocols. Further the paper reviewed the comparison among existing protocols on the basis of some selected performance metrics such as scalability, overhead, reliability etc.

Keywords: Ad hoc network, MANET, Routing protocols, Reactive, Proactive, Hybrid.

I. INTRODUCTION

Computer Network [1] is the group or system of inter-connected nodes that interact with each other to exchange information. Computer network can be built using either wired or wireless technology. Wired LAN [2], [3] use Ethernet cables and network adapters for data transmission and two computers can be directly wired to each other using an Ethernet crossover cable. Wired LANs can also require central devices like hubs, switches, or routers [3], [4] to cultivate more computers.

Wired technology is expensive and time consuming as network are first established through cables leads to demand for the wireless techniques. With the increasing growth in networking technology, people are attracted more towards the wireless networks as it is more convenient and scalable than other communication means. Wireless networks are classified in to two basic types that is Infrastructure based wireless networks and Ad-hoc [4], [5], [6] based wireless networks. "Infrastructure" mode involves access point from where communication of wireless and wired devices takes place. "Ad-hoc" mode allows wireless devices to communicate in peer-to-peer manner with each other. An ad-hoc network is a limited geographical network that is built rapidly as devices connect.

Instead of trusting on a access point that act as base station to control the flow of messages to each node in the network, the individual nodes forward packets to and from each other. As MANET's [7] have mobile node, they use wireless technology to connect to various networks. An ad hoc routing protocol [8] is a method that controls nodes to decide the route to send the packets between computing devices in MANET. In ad hoc networks, topologies are not fixed. Instead, they have to discover it, and rather, a new node introduces its presence and listens for announcements broadcast by its neighbors. Each node discovers others node nearby and learn how to reach them, and may announce that they too can reach them. This research paper made comparison between some selected MANET routing protocol on the basis of performance metrics like scalability reliability, overhead etc. and aims to provide a short description of four main classes of protocol namely proactive, reactive, hierarchical and hybrid [9], [10].

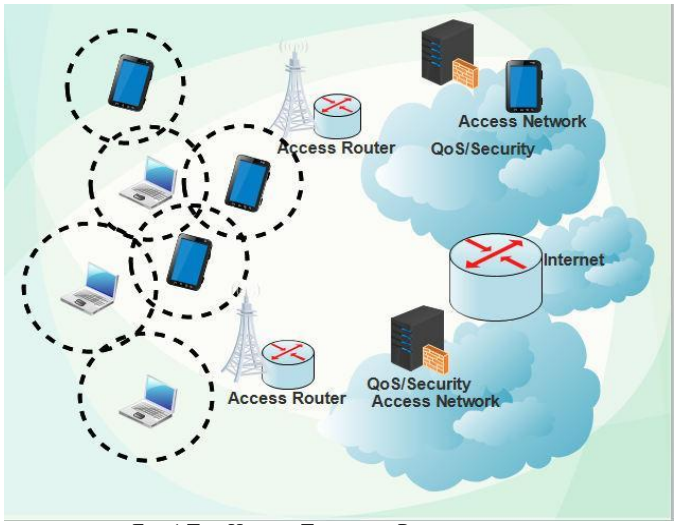

FIG. 1 THE HIDDEN TERMINAL PROBLEM

Rest of the paper is organized as follows: Section 2 presents a brief classification of routing protocols. Section 3 gives the description of various performance metrics for these routing protocols and section 4 provides comparison between them and finally section 5 concludes the paper with consolidated results of investigations present in the studied literature.

II. ROUTING PROTOCOLS

The routing protocols are used to find the path between Source and Destination. There are different reasons for designing and classifying routing protocols for wireless ad-hoc networks. Routing protocols provide crucial role in the modern communication networks. Each one of the routing protocols, has different structure in comparison to others, as a result each of them, depending on parameters which related to the network, demonstrate excellent performance. Mainly routing protocols are divided into two categories: table-driven and on-demand routing based on how to discover the routes. In table driven routing protocols consistent and up-to-date routing information to all nodes is maintained at each node whereas in on-demand routing the routes are created only when desired by the source host. Furthermore, these can also be broadly classified into hybrid and hierarchical. All these four classification are briefly explained below along with their examples.

A) *Reactive Routing Protocol*: The protocols find route on demand by flooding the network with Route Request (RREQ) packets to the nodes. In reactive routing protocols, the route is calculated only when a node needs to send data to an unknown destination. Thus, route discovery is initiated only when needed. Determine a route only when there is data to transfer. These protocols have longer delay and low routing overhead. e.g. -AODV.

a. *AODV:*Ad hoc On-Demand Distance Vector (AODV) Routing [11] is a protocol used for routing in MANETs and other wireless ad-hoc networks. It is an improvement over DSDV [12], which minimizes the number of required broadcasts by creating routes on demand. Nodes which does not move on selected path cannot contribute in maintaining routing information or participate in routing table exchanges. A source node introduces a path discovery process to locate the other intermediate nodes (and the destination), by broadcasting a RREQ packet to its neighbors.

b. *DSR*: Dynamic Source Routing (DSR) [13] in Ad-Hoc Wireless Network. It is the type of on-demand source routing. Each host maintains a route cache containing all routes it has learned. The protocol consists of two major phases: Route Discovery and Route Maintenance. When a mobile node has a packet to send to some destination, it first consults its route cache to check whether it has a route to that destination. If it is an un-expired route, it will use this route. If the node does not have a route, it initiates route discovery by broadcasting a Route Request packet.

This Route Request contains the address of the destination, along with the source address. Each node receiving the packet checks to see whether it has a route to the destination. If this does not happen, then it adds its address to the route record of the packet and forwards it. Route reply is generated when the request reaches either the destination itself or an intermediate node that contains in its route cache an un-expired route to that destination. If the node generating the route reply is the destination node, it places the route request into the route reply.

c. *ABR*: Associativity Based Routing (ABR) [14] has three phases: route discovery, route reconstruction, route deletion. In ABR a route is selected based on the degree of stability associated with mobile nodes. Association stability is defined by connection stability of one node with respect to another node over time and space. Each node generates a beacon to

signify its existence. When received by neighboring nodes, the beacon causes their associativity tables to be updated. The route discovery is carried by a Broadcast Query-Reply (BQ-REPLY) cycle. When a discovered route is no longer desired, the source node initiates a Route Delete broadcast so that all the nodes along the route update their routing tables.

d. *TORA*: A highly adaptive, loop-free and distributed routing algorithm based on the concept of link reversal is Temporarily Ordered Routing Algorithm (TORA) [15]. TORA decouples the generation of potentially far-reaching control messages from the rate of topological changes. The protocol performs three basic functions: route creation, route maintenance, route erase. The Directed Acyclic Graph (DAG) rooted at the destination is establish during the route creation and maintenance phases nodes that use a height metric. Thereafter, links are assigned in a direction based on the relative heights.

B) *Pro-active Routing Protocol:* This category of protocol finds path in advance and every node attempt to keep up-to-date topological map of entire network and continuously evaluate the routes. When a node needs to forward a packet, the route is already available; so, there is no delay in searching for a route. Its an attempt to maintain consistent, up-to-date routing information. When the network topology changes, the protocol responds by propagating updates throughout the network to maintain a consistent view. In this type of table-driven technique, routing overhead is high. e.g.- OSLR [16] & DSDV

a. *DSDV*: Highly Dynamic Destination-Sequence Distance-Vector Routing (DSDV) for Mobile Computers based on Bellman-Ford algorithm. Each mobile node maintains a routing table in terms of number of hops to each destination. Routing table updates are periodically transmitted. Each entry is tagged with a sequence number originated by the destination node. Each node periodically broadcasts its distance vector. Broadcast is limited to one hop.

b. *OSLR*: Optimized Link State Routing (OSLR) Protocol uses multipoint-relays to reduce excess broadcast packet retransmission and also the size of the Link State packets. It leads to efficient flooding of control messages in the network. Only the MultiPoint Relays nodes (MPRs) need to forward LS updates. OLSR is particularly suited for dense networks. In sparse networks, every neighbor becomes a multipoint relay, and then OLSR reduces to pure LS protocol.

C) *Hybrid Protocols***:** Hybrid Routing [10] is a third classification of routing algorithm. It is the combination of Proactive and Reactive. It has advantage of both. It integrates merits of both proactive and reactive routing protocols to overcome their demerits. Generally, hybrid routing protocols for MANET exploit hierarchical network architectures. At initial, all routers will establish certain proactive routes and start computing. Afterwards, an on-demand scenario will start working by flooding multiple RR packets. Zone Routing Protocol (ZRP) [17] is one of the types of routing protocol that is hybrid in nature.

a. *ZRP*: A hybrid routing protocol that combines both proactive and on-demand routing strategies where each node has a predefined zone. Inside zones are for proactive routing and outside zones perform on-demand routing. ZRP provides more flexibility. ZRP is an efficient and reliable protocol to be used in any ad hoc network, as it supports an appropriate manner to send and receive necessary routing information from all the routers within the boundaries. Thus, this method is an efficient method to find the most appropriate route to establish computing in between the devices. ZRP contributes towards in faster delivery of data packets to destination devices and helps in reducing the processing overhead by a series of operations needed to select the most appropriate route to data transfer.

D) *Hierarchical Protocol***:** The choice of proactive and of reactive routing depends on the hierarchic level in which a node resides. Hierarchical routing is based on organizing nodes into the groups and assigning nodes different functionalities inside and outside a group. e.g.- CBRP [18] and FSR [19].

a. *FSR:* Fisheye State Routing is a simple, efficient LS type routing protocol. FSR exchanges the entire link state information only with neighbors. Link state exchange is periodical. Periodical broadcasts of LS info are conducted in different frequencies depending on the hop distances.

III. COMPARISON ON THE BASIS OF PERFORMANCE METRICS

In order to measure the performance of a routing protocol, one needs metric to measure its suitability and performance. MANET has number of qualitative and quantitative metrics that can be used to compare ad hoc routing Protocols. Following is a list of popular properties of MANET routing protocols. Some of the metrics are applied to compare the proactive and reactive and hybrid routing protocols in terms of overhead, scalability, and loop-freedom.

A. *Scalability:* - A scalable [8] network is one that can be require. A good routing protocol has to be scalable and adaptive to the changes in the network topology. The scalable protocol should perform well as the network grows larger or as the workload increases. In this paper, routing protocols for MANETS are evaluated and their performances are measured to determine their capability for supporting network scalability.

B. *Reliability [1]:* - It is the ability to perform its required functions under stated conditions for a specified time by a routing protocol.

C. *Control overhead:* - Overhead [20] is measured as combination of excess and indirect computation time, memory, and no. of packets, bandwidth or other resources that are required to attain a particular goal. The control overhead in protocols is mainly due to flooding. Excess no. of packets in network leads to increase in overhead value. On-demand protocols have low overhead as compares to table-driven i.e. Pro-active protocol.

D. *Routing loops:* - When an error occurs in the operation of the routing algorithm, the path to a particular destination forms a loop. In the simplest way, a routing loop [21] of size two, node A thinks that the path to some destination C is through, node B. At that time, node B thinks that the path to C starts from node A. Thus, whenever traffic for C reaches at either A or B, it will loop endlessly between A and B, unless some mechanism exists to avoid that behaviour.

E. *Routing philosophy:* - One of the most important research areas in the MANETs is to establishing and maintaining the ad-hoc network through the use of routing protocols. It can be proactive, reactive or hybrid.

F. *Method:* - Routing schemes differ in how they deliver messages, unicast delivers a message to a single specific, multicast delivers a message to a group of nodes that have expressed interest in receiving the message, broadcast delivers a message to all nodes in the network, unicast is the dominant form of message delivery on the Internet.

G. *Bandwidth [20], [22]:*-It is the bit-rate of available or used information capacity expressed typically in metric multiples of bits\ second.

H. *Updating:* - As a node receives this information, it updates its view of the network topology and routing table.

I. *Routing metric:* - The cost values used by routers to determine the best path to a destination network are called metrics. Many factors help dynamic routing protocols to decide which is the preferred or shortest path to a particular destination.

J. *Storage complexity:* - It is the metric that measure the storage used by the protocol to store the packet sends to node.

IV. COMPARATIVE ANALYSIS OF PERFORMANACE METRICS

Protocols / **Metrics**	**ABR**	**AODV**	**DSDV**	**DSR**	**OLSR**	**FSR**	**ZRP**	**TORA**
Scalability	No	No	No	No	No	Potential Scalability	Improve	Yes
Reliability	Yes	Yes	Yes	Yes	No	No	Reliability Increase	Yes
Control Overhead	Optimize	Optimize	High O(n)	Optimize	High $O(n^2)$	Reduce O(n)	Greatly reduce	Reduce
Loop-Free	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Routing Philosophy	Reactive	Reactive	Proactive	Reactive	Proactive	Hierarchical	Hybrid	Reactive
Method	Broadcast	Unicast/ multicast	Broadcast	Unicast/ Multi-hop	Broadcast	Broadcast	Broadcast/ multicast	Multi-hop
Bandwidth Used	Limited	Limited	High	Limited	Extremely High	High	Limited	Limited
Updates	When Broadcast	As Needed	Periodic & as Needed (100 ms)	As Needed	Periodically	Periodically	Periodically	As needed

Routing Metric	Link Associativity & Shortest Path	Shortest Path	Shortest Path	Shortest Path	Shortest path	Shortest path	Local Shortest path	Shortest path
Storage Complexity	O(N)	O(e)	O(n)	O(e)	O(n)	O(n)	O(l) + O(e)	O(N)

TABLE 1: Media Access Delay in WLAN.

The analysis for different performance metrics on different aspects is as following:

Table 1 presents over all comparison of MANET routing protocols, first generalized DSDV, AODV, FSR, DSR, ZRP,TORA, OLSR and ABR protocols after that analysis for same groups as discussed above. We have presented the comparison among routing protocols as shown in table 1, the kind of protocols such as, DSDV and OLSR are proactive, DSR, AODV, TORA and ABR are reactive where as ZRP is zone-based hybrid routing and FSR is Hierarchical based routing. Periodic updates are utilized in DSDV; therefore, their performance is related with the network size and node mobility pattern. In OLSR there is wastage of bandwidth due to unnecessary advertising of routing information even if there is no change in the network topology. With high density network OLSR works more accurately and requires that it continuously have some bandwidth. AODV support multicast and unicast and it is on-demand loop free protocol which has optimize overhead. TORA does not require a periodic update, with that communication overhead and bandwidth utilization is also minimized. TORA are proposed to minimize the control traffic overhead and improve scalability. In small to moderately sized networks, the DSR protocol performs better than AODV, and TORA routing protocols.

The DSR protocol also has many advantages over the above-mentioned routing protocols, there is no such periodic routing of messages in DSR routing protocol, thus helps in reducing the network bandwidth overhead.

As reactive routing protocols for MANET, DSR, AODV and TORA are proposed to reduce the control traffic overhead and improve scalability. ABR has reduced amount limited bandwidth. DSDV of control packet traffic and FSR have dissimilar features and use different mechanisms for loop-free guarantee.

AODV and ZRP have multicasting capability whereas other protocols have no such capability. As a Link State routing protocol, FSR has high storage complexity. ZRP is an efficient and reliable protocol to be used in any ad hoc network. The drawbacks of proactive schemes are the constant bandwidth consumption due to periodic routing updates.

Reactive routing schemes overcome this problem by searching the routes available from source to destinations only when required, thus keeping bandwidth usage and routing table storage low. One of the two popular on-demand schemes, AODV and DSR, scale well for large networks when communication pattern is sparse and mobility is low.

V. SIMULATION

According to above study the result can be concluded. Now the simulation is performed for the protocol that shows the best and worst performance.

This section is an experimental section that includes simulation environment under which scenarios need to be implemented to compare the performance of routing protocol for mobile nodes. In the proposed simulation environment, computing with routing protocols is encouraged along with ad hoc network methodology, i.e. work stations operating in this environment are allowed to move freely in a network and are allowed to communicate while moving along the network.

Two different scenarios are implemented to measure the performance metrics for two different routing protocol that computes simulation. Furthermore, configuration for the network can be described, as shown in Fig. 2:

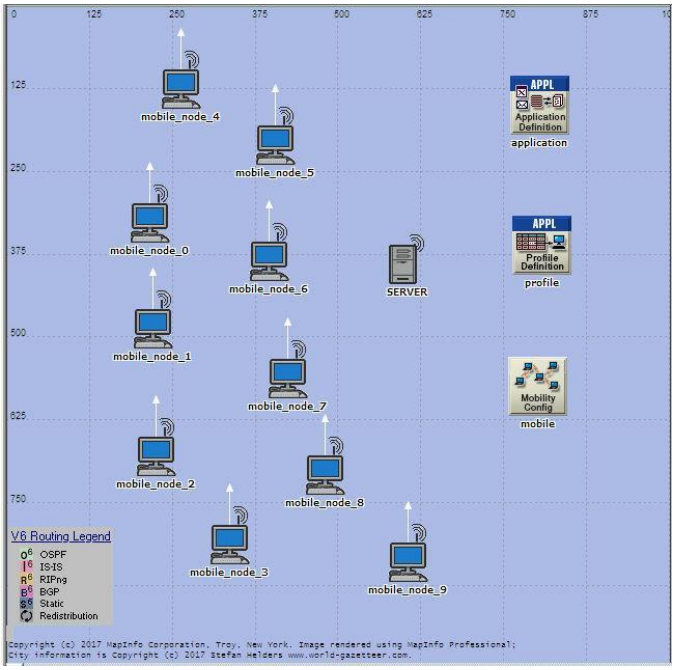

Fig 2. Scenario with routers enabled with routing protocols in Ad Hoc Network

In the above environment, two scenarios can be implemented in the following manner, one for AODV and the other for TORA network. The list of scenarios can be, such as:

A. Scenario 1: AODV

In this scenario Mobile ad-hoc network is used for evaluating the performance of AODV routing protocol in IPv6 environment. All the mobile nodes and the wireless LAN server are selected and similar settings are done. Now all the nodes and server communicates using the AODV protocol default AODV routing protocol parameters are used.

B. Scenario 2: TORA

In this scenario TORA is used as the ad-hoc routing protocol. All the mobile nodes and the wireless LAN server are selected and similar settings are done. Now all the nodes and server communicates using the TORA protocol and as the main aim of this simulation is to evaluate the performance of TORA.

VI. SIMULATION ENVIRONMENT

This section underlines the analysis of scenarios based on certain experimental factors. An analysis has been done to judge the performance of communicating devices through a list of performance metrics. Further analysis is done to measure the performance of routing protocol in an IPv6 environment.

A. *Load:-* Load can be defined as the traffic that is flowing into the network endlessly. Unlike to the delay factor, load should also be kept at minimum ranges, so that faster communication is done. Load for the two routing protocol is shown in Fig. 3 in wireless LAN for IPv 6 environment.

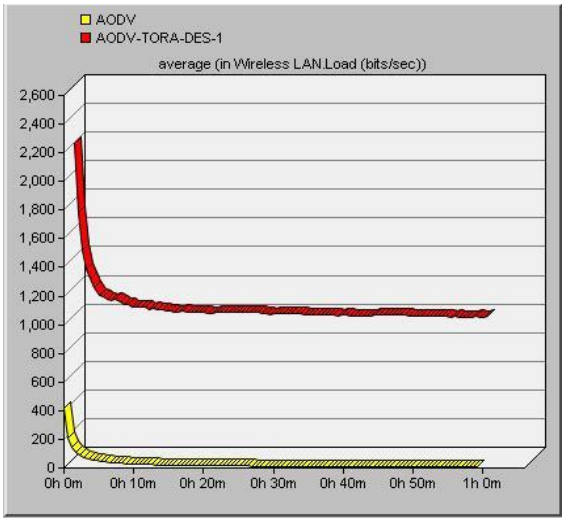

Fig 3. Load for AODV and TORA

B. Delay:- Delay can be defined as the amount of time spent in transferring the data packets from one device to another device. The delay factor should always be kept at minimum so that effectively data transmission can take place. The lesser the delay is, the more efficient network is. Delay for the two routing protocol is shown in Fig. 4 in Wireless LAN for IPv 6 environment.

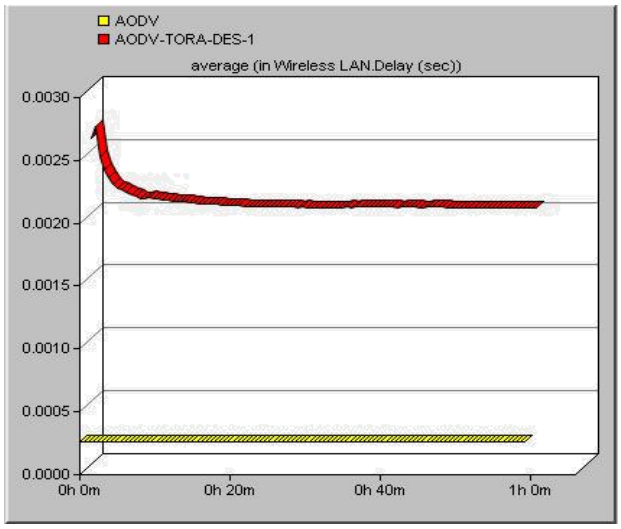

Fig 4.Delay for AODV and TORA

TABLE 2 Comparison of AODV and TORA

Performance metrics Routing protocol	Delay	Throughput	Load
AODV	Less	More	Less
TORA	More	Less	More

VII. CONCLUSION

This paper has discussed about MANETs, and evaluated some of the most important routing protocols. The results which are obtained from the assessment and comparisons of the efficiency were shown for the eight MANET routing protocols DSR, AODV, DSDV, TORA, FSR, ZRP, OLSR and AODV. Based on these results, the AODV and DSR protocols have shown much better performance than other protocols. TORA has not shown the better result and DSDV has fixed behavior in all scenarios due to its table-driven specification. From the detailed comparison results and analysis, a suitable routing protocol can be chosen for a any given network and goal. Reactive protocols are more efficient when route requests are infrequent, where proactive protocols tend to be more efficient when route requests are frequent (since route discovery typically involves flooding). In addition, the delay required by reactive protocols for route discovery may be too large for some applications. Therefore, the best solution can be hybrid routing solution that combines proactive and reactive and changes dynamically between proactive and reactive methods, based on network measurements.

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