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A comprehensive study of Routing protocols in Mobile Ad hoc Networks: Research Survey

B. Prabhakara Reddy[1] E. Suresh Babu[2] M. L. Ravi Chandra[3]
Associate Professor
Dept of ECE, Bheema Institute of Technology & Science, Adoni, AP, India[1]
Dept of CSE, PACE Institute of Technology & Science, Ongole, AP, India[2]
Dept of ECE, Netaji Institute of Technology & Science, Hyderabad, AP, India[3]

ABSTRACT **-** Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that communicate with each other over wireless links and dynamically form a temporary network without any support of central administration. Generally in a MANET nodes have limited transmission ranges and some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router. As nodes move arbitrarily in a Mobile Ad hoc Network, the network may experience rapid and unpredictable topology changes. Hence, routing in MANET is a critical task due to highly dynamic environment. A several protocols are introduced for improving the routing mechanism to find route between any source and destination host across the network. This paper presents A comparison of proactive and reactive protocols DSDV, AODV and DSR based on metrics such as bandwidth utilization, Scalability, Overheads per packet, consumption of energy, Latency etc.

KEYWORDS: DSDV, AODV, DSR, Bandwidth, Scalability, Latency.

1. INTRODUCTION

A MANET is a collection of mobile nodes that can communicate with each other without the use of predefined infrastructure or centralized administration (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. Due to self-organize and rapidly deploy capability, MANET can be applied to different applications including battlefield communications, emergency relief scenarios, law enforcement, public meeting, virtual class room and other security-sensitive computing environments. There are 15 major issues and sub-issues involve in MANET such as routing, multicasting/broadcasting, location service, clustering, mobility management, TCP/UDP, IP addressing, multiple access, radio interface, bandwidth management, power management, security, fault tolerance, QoS/multimedia and standards/products. Currently, the routing, power management, bandwidth management, radio interface, and security are hot topics in MANET research. The routing protocol is required whenever the source needs to transmit and delivers the packets to the destination. Many routing protocols have been proposed for mobile ad hoc network. In this paper we present a number of ways of classification or categorization of these routing protocols and the relative performance of an AODV, DSDV and DSR protocols.

One of the important research areas in MANET is establishing and maintaining an ad hoc network using routing protocols. Though there are so many routing protocols available, this paper considers DSDV, AODV and DSR for performance comparisons due to its familiarity among all other protocols. These protocols are analyzed based on the important metrics such as bandwidth utilization, Scalability, Overheads per packet, consumption of energy, latency.

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 section 4 presents the functionality of the three familiar routing protocols DSDV, AODV and DSR. The performance comparison of the three above said routing protocols are discussed in Section 5. Finally, Section 6 emphasizes comparison of most popular routing protocols DSDV, AODV & DSR, as these are best suited for ad-hoc networks. Our work is to methodically investigate the characteristics of proactive and on-demand routing approaches by studying some of the protocols.

2. ASSOCIATED WORK

A number of routing protocols have been proposed and implemented for MANETs in order to enhance the bandwidth utilization, higher throughputs, lesser overheads per packet, minimum consumption of energy and others. All these protocols have their own advantages and disadvantages under certain circumstances. The major requirements of a routing protocol was proposed by Zuraida Binti et al.[2] that includes minimum route acquisition delay, quick routing reconfiguration, loop-free routing, distributed routing approach, minimum control overhead and scalability.

MANET Routing Protocols possess two properties such as Qualitative properties (distributed operation, loop freedom, demand based routing & security) and Quantitative properties (end-to-end throughput, delay, route discovery time, memory byte requirement & network recovery time). Obviously, most of the routing protocols are qualitatively enabled. A lot of simulation studies were carried out in the paper [3] to review the quantitative properties of routing protocols.

A number of extensive simulation studies on various MANET routing protocols have been performed in terms of control overhead, memory overhead, time complexity, communication complexity, route discovery and route maintenance(4)(2). However, there is a severe lacking in implementation and operational experiences with existing MANET routing protocols. The various types of mobility models were identified and evaluated by Tracy Camp et al. (5) because the mobility of a node will also affect the overall performance of the routing protocols. A framework for the ad hoc routing protocols was proposed by Tao Lin et al. (6) using Relay Node Set which would be helpful for comparing the various routing protocols like AODV, OLSR & TBRPF (7).

The performance of the routing protocols OLSR, AODV and DSR was examined by considering the metrics of packet delivery ratio, control traffic overhead and route length by using NS-2 simulator (8)(9)(10)(11). The performance of the routing protocols OLSR, AODV, DSR and TORA was also evaluated with the metrics of packet delivery ratio, end-to-end delay, media access delay and throughput by also using OPNET simulator (12)(13)(14).

3. ROUTING PROTOCOLS FOR MOBILE AD HOC NETWORK

3.1. Classification of Protocols

MANET protocols are used to create routes between multiple nodes in mobile ad-hoc networks. IETF (Internet Engineering Task Force) MANET working group is responsible to analyze the problems in the ad-hoc networks and to observe their performance. There are different reasons for designing and classifying routing protocols for wireless ad-hoc networks. The MANET protocols are classified into three huge groups, namely Proactive (Table-Driven), Reactive (On-Demand) routing protocol and hybrid routing protocols. The following figure shows the classification of protocols (15).

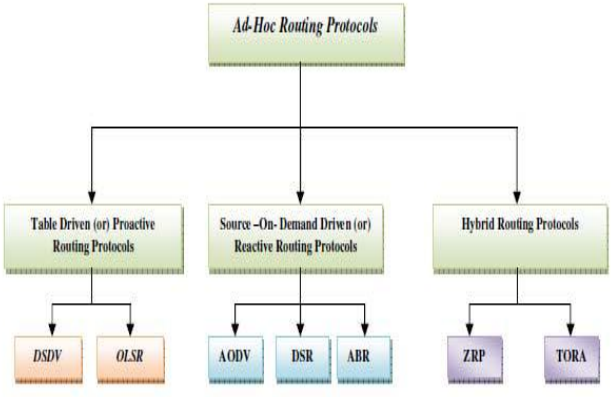

Fig.1: Different type of routing protocols in Wireless Ad-hoc network

3.1.1. Proactive Protocols

These types of protocols are called table driven protocols in which, each and every node maintains complete information about the network topology by continuously evaluating routes to all the nodes. Hence, they maintain consistent and up-to-date routing information. These protocols are known as proactive since they maintain the routing information before it is needed. Each and every node in the network maintains routing information about how to reach every other node in the network. The route information in proactive routing is maintained in the routing tables and is updated as and when the network topology changes. This causes more overhead in the routing table leading to consumption of more bandwidth. Packets are transferred over the redefined route specified in the routing table. In this scheme, the packet forwarding is done faster but the routing overhead is greater because all the routes have to be defined before transferring the packets. Proactive protocols have lower latency because all the routes are maintained at all the times. There are various existing proactive routing protocols. The areas in which they differ are the number of necessary routing tables and the methods by which changes in the network topology are broadcast. Some of the existing proactive protocols are Destination-Sequenced Distance Vector (DSDV) [16], Optimized Link State Routing (OLSR), Global State Routing (GSR) [20], and Fisheye State Routing (FSR) [21]

3.1.2. Reactive Protocols

These types of protocols are also called On Demand Routing Protocols where the routes are not predefined for routing. In this approach, a routing path is discovered only when the need arises. These are called reactive since it is not necessary to maintain routing information at the nodes if there is no communication. A Source node calls for the route discovery phase to determine a new route whenever a transmission is needed. This route discovery mechanism is based on flooding algorithm which employs on the technique that a node just broadcasts the packet to all of its neighbors and intermediate nodes just forward that packet to their neighbors. This is a repetitive technique until it reaches the destination. Reactive techniques have smaller routing overheads but higher latency. Some of the existing reactive

	Table-driven	On-demand
Availability of Routing Information	Always available (in routing table)	Available when needed
Route Updates	Periodic	When requested
Routing Structure	Both flat and hierarchical	Mostly flat
Storage Requirements	High	Usually lower than proactive
Routing Overhead	Proportional to the size of network	Proportional to the number of communicating nodes
Latency	Small	Most applications suffer a long delay

protocols are Ad hoc On-Demand Distance Vector (AODV) [17], Dynamic Source Routing (DSR) [18], Associatively Based Routing (ABR) [22], Signal stability based adaptive Routing (SSR) [23].

Table 1 comparison of the table-driven and on-demand routing protocols**.**

3.1.3. Hybrid Protocols

Hybrid protocols are the combinations of reactive and proactive protocols and takes advantages of these two protocols and as a result, routes are found quickly in the routing zone.
Example: ZRP (Zone Routing Protocol)

4. Description of Routing Protocols

This section describes some of the important proactive and reactive routing protocols

4.1 Destination-Sequence Distance Vector (DSDV) routing protocol

The DSDV protocol described in [16] is a table-driven protocol based on the classical Bellman-Ford algorithm. Each node in the network maintains a routing table that contains a list of all the possible destinations within the network. Each entry in the table contains the destination address, the shortest metric to that destination in terms of hop count, the next hop address and a sequence number generated by the destination node. The route with the greater sequence number is preferred. Sequence numbers are used to distinguish stale routes from fresh ones, thereby avoiding the routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain updated information in the table and its consistency. The route updates can be either time-driven or event-driven. Every node periodically transmits routing information to its immediate neighbors. Instead of transmitting the entire routing table, a node can also propagate its changed routing table since the last update. To reduce the large amount of network traffic that such updates can create, route updates can employ two possible types of packets. The first is known as a full dump. This type of packet carries complete routing information and can be required of multiple network protocol data units (NPDUs). During periods of infrequent movement, these packets are transmitted occasionally. Smaller incremental packets are used to transmit only that information which has changed since the last full dump

Advantages

• Guarantees loop free paths.

• Sequence number ensures the freshness of routing information available in the routing table.

• DSDV avoids extra traffic by using incremental updates instead of full dump updates.

• DSDV maintains only the best path or shortest path to every destination. Hence, amount of space in routing table is reduced.

Limitations

• Large amount of overhead due to the requirement of periodic update messages, which makes them in-effective in large networks.

• It doesn't support multi path routing.

• Wastage of bandwidth due to needless advertising of routing information even if there is no change in the network topology

4.2 Dynamic Source Routing (DSR)

DSR [18], a reactive unicast protocol is based on source routing algorithm. In source routing, each data packet contains complete routing information to reach its destination. There are two major phases in DSR: route discovery and route maintenance. When a source node wants to send a packet, it first searches for an entry in its route cache. If the route is available, the source node includes the routing information inside the data packet before sending it. Otherwise, the source node initiates a route discovery operation by broadcasting route request (RREQ) packets. Each RREQ packet is uniquely identified by the source address and the request id (a unique number). On receipt it the RREQ packet, an intermediary node checks its route cache. If the node doesn't have routing information for the requested destination, it appends its own address to the route record field of the route request packet. Then, the request packet is forwarded to its

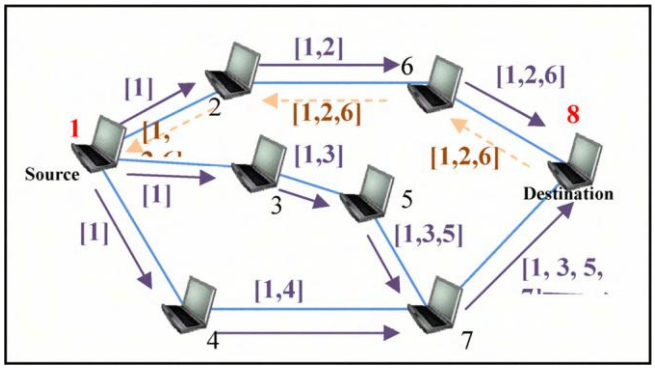

Figure 2. Dynamic Source Routing

neighbors. A node processes route request packets only if it has not seen the packet before and its address is not presented in the route record field. If the route request packet reaches the destination or an intermediate node has routing information to the destination, a route reply packet is generated. When the route reply packet is generated by the destination, it comprises addresses of nodes that have been traversed by the route request packet. Otherwise, the route reply packet comprises the addresses of nodes the

route request packet has traversed concatenated with the route in the intermediate node's route cache.

Advantages

• Reduction of route discovery overheads with the use of route cache

• Supports multi path routing.

• Does not require any periodic beaconing or hello message exchanges.

Limitations

• DSR is not very effective in large networks, as the amount of overhead carried in the packet will continue to increase as the network diameter increases.

• Because of source routing, packet size keeps on increasing with route length.

• Being a reactive protocol, DSR suffers from high route discovery latency

4.3 Ad-Hoc on-Demand Distance Vector (AODV) Routing protocol

As a reactive protocol, AODV [7] only needs to maintain the routing information about the active paths. Every node keeps a next-hop routing table, which includes only those destinations to which it currently has a route. A route entry in the routing table expires if it has not been used for a pre- specified expiration time. Moreover, AODV adapts the destination sequence number technique used by DSDV.

In AODV , when a source node wants to send packets to the destination, it initiates a route discovery operation if no route is available. In the route discovery operation, the source broadcasts route request (RREQ) packets. A RREQ includes addresses of the source and the destination, the broadcast ID, which is used as its identifier, the last seen sequence number of the destination as well as the source node's sequence number. Sequence numbers ensure loop-free and up-to-date routes. In AODV, each node maintains a cache to keep track of RREQs it has received. The cache also stores the path back to each RREQ originator. When the destination or a node that has a route to the destination receives the RREQ, it checks the destination sequence numbers it currently knows with lower destination sequence number will be dropped. If a link break occurs in an active route, the node broadcasts a route error (RERR) packet to its neighbors, which in turn propagates the RERR packet towards the source node. Then, the affected source can re-initiate a route discovery operation to find a route to the desired destination.

Advantages

• AODV can handle highly dynamic MANETs.

• Less amount of storage space as compared to other reactive routing protocols, since routing information which is not in use expires after a pre-specified expiration time.

• Supports multicasting.

Limitations

• AODV lacks an efficient route maintenance technique. The routing information is always obtained on demand.

• Similar to DSR, AODV also suffers from high route discovery latency.

•More number of control overheads due to many route reply messages for single route request.

5. COMPARISION

This section provides comparative analysis between routing protocols described in the previous section. Time complexity is defined as the number of steps needed to perform a protocol operation and communication complexity is the number of messages needed to perform a protocol operation. Also, the values for these metrics represent the worst-case behavior. Control traffic overhead and loop-free properties are two important issues with proactive routing protocols in MANETs. The proactive routing used for wired networks normally have predictable control traffic overhead because topology changes rarely and most routing updates are periodically propagated.

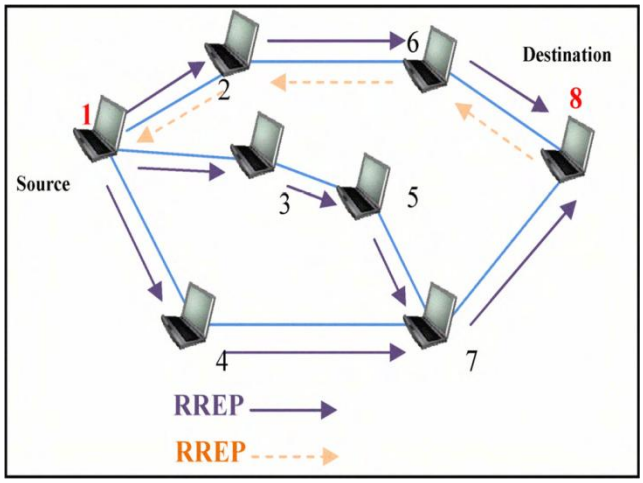

Figure 3. Ad hoc on-Demand Distance Vector protocol

As stated earlier, DSDV is essentially a modification of the basic Bellman-Ford routing algorithm. The modification includes the guarantee of loop-free routing and a simple route update protocol. DSDV selects the shortest path by using number of hops required to reach the destination as the routing metric. It utilizes destination sequence number to avoid route loops. Both periodic and

triggered updates are utilized in DSDV. However, DSDV is inefficient because of the requirement of periodic update transmission, regardless of the number of changes in the network topology. Reactive routing protocols were proposed to reduce the traffic control overhead and improve scalability. The DSR algorithm is intended for networks in which the mobiles move at moderate speed with respect to packet transmission latency .

As compared to the other reactive protocols, DSR does not make use of periodic routing advertisements, thus saving bandwidth and reducing power consumption. However, because of the small diameter assumption and the source routing requirement, DSR is not scalable to large networks.

Similar to DSR, AODV employs a route discovery procedure, but the DSR overhead is potentially larger than that of AODV since AODV packet only contain the destination address instead of the complete routing information. Another advantage of AODV is that it supports multicasting.

AODV exploits both the distance vector used in DSDV and source routing from DSR. Among the three protocols, AODV has less traffic control overhead and is most scalable (because of the smaller size of data packets as compared to DSR and no periodic route updates as compared to DSDV). However, AODV does require hello message exchanges periodically with their neighbors to monitor link disconnections.

In AODV & DSR, a node notifies the source to initiate a new route discovery operation when a routing path disconnection is detected. Both use flooding to inform nodes. Both AODV and DSDV use sequence numbers to avoid formation of route loops. Since DSR employs source routing approach, formation of a loop can be avoided by checking addresses in route record field of data packets.

6. CONCLUSION

This article describes the classification of several routing schemes according to the routing strategy. We discussed some important characteristics of the two routing strategies (proactive and reactive). Table 1 highlighted few differences between them.

In this paper, an effort has been made to concentrate on the relative study of DSDV, AODV & DSR. Moreover, a single routing protocol can't perform the best in all situations. So, the choice of routing protocol should be done carefully according to the requirements of the specific application. The focus of the study in our future research work is to propose an extension of the existing conventional routing protocols which will be better in terms of bandwidth utilization, Scalability, Overheads per packet, consumption of energy, Latency security, throughput, quality of service etc.

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Authors profile

Prabhakara Reddy Baggidi received B.Tech degree in Electronics and Communication Engineering in the year 1997 from SV University, Tirupathi, India. He is awarded with M-Tech degree in Digital Systems & Computer Electronics in the year 2002 and currently carrying out Ph.D research work in association with Jawaharlal Nehru Technological University, Anantapur, India. He guided many academic projects for the last 15 years of teaching experience. His research interests are in the field of Mobile Ad hoc Networks and Optical Networks.

E. Suresh Babu pursuing his Ph.D from Jawaharlal Nehru Technological University, Kakinada, India. Presently, he is working as Associate Professor in the Department of Computer Science and Engineering for Pace Institute of Technology & Sciences, Ongole. He is having 10 years of teaching Experience. His areas of interests are wireless communication and MANETs.

Mr. M. L. Ravi Chandra graduated from S.V. University and received his M.Tech from JNTUCE Anantapur. He is pursuing his Ph.D from JNTU Hyderabad. Presently he is working as Associate Professor in ECE Department for Netaji Institute of Engineering & Technology, Hyderabad. He is having 13 years of teaching Experience. His areas of interests are wireless communication, mobile communication and MANETs.