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A Review On Routing Protocols In Mobile Adhoc Networks

Dr.P.Suresh Varma
Professor, Department of Computer Science
Adikavi Nannaya University
Rajahmundry, India
vermaps@yahoo.com

G.Jose Moses*
Research Scholar, Department of Computer Science
Adikavi Nannaya University
Rajahmundry, India.
josemoses@gmail.com

N.Supriya
Faculty, Department of Computer Science
Adikavi Nannaya University
Rajahmundry, India.
npriya_2005@yahoo.com

Abstract: Mobile ad hoc networks (MANET) are autonomously self-organized networks without infrastructure support. In a mobile ad hoc network, nodes move arbitrarily, therefore the network may experiences rapid and unpredictable topology changes. Mobile ad hoc networks are appropriate for mobile applications either in hostile environments where no infrastructure is available, or temporarily established. To facilitate communication within the network a routing protocol is used to discover routes between nodes. The goal of the routing protocol is to have an efficient route establishment between a pair of nodes, so that messages can be delivered in a timely manner. One interesting research area in MANET is routing. Routing in the MANETs is a challenging task and has received a tremendous amount of attention from researches. This has led to development of many different routing protocols for MANETs, In this paper, we provide an overview of a wide range of routing protocols proposed in the literature.

Keywords: MANET; Routing Protocol.

I. INTRODUCTION

Infrastructure less mobile network commonly known as AD-HOC network. They have no fixed routers. All nodes are capable of moving and be connected in an arbitrary manner. These nodes function as routers, which discover and maintain routes to other nodes in the network. Ad-hoc networks can be used in areas where there is little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use.

An ad-hoc network is a collection of mobile nodes, which forms a temporary network without the aid of centralized administration or standard support services regularly available on conventional networks. The nodes are free to move randomly and organize themselves arbitrarily, thus the network's wireless topology may change rapidly and unpredictably.

Mobile ad-hoc networks are infrastructure less networks since they do not require any fixed infrastructure such as a base station for their operation. In general routes between nodes in an ad-hoc network may include multiple hops and hence it is appropriate to call such networks as "multi-hop wireless ad-hoc networks". Each node will be able to communicate directly with any other node that resides within the transmission range.

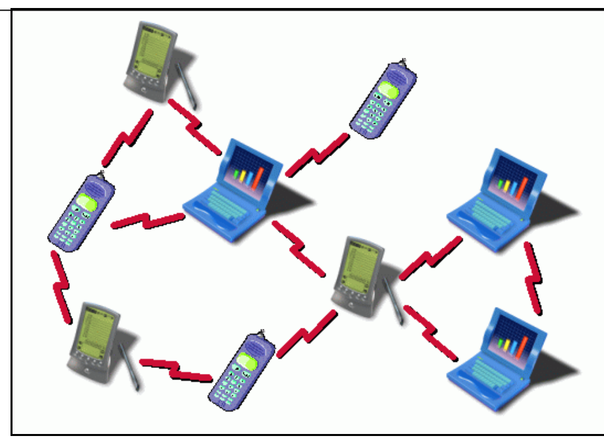


Figure 1: An example of Mobile Ad hoc Network

II. ROUTING PROTOCOLS

A number of routing protocols have been proposed for MANETs. MANET routing protocols are typically subdivided into two main categories [1]:

· Proactive/Table Driven routing protocols

And

· Reactive/On-Demand routing protocols

Proactive routing protocols are derived from Internet distance-vector and link-state protocols. They attempt to maintain consistent and updated routing information for every pair of network nodes by propagating, proactively, route updates at fixed time intervals. As the routing information is usually maintained in tables, these protocols are sometimes referred to as Table-Driven protocols.

Reactive on demand routing protocols, on the other hand, establish the route to a destination only when there is a demand for it. The source node through the route discovery process usually initiates the route requested. Once a route has been established, it is maintained until either the destination becomes inaccessible (along every path from the source), or until the route is no longer used, or expired [2].

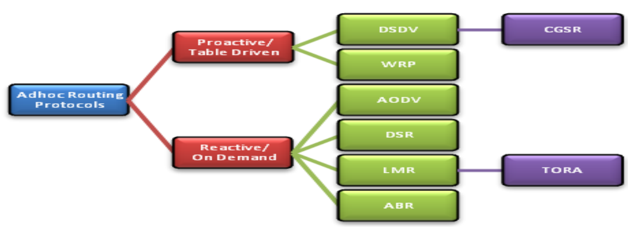


Figure 2: Categorization of Ad hoc Routing Protocols

III. TABLE DRIVEN PROTOCOLS

Table driven protocols maintain consistent and up to date routing information about each node in the network. These protocols require each node to store their routing information and when there is a change in network topology updation has to be made throughout the network. Some of the existing table driven protocols are

Destination sequenced Distance vector routing (DSDV)
Wireless routing protocol (WRP)
Cluster Gateway switch routing protocol (CGSR)

The Destination-Sequenced Distance-Vector (DSDV) protocol [3] is a distance-vector protocol with extensions to make it suitable to MANET. Every node maintains a routing table with one route entry for each destination in which the shortest path route (based on number of hops) is recorded. To avoid routing loops, a destination sequence number is used. A node increments its sequence number whenever a change occurs in its neighborhood. This number is used to select among alternative routes for the same destination. Nodes always select the route with the greatest number, thus selecting the most recent information. CGSR extends DSDV with clustering to increase the protocol scalability [4]. In addition, heuristic methods like priority token scheduling, gateway code scheduling, and path reservation are used to improve the protocols performance. Unfortunately, setting up the structure in a highly dynamic environment can adversely affect protocol performance since the structure might not persist for a very long time. WRP is another loop-free proactive protocol where four tables are used to maintain distance, link cost, routes and message retransmission information [5]. Loop avoidance is based on providing for the shortest path to each destination both the distance and the second-to-last hop (predecessor) information. Despite the variance in the number of routing tables used, and the difference in routing information maintained in these tables, proactive routing protocols like DSDV, CGSR and WRP are all distance vector shortest-path based, and have the same degree of complexity during link failures and additions.

A. Dynamic Destination-Sequenced Distance – Vector Routing Protocol:

Dynamic Destination-Sequenced Distance-Vector Routing Protocol (DSDV) [6] is developed on the basis of Bellman–Ford routing [7] algorithm with some modifications. In this routing protocol, each mobile node in the network keeps a routing table. Each of the routing table contains the list of all available destinations and the number of hops to each. Each table entry is tagged with a sequence number, which is originated by the destination node. Periodic transmissions of updates of the routing tables help maintaining the topology information of the network. If there is any new significant change for the routing information, the updates are transmitted immediately. So, the routing information updates might either be periodic or event-driven. DSDV protocol requires each mobile node in the network to advertise its own routing table to its current neighbors. The advertisement is done either by broadcasting or by multicasting. By the advertisements, the neighboring nodes can know about any change that has occurred in the network due to the movements of nodes.

The routing updates could be sent in two ways: one is called a ‘‘full dump’’ and another is ‘‘incremental.’’ In case of full dump, the entire routing table is sent to the neighbors, whereas in case of incremental update, only the entries that require changes are sent. Full dump is transmitted relatively infrequently when no movement of nodes occur. The incremental updates could be more appropriate when the network is relatively stable so that extra traffic could be avoided. But, when the movements of nodes become frequent, the sizes of the incremental updates become large and approach the network protocol data unit (NPDU). Hence, in such a case, full dump could be used. Each of the route update packets also has a sequence number assigned by the transmitter. For updating the routing information in a node, the update packet with the highest sequence number is used, as the highest number means the most recent update packet. Each node waits up to certain time interval to transmit the advertisement message to its neighbors so that the latest information with better route to a destination could be informed to the neighbors.

B. Wireless Routing Protocol:

Wireless Routing Protocol (WRP) [8] belongs to the general class of path-finding algorithms [7, 9, 10], defined as the set of distributed shortest-path algorithms that calculate the paths using information regarding the length and second-to-last hop of the shortest path to each destination. WRP reduces the number of cases in which a temporary routing loop can occur. For the purpose of routing, each node maintains four things:

a. A distance table
b. A routing table
c. A link-cost table
d. A message retransmission list (MRL)

Using WRP, each mobile node maintains a distance table, a routing table, a link-cost table and a Message Retransmission List (MRL). An entry in the routing table contains the distance to a destination node, the predecessor and the successor along the paths to the destination, and a tag to identify its state, i.e., is it a simple path, a loop or invalid. Storing predecessor and successor in the routing table helps to detect routing loops and avoid counting-to-infinity problem, which is the main shortcoming of the original distance vector routing algorithm. A mobile node creates an entry for each neighbor in its link-cost table. The entry contains cost of the link connecting to the neighbor, and the number of timeouts since an error-free message was received from that neighbor. In WRP, mobile nodes exchange routing tables with their neighbors using update messages. The update messages can be sent either periodically or whenever link state changes happen. The MRL contains information about which neighbor has not acknowledged an update message. If needed, the update message will be retransmitted to the neighbor. Additionally, if there is no change in its routing table since last update, a node is required to send a Hello message to ensure connectivity. On receiving an update message, the node modifies its distance table and looks for better routing paths according to the updated information.

In WRP, a node checks the consistency of its neighbors after detecting any link change. A consistency check helps to eliminate loops and speed up convergence. One shortcoming of WRP is that it needs large memory storage and computing resource to maintain several tables. Moreover, as a proactive routing protocol, it has a limited scalability and is not suitable for large mobile ad hoc networks.

C. Cluster Gateway Switch Routing Protocol:

Cluster Gateway Switch Routing Protocol (CGSR) [11] considers a clustered mobile wireless network instead of a ‘‘flat’’ network. For structuring the network into separate but interrelated groups, cluster heads are elected using a cluster head selection algorithm. By forming several clusters, this protocol achieves a distributed processing mechanism in the network. However, one drawback of this protocol is that, frequent change or selection of cluster heads might be resource hungry and it might affect the routing performance.

CGSR uses DSDV protocol as the underlying routing scheme and, hence, it has the same overhead as DSDV. However, it modifies DSDV by using a hierarchical cluster-head-to-gateway routing approach to route traffic from source to destination. Gateway nodes are nodes that are within the communication ranges of two or more cluster heads. A packet sent by a node is first sent to its cluster head, and then the packet is sent from the cluster head to a gateway to another cluster head, and so on until the cluster head of the destination node is reached. The packet is then transmitted to the destination from its own cluster head.

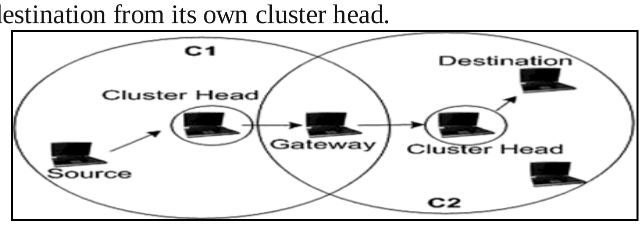


Figure 3: Clustered MANET

Figure 3 shows two clusters C1 and C2 each of which has a cluster head. A gateway is the common node between two clusters. Any source node passes the packet first to its own cluster head, which in turn passes that to the gateway. The gateway relays the packet to another cluster head and this process continues until the destination is reached. In this method, each node must keep a ‘‘cluster member table’’ where it stores the destination cluster head for each mobile node in the network. These cluster member tables are broadcasted by each node periodically using the DSDV algorithm. Nodes update their cluster member tables on reception of such a table from a neighbor. Also each node maintains a routing table that is used to determine the next hop to reach the destination.

IV. SOURCE INITIATED DEMAND DRIVEN

In on-demand routing protocols routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destinations. The route remains valid till the destination is reachable or until the route is no longer needed.

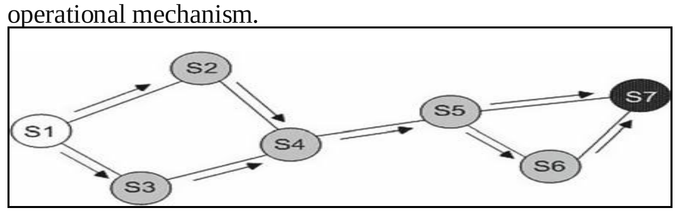
The different types of On Demand driven protocols are:
Ad hoc On Demand Distance Vector (AODV)
Dynamic Source routing protocol (DSR)
Light-weight mobile routing (LMR)
Associativity Based routing (ABR)
Temporally ordered routing algorithm (TORA)

A. Ad Hoc On-Demand Distance Vector Routing:

Ad Hoc On-Demand Distance Vector Routing (AODV) [12] is basically an improvement of DSDV. But, AODV is a reactive routing protocol instead of proactive. It minimizes the number of broadcasts by creating routes based on demand, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighboring nodes in turn broadcast the packet to their neighbors and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. The reply is sent using the reverse path.

For route maintenance, when a source node moves, it can re-initiate a route discovery process. If any intermediate node moves within a particular route, the neighbor of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbor. This process continues until the failure notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase.

Figure 4 shows an example of AODV protocol’s operational mechanism.



(a) Source node broadcasting the route request packet.

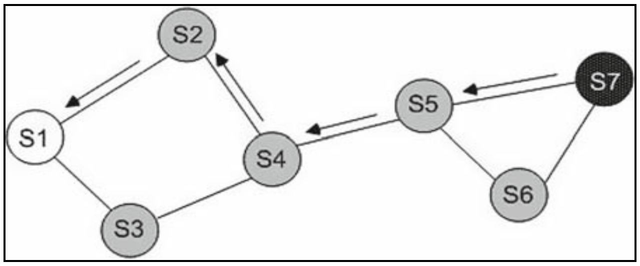


Figure: 4 (b) Route reply is sent by the destination using the reverse path S1 is the source node and S7 is the destination node.

The source initiates the route request and the route is created based on demand. Route reply is sent using the reverse path from the destination.

B. Dynamic Source Routing:

Dynamic Source Routing (DSR) [13] allows nodes in the MANET to dynamically discover a source route across multiple network hops to any destination.

In this protocol, the mobile nodes are required to maintain route caches or the known routes. The route cache is updated when any new route is known for a particular entry in the route cache. Routing in DSR is done using two phases: route discovery and route maintenance. When a source node wants to send a packet to a destination, it first consults its route cache to determine whether it already knows about any route to the destination or not. If already there is an entry for that destination, the source uses that to send the packet. If not, it initiates a route request broadcast. This request includes the destination address, source address, and a unique identification number. Each intermediate node checks whether it knows about the destination or not. If the intermediate node does not know about the destination, it again forwards the packet and eventually this reaches the destination. A node processes the route request packet only if it has not previously processed the packet and its address is not present in the route record of the packet. A route reply is generated by the destination or by any of the intermediate nodes when it knows about how to reach the destination. Figure 5 shows the operational method of the dynamic source routing protocol.

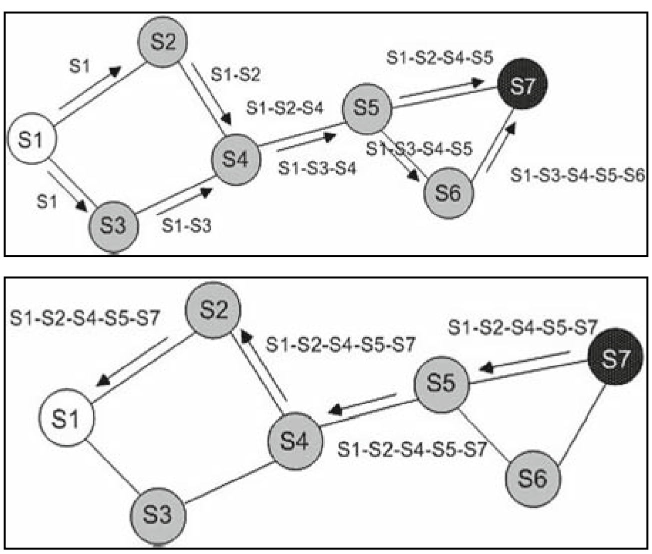


Figure. 5 (a) Route Discovery (b) Using route record to send the route reply

In this example, the destination gets the request through two paths. It chooses one path based on the route records in the incoming request packet and accordingly sends a reply using the reverse path to the source node. At each hop, the best route with minimum hop is stored. In this example, we have shown the route record status at each hop to reach the destination from the source node. Here, the chosen route is S1-S2-S4-S5-S7.

C. Light-weight mobile routing (LMR:)

The LMR protocol is another on-demand routing protocol, which uses a flooding technique to determine its routes. The nodes in LMR maintain multiple routes to each required destination.

This increases the reliability of the protocol by allowing nodes to select the next available route to a particular destination without initiating a route discovery procedure. Another advantage of this protocol is that each node only maintains routing information to their neighbours. This means avoids extra delays and storage overheads associated with maintaining complete routes. However, LMR may produce temporary invalid routes, which introduces extra delays in determining a correct loop.

D. Temporarily Ordered Routing Algorithm:

Temporally Ordered Routing Algorithm (TORA) [14] is a reactive routing protocol with some proactive enhancements where a link between nodes is established creating a Directed Acyclic Graph (DAG) of the route from the source node to the destination. This protocol uses a ‘‘link reversal’’ model in route discovery. A route discovery query is broadcasted and propagated throughout the network until it reaches the destination or a node that has information about how to reach the destination. TORA defines a parameter, termed height. Height is a measure of the distance of the responding node’s distance up to the required destination node. In the route discovery phase, this parameter is returned to the querying node. As the query response propagates back, each intermediate node updates its TORA table with the route and height to the destination node. The source node then uses the height to select the best route toward the destination. This protocol has an interesting property that it frequently chooses the most convenient route, rather than the shortest route. For all these attempts, TORA tries to minimize the routing management traffic overhead.

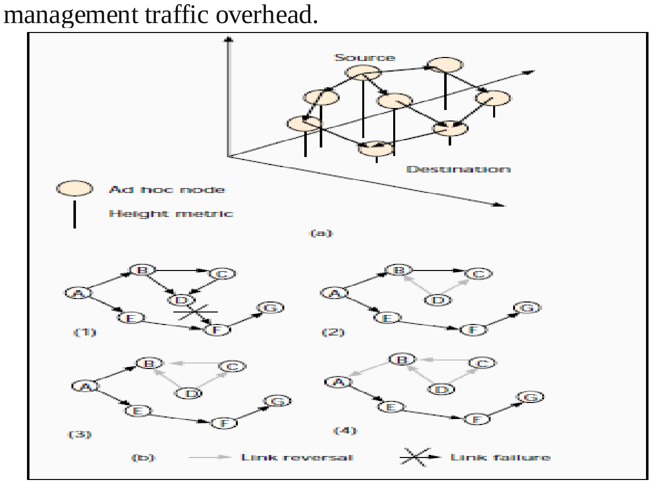


Figure. 6 a) Route creation showing link direction b) route maintenance showing the link reversal phenomenon in TORA.

E. Associativity-Based Routing (ABR):

Associativity-Based Routing [15] protocol defines a new type of routing metric for mobile ad hoc networks. This routing metric is termed as degree of association stability. In this routing protocol, a route is selected based on the degree of association stability of mobile nodes. Each node periodically generates beacon to announce its existence. Upon receiving the beacon message, a neighbor node updates its own associativity table. For each beacon received, the associativity tick of the receiving node with the beaconing node is increased. A high value of associativity tick for any particular beaconing node means that the node is relatively static. Associativity tick is reset when any neighboring node moves out of the neighborhood of any other node. ABR protocol has three phases for the routing operations:

a. Route discovery
b. Route reconstruction
c. Route deletion

The route discovery phase is done by a broadcast query and await-reply (BQREPLY) cycle. When a source node wants to send message to a destination, it sends the query. All other nodes receiving the query append their addresses and their associativity ticks with their neighbors along with QoS information to the query packet. A downstream node erases its immediate upstream node's associativity tick entries and retains only the entry concerned with itself and its upstream node. This process continues and eventually the packet reaches the destination. On receiving the packet with the associativity information, the destination chooses the best route and sends the REPLY packet using that path. If there are multiple paths with same overall degree of association stability, the route with the minimum number of hops is selected. Route reconstruction is needed when any path becomes invalid or broken for the mobility or failure of any intermediate node. If a source or upstream node moves, a route notification (RN) message is used to erase the route entries associated with downstream nodes. When the destination node moves, the destination's immediate upstream node erases its route. A localized query (LQ[H]) process, where H refers to the hop count from the upstream node to the destination, is initiated to determine whether the node is still reachable or not. Route deletion broadcast is done if any discovered route is no longer needed.

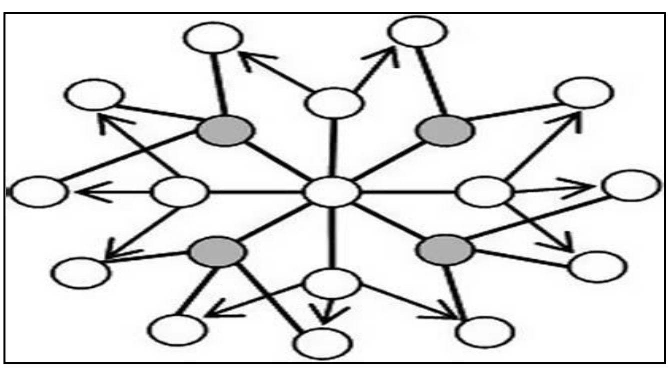


Figure. 7 Multipoint Relays (MPRs) are in gray color. The transmitting node is shown at the center of the sample structure the working principle of ABR protocol.

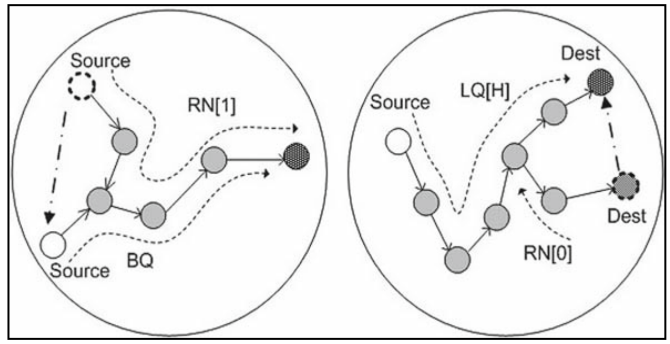


Figure 8 shows two different scenarios for route maintenance where ABR is used. In Fig. 8(a), the source moves to another place, as a result of which a new BQ request is used to find out the route to the destination. The RN [1] message is used to erase the route entries associated with the downstream nodes. In Fig. 8(b), the destination changed its position. Hence, immediate upstream node erases its route and determines if the node is still reachable by a localized query (LQ[H]) process.

V. CONCLUSION

Routing is an essential component of communication protocols in mobile ad hoc networks. The design of the protocols are driven by specific goals and requirements based on respective assumptions about the network properties or application area. In this paper we have provided descriptions of several routing schemes proposed for ad-hoc mobile networks. We have also provided a classification of different schemes according the routing strategy .i.e., table driven and on demand. We have presented these two categories of routing protocols, their features and characteristics. The survey tries to review typical routing protocols and reveal the characteristics and trade-offs.

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Short Bio Data for the Author's

Dr. P. Suresh Varma received the Master's degree M.Tech in Computer Science & Technology from Andhra University. He received Ph.D. degree in Computer Science & Engineering from Acharya Nagarjuna University. He is currently working as Professor in Department of Computer Science in Adikavi Nannaya University, Rajahmundry, A.P., India. He published several papers in National and International Journals. He is active member of various professional bodies. His current research is focused on Computer Networks, Cloud Computing and Data Mining.

Mr. G. Jose Moses is a Research Scholar in the Department of Computer Science, Adikavi Nannaya University, Rajahmundry, A.P., India. He obtained his B.Tech from JNTU, Kakinada, M.Tech from Acharya Nagarjuna University. His research interests lies in Computer Networks, Cloud Computing.

Mrs. N.Supriya Working as Academic Consultant, in the department of Computer Science, Adikavi Nannaya university, Rajahmundry. She is at present pursuing Ph.D at Acharya Nagarjuna University. Her research interests lies in Software Engineering, Data Mining and Computer Networks.