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A Review Study of Various Routing Protocols Based on Routing Information Update Mechanism of Mobile Ad Hoc Networks

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ABSTRACT
Ad Hoc means "In this purpose". A Mobile Ad hoc Networks (MANETs) is a self- arranging network without structure and centralized control contains collection of mobile nodes connected by wireless network that communicates with each other. Each node in this network is free to move independently in all direction. Such networks have no fixed topology due to the node mobility. Because of this dynamically changing topology routing is a major issue and challenge. Many routing protocol is proposed to solve this problems. Mainly protocols are categorized into four categories: (i).based on routing information update mechanism, (ii).based on the use of temporal information for routing, (iii).based on the routing topology, (iv). Based on the utilization of a specific resource. The objective of this paper is to provide a review study of various routing protocols based on routing information update mechanism and its brief designed indication in mobile ad hoc network.
Keywords: Mobile Ad Hoc Networks, Routing protocols

I. INTRODUCTION

Wireless networks are of two types: Infrastructure or Infrastructure-less. In Infrastructure wireless networks, at the time of communication-nodes can move, the base stations are fixed and nodes communicate with in the range of base stations. Infrastructure wireless networks in which nodes are connected by hubs which are fixed access point. In infrastructureless or Ad-hoc wireless network, at the time of communication -nodes can move, there is no fixed base stations are there in the network and the nodes in the network act as routers. In the Ad-hoc network the mobile nodes need to form their own network dynamically establish routing among them.
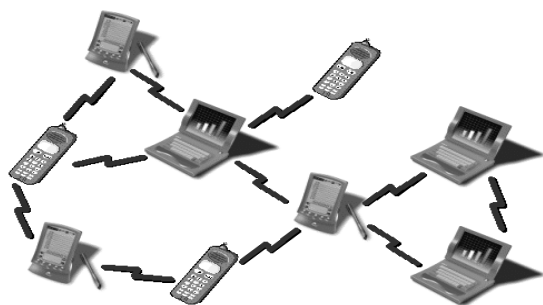

Figure 1.1 Example Mobile Ad-hoc Network

A **Mobile Ad-hoc Network (MANET)** [1] consists of mobile hosts equipped with wireless communication devices. The transmission of a mobile host is received by all hosts within its transmission range due to the broadcast nature of wireless communication and Omni-directional antennae. If two wireless hosts are out of their transmission ranges in the ad hoc networks, other mobile hosts located between them can forward their messages, which effectively build connected networks among the mobile hosts in the deployed area. Due to the mobility of wireless hosts, each host needs to be equipped with the capability of an autonomous system, or a routing function without any statically established infrastructure or centralized administration.

The ***challenges*** of Mobile Ad Hoc Networks are Self Operated and Infrastructureless, Dynamic Topology, Limited Resources, Scalability, Network Configuration, Error Prone State, Limited Physical Security, Blurring of IP Address and Bandwidth Constraints

A number of ***quantitative and qualitative parameters*** are used to compare the routing protocols are Routing Overhead, Packet Delivery Ration, Throughput, Network Load, Retransmission Attempts, Media Access Delay, Optimal Path, and Life Time.

II. ROUTING PROTOCOL

Routing is used to find as well as maintain routes between nodes in a rapidly changing topology with possibly unit-directional links, by using minimum resources .Whenever a packet via number of nodes needs to be transmitted to a destination a routing protocol is needed. Routing protocols deliver the packet to the correct destination via finding route

for packet. Routing protocols between any two mobile nodes of this network is difficult because each mobile node can arbitrarily move in the network and it is even possible that the node be removed from the network randomly and suddenly. This means that an optimum path may appear a few seconds after being removed from the network and recalculating for optimum routing should take place.

MANET routing protocols are categorized into three categories active, reactive and hybrid. In this class of routing protocols, all nodes have common duty in term of route discovery. All nodes are identical in terms of software, hardware and routing function and refuse any sort class between the nodes. All nodes preserve global routing information and information is flooded to all nodes. There are other types of routing protocol beside such as hierarchical routing and geographical position assisted routing.

For efficient routing a routing protocol has to follows a quantity of points which are as follows:
- Routing Protocol must be Aware of Power.
- Quality of Service should consider in routing protocol.
- Routing Protocol should be less vulnerable to security attacks.
- Routing Protocol should be less proactive than reactive to avoid overhead.
- Time synchronization concept should be in routing protocol.

Routing Metrics: To determine the optimum path between senders and receivers specific metrics are used by routing algorithm which are as follows:
- Minimum Power Routing: To get a packet from source to destination, minimizing the amount of power required as well as energy per bit.
- Multi-Path Battery Cost: To balance the energy consumption of all the nodes in a static wireless Ad-hoc network.
- Power Controlled MAC: Source uses an appropriate power level to transmit the packet and increase channel utilization.
- Battery Cost Aware Routing: Three different types of batter-cost–aware routing algorithms exists which are:
  1. Minimum Battery Cost: Minimize the total battery used for all nodes on the routing path.
  2. Min-Max Battery Cost: To avoid the routes with the nodes which have least battery remaining.
  3. Conditional Max-Min Battery Capacity: Route is chosen on the basis of minimum total transmission power.

Requirements of routing protocols are as follows: Fully distributed: A centralized routing scheme, Adaptive to dynamically changing network topology: Mobility, Less number of nodes involved in connection setup, Local State Maintenance, Loop free and stale routes free, Converge to optimal routes for the topologically stable networks, It must consider the limited resource of the nodes and the transmission medium.

Classification: Ad hoc routing protocols are classified based on four criteria

(i). Based on the routing information update mechanism
a) *Proactive or Table driven routing protocols:* Periodic exchange of routing information (high routing overhead). Each node maintains its own routing table.
b) *Reactive or On Demand routing protocols:* No periodic exchange of routing information (Routing overhead grows according to actual needs).Route is found when required.
c) *Hybrid routing protocols:* Protocols combine the best features of the above two categories. For routing within this zone, a table-driven approach is used. For nodes that are located beyond this zone, an on-demand approach is used.

(ii). Based on the use of temporal information for routing
a) *Routing protocols using past temporal information:* Using available information at the time of making the routing decisions. Information about the current availability of links with shortest path algorithm is used. Here it is having an optimal route which means the highly probable link breaks during sessions.
b) *Routing protocols that use future temporal information*: Using predictions of the future state of the links. The future status of the links is predicted.

(iii).Based on the routing topology
a) *Flat topology routing protocols*: Routing and data packets are transmitted across any number of nodes in the network. It's more suitable for small number of nodes. It has limited scalability.
b) *Hierarchical topology routing protocols*: As the number of nodes increases, clustering of nodes is applied to form hierarchies. More coordination among nodes in the same cluster. Traffic inside/among clusters is better scheduled. More resources consuming efficiency.

(iv). Based on the utilization of a specific resource

a) Power aware routing: Make use of a flat addressing scheme and geographical information assisted routing.

III. PROACTIVE ROUTING PROTOCOLS

The Wireless Routing Protocol (WRP)

The Wireless Routing Protocol (WRP) [[16]] is a proactive unicast routing protocol for mobile ad hoc networks. WRP uses improved Bellman-Ford Distance Vector routing algorithm. To adapt to the dynamic features of mobile ad hoc networks, some mechanisms are introduced to ensure the reliable exchange of update messages and reduces route loops.

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.

The Destination Sequence Distance Vector (DSDV) routing protocol

The Destination Sequence Distance Vector (DSDV) [4] is a proactive unicast mobile ad hoc network routing protocol. Like WRP, DSDV is also based on the traditional Bellman-Ford algorithm. However, their mechanisms to improve routing performance in mobile ad hoc networks are quite different.

In routing tables of DSDV, an entry stores the next hop towards a destination, the cost metric for the routing path to the destination and a destination sequence number that is created by the destination. Sequence numbers are used in DSDV to distinguish stale routes from fresh ones and avoid formation of route loops.

The route updates of DSDV can be either time-driven or event-driven. Every node periodically transmits updates including its routing information to its immediate neighbors. While a significant change occurs from the last update, a node can transmit its changed routing table in an event-triggered style. Moreover, the DSDV has two ways when sending routing table updates. One is "full dump" update type and the full routing table is included inside the update. A "full dump" update could span many packets. An incremental update contains only those entries that with metric have been changed since the last update is sent. Additionally, the incremental update fits in one packet.

The Fisheye State Routing (FSR)

The Fisheye State Routing (FSR) [[17]] is a proactive unicast routing protocol based on Link State routing algorithm with effectively reduced overhead to maintain network topology information. As indicated in its name, FSR utilizes a function similar to a fish eye. The eyes of fishes catch the pixels near the focal with high detail, and the detail decreases as the distance from the focal point increases. Similar to fish eyes, FSR maintains the accurate distance and path quality information about the immediate neighboring nodes, and progressively reduces detail as the distance increases.

In Link State routing algorithm used for wired networks, link state updates are generated and flooded through the network whenever a node detects a topology change. In FSR, however, nodes exchange link state information only with the neighboring nodes to maintain up-to-date topology information. Link state updates are exchanged periodically in FSR, and each node keeps a full topology map of the network. To reduce the size of link state update messages, the key improvement in FSR is to use different update periods for different entries in the routing table. Link state updates corresponding to the nodes within a smaller scope are propagated with higher frequency.

FSR exhibits a better scalability concerning the network size compared to other link state protocols because it doesn't strive for keeping all nodes in the network on the same knowledge level

about link states. Instead, the accuracy of topology information is reverse proportional to the distance. This reduces the traffic overhead caused by exchanging link state information because this information is exchanged more frequently with node nearby than with nodes far away.

IV. REACTIVE ROUTINGPROTOCOLS

The Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [5] is a reactive unicast routing protocol that utilizes source routing algorithm. In source routing algorithm, each data packet contains complete routing information to reach its dissemination. Additionally, in DSR each node uses caching technology to maintain route information that it has learnt.

There are two major phases in DSR, the *route discovery phase* and *the route maintenance phase.* When a source node wants to send a packet, it firstly consults its route cache. If the required 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 packets. A route request packet contains addresses of both the source and the destination and a unique number to identify the request. Receiving a route request packet, a 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 neighbors. To limit the communication overhead of route request packets, a node processes route request packets that both it has not seen 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.
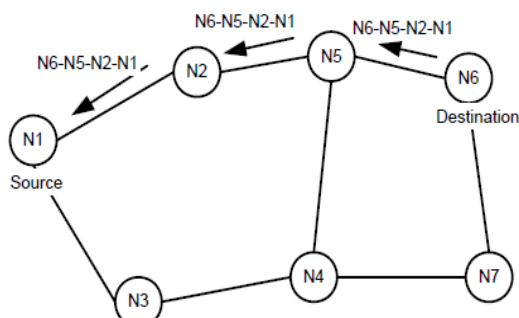

Fig. 1. Route Reply with route record in DSR

After being created, either by the destination or an intermediate node, a route reply packet needs a route back to the source. There are three possibilities to get a backward route. The first one is that the node already has a route to the source. The second possibility is that the network has symmetric (bi-directional) links. The route reply packet is sent using the collected routing information in the route record field, but in a reverse order as shown in Figure 1. In the last case, there exists asymmetric (uni-directional) links and a new route discovery procedure is initiated to the source. The discovered route is piggybacked in the route request packet.

In DSR, when the data link layer detects a link disconnection, a ROUTE_ERROR packet is sent backward to the source. After receiving the ROUTE_ERROR packet, the source node initiates another route discovery operation. Additionally, all routes containing the broken link should be removed from the route caches of the immediate nodes when the ROUTE_ERROR packet is transmitted to the source.

DSR has increased traffic overhead by containing complete routing information into each data packet, which degrades its routing performance.

The Ad Hoc On-demand Distance Vector Routing (AODV) protocol

The Ad Hoc On-demand Distance Vector Routing (AODV) protocol [8] is a reactive unicast routing protocol for mobile ad hoc networks. As a reactive routing protocol, AODV only needs to maintain the routing information about the active paths. In AODV, routing information is maintained in routing tables at nodes. Every mobile node keeps a next-hop routing table, which contains the destinations to which it currently has a route. A routing table entry expires if it has not been used or reactivated for a pre-specified expiration time. Moreover, AODV adopts the destination sequence number technique used by DSDV in an on-demand way.

In AODV, when a source node wants to send packets to the destination but no route is available, it initiates a route discovery operation. 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 are important to ensure loop-free and up-to-date routes. To reduce the flooding overhead, a node discards RREQs that it has seen before and the expanding ring search algorithm is used in route discovery operation. The RREQ starts with a small TTL (Time-To-Live) value. If the destination is not found, the TTL is increased in following RREQs.
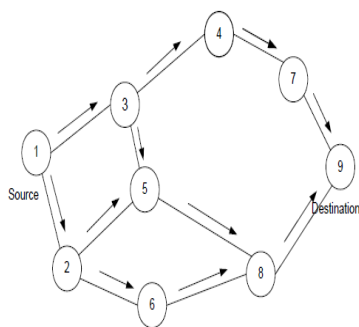
Fig. 2. The Route Request packets flooding in AODV

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 and the one specified in the RREQ. To guarantee the freshness of the routing information, a route reply (RREP) packet is created and forwarded back to the source only if the destination sequence number is equal to or greater than the one specified in RREQ. AODV uses only symmetric links and a RREP follows the reverse path of the respective RREP.
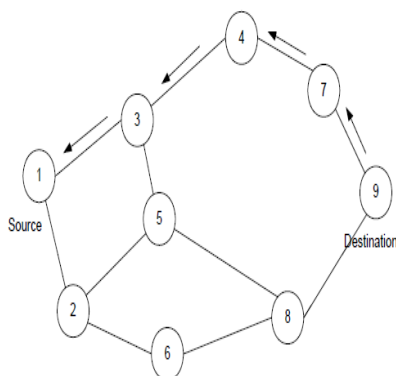

Fig. 3. The forwarding of Route Reply packet in AODV

In AODV, a node uses hello messages to notify its existence to its neighbors. Therefore, the link status to the next hop in an active route can be monitored. When a node discovers a link disconnection, it broadcasts a route error (RERR) packet to its neighbors, which in turn propagates the RERR packet towards nodes whose routes may be affected by the disconnected link. Then, the affected source can re-initiate a route discovery operation if the route is still needed.

The Temporally Ordered Routing Algorithm (TORA)

The Temporally Ordered Routing Algorithm (TORA) [[9],[10]] is a reactive routing algorithm based on the concept of link reversal. TORA improves the partial link reversal method by detecting partitions and stopping non-productive link reversals. TORA can be used for highly dynamic mobile ad hoc networks.

In TORA, the network topology is regarded as a directed graph. A Directional Acyclical Graph (DAG) is accomplished for the network by assigning each node i a height metric hi. A link directional from i to j means $hi > hj$.

TORA has three basic operations: *route creation, route maintenance* and *route erasure*. A route creation operation starts with setting the height of the destination to 0 and heights of all other nodes to NULL. A route maintenance has the unique feature that control messages are localized into a small set of nodes near the occurrence of topology changes. After a node loses its last downstream link, it generates a new reference level and broadcasts the reference to its neighbors. Therefore, links are reversed to reflect the topology change and adapt to the new reference level. The erase operation in TORA floods CLR packets through the network and erase invalid routes.

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. The survey tries to review typical routing protocols and reveal the characteristics and trade-offs. There are still many issues which have not been considered in this report e.g. related to quality of service or recent work on position-based and geographical routing. This will be subject of further investigations.

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