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A COMPARISON OF REACTIVE ROUTING PROTOCOLS DSR, AODV AND TORA IN MANET

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***Abstract*— Reactive routing protocol is a bandwidth efficient on-demand routing protocol for mobile ad hoc networks. If a node wants to initiate communication with another node to which it has no route, the routing protocol will try to establish such a route. The reactive (On-demand) routing algorithms considered are DSR, AODV AND TORA that are based on protocol parameters such as route discovery, route maintenance, network, node overhead.**

Index Terms*— *AODV, DSR, MANET, Reactive Routing protocol, TORA.

I. Introduction

A mobile ad hoc network (MANET) is a collection of mobile nodes which is connected through wireless medium forming rapidly changing topologies. Mobile nodes communicate with each other without the intervention of a centralized access point or base station. Routes between two nodes consist of hops through other nodes in the network. Each mobile node works not only as a host but also as a router forwarding packets to other mobile nodes in the network. Therefore, each mobile node takes part in discovery and maintenance of routes to other nodes. The MANET routing algorithms are classified into two categories proactive and reactive.

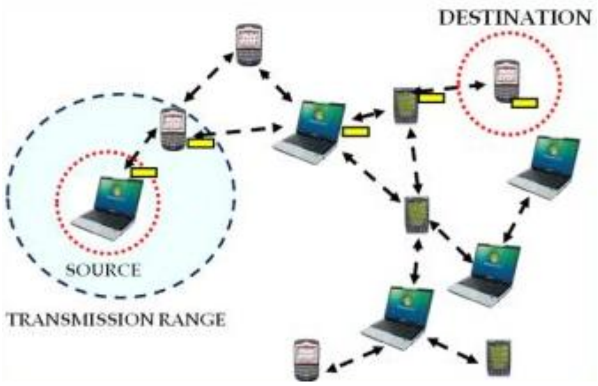

Fig 1: MANET Working

II. Reactive Routing Protocol

The reactive routing protocols are on demand routing protocols. The routes are propagated only on demand. In reactive routing protocol, if a node wants to send a packet to another node, then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The on-demand routing protocol is easy to eliminate periodic updates and so adaptive to network dynamics. Compared to the proactive routing protocols for mobile ad hoc networks, less control overhead is a distinct advantage of the reactive routing protocols. Thus, reactive routing protocols have better scalability than proactive routing protocols in mobile ad hoc networks. Routing in reactive protocol typically consists of two phases: *source routing* and *hop-by-hop routing*.

In *Source routed* on-demand protocols, each data packets carry the complete source to destination address. Therefore, each intermediate node forwards these packets according to the information kept in the header of each packet. This means that the intermediate nodes do not need to maintain up-to-date routing information for each active route in order to forward the packet towards the destination.

In *hop-by-hop routing* (also known as point-to-point routing), each data packet only carries the destination address and the next hop address. Therefore, each intermediate node in the path to the destination uses its routing table to forward each data packet towards the destination. The advantage of this strategy is that routes are adaptable to the dynamically changing environment of MANETs, since each node can update its routing table when they receiver fresher topology information and hence forward the data packets over better routes.

This paper is to provide a realistic, quantitative analysis comparing the performance of a variety of reactive routing protocols. We present results of detailed simulations showing the relative performance of three recently proposed mobile ad hoc routing protocols:

i) Dynamic Source Routing (DSR**)**
ii) Ad Hoc On-Demand Distance Vector (AODV)
iii) Temporally-Ordered Routing Algorithm (TORA)

III. Dynamic Source Routing (DSR)

The *Dynamic Source Routing* protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes.

Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure. Network nodes cooperate to send packets for each other node to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network, and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR routing protocol. Since the number or sequence of intermediate hops needed to reach any destination may change at any time, the resulting network topology may be quite rich and rapidly changing.

DSR uses source routing rather than hop-by-hop routing, with each packet to be routed carrying in its header the complete, ordered list of nodes through which the packet must pass. The key advantage of source routing is that

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intermediate nodes do not need to maintain up-to-date routing information in order to route the packets they forward, since the packets themselves already contain all the routing decisions. This fact, coupled with the on-demand nature of the protocol, eliminates the need for the periodic route advertisement and neighbor detection packets present in other protocols.

A. *DSR Mechanisms*

The DSR protocol is composed of two mechanisms:
Route Discovery
Route Maintenance

1) *Route Discovery*

Route discovery function is responsible for creating a new route, which one node is needed. In a reactive routing protocol, routing paths are searched only when needed. Route discovery process is used in on-demand routing by flooding the route request (*RREQ*) packets throughout the network. If a node wants to initiate communication with another to which it has no route, the routing protocol will establish such a route.

When a node **A** wishing to send a packet to a destination node **E** obtains a source route to **E**. Route Discovery is used only when **A** attempts to send a packet to **E** and does not already know a route to **E**.

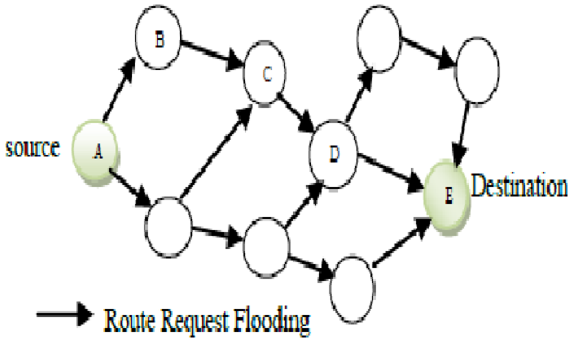

Fig. 2: Route Request in DSR

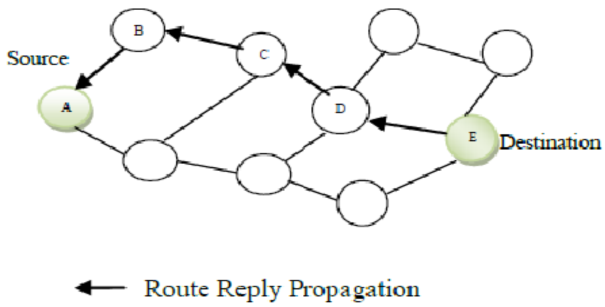

Fig 3: Route Reply in DSR

2) *Route Maintenance*

Route maintenance function is responsible for the detection of link breakups and repairs of an existing route. In a mobile ad hoc network, active routes may be disconnected due to node mobility. Therefore, route maintenance is an important operation of reactive routing protocols. When a mobile host wants to communicate with another host, it tries to create a good route to the destination, on which the data packets are forwarded.

Route maintenance, under our definition, should address two issues: Route deterioration and Route breakage.

Route deterioration refers to the situation where an existing route becomes worse than other routes due to host mobility. However, in existing protocols, a sending host will stick with the discovered route until it is expired or broken, even if some better routes are newly being formed in the system. One straightforward solution is to run the route discovery procedure more frequently to detect such possibility. However, this is very costly as route discovery is typically done by network flooding.

To deal with the *route breakage problem*, most existing protocols will send a route error packet back to the source node from the position where breakage is found, which will then invoke another route discovery procedure.

B. *Advantages and Disadvantages*

DSR uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.

The disadvantage of DSR is that the route maintenance mechanism does not locally repair a broken down link. The connection setup delay is higher than in table driven protocols. Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. Also, considerable routing overhead is involved due to the source-routing mechanism employed in DSR. This routing overhead is directly proportional to the path length.

IV. AD HOC ON-DEMAND DISTANCE VECTOR (AODV)

Ad hoc On-Demand Distance Vector (AODV) is a reactive routing protocol which initiates a route discovery process only when it has data packets to transmit and it does not have any route path towards the destination node, that is, route discovery in AODV is called as on-demand. AODV is capable of both unicast and multicast routing.

A. *AODV Mechanisms:*

AODV defines three types of control messages for route maintenance:
Route Request
Route Reply
Route Error

1) *Route Request (RREQ)*

A route request message is transmitted by a node requiring a route to a node. As an optimization AODV uses an expanding ring technique when flooding these messages. Every *RREQ* carries a *time to live* (TTL) value that states for how many hops this message should be forwarded. This value is set to a predefined value at the first transmission and increased at retransmissions. Retransmissions occur if no replies are received. Data packets waiting to be transmitted (i.e. the packets that initiated the *RREQ).*

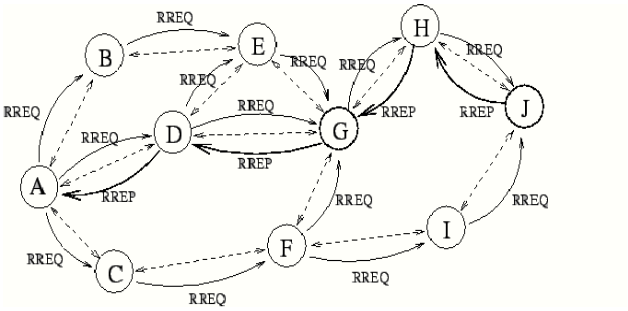

Fig. 4: Route Request and Route Reply in AODV

2) Route Reply (RREO)

A route reply message is unicasted back to the originator of a *RREQ* if the receiver is either the node using the requested address, or it has a valid route to the requested address. The reason one can unicast the message back, is that every route forwarding a *RREQ* caches a route back to the originator.

3) Route Error (RERR)

Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, *a RERR* message is used to notify other nodes of the loss of the link. In order to enable this report in "precursor list", containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination.

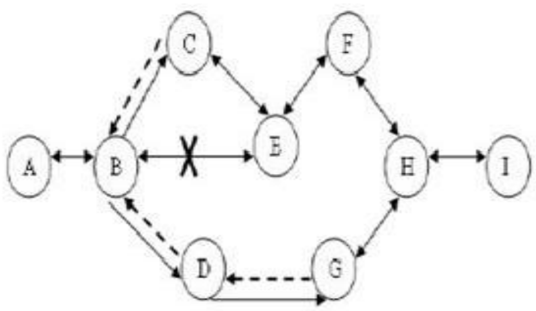

Fig. 5: Route Error in AODV

B. *Advantages and Disadvantages*

The main advantage of AODV protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The connection setup delay is less. One of the disadvantages of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. Another disadvantage of AODV is that the periodic beaconing leads to unnecessary bandwidth consumption.

V. Temporally-Ordered Routing Algorithm (TORA)

TORA is a distributed routing protocol based on a "link reversal" algorithm. It is designed to discover routes on demand, provide multiple routes to a destination, establish routes quickly, and minimize communication overhead by localizing algorithmic reaction to topological changes when possible. Route optimality (shortest-path routing) is considered of secondary importance, and longer routes are often used to avoid the overhead of discovering newer routes.

TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It finds multiple routes from a source node to a destination node. The main feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes maintain routing information about adjacent nodes. TORA has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the event of network partitions the protocol is able to detect the partition and erase all invalid routes.

A. *TORA Mechanisms*

The protocol has three basic functions:

- Route Creation
- Route Maintenance
- Route Erasure

1) Route Creation

A node which requires a link to a destination because it has no downstream neighbors for it sends a query packet and sets its route-required flag. A *QUERY* packet contains the destination id of the node a route is sought to. The reply to a query is called an *UPDATE* packet. It contains the height quintuple of the neighbor node answering to a query and the destination field which tells for which destination the update was meant for a node receiving a *QUERY* packet does one of the following:

a. If its route required flag is set, this means that it doesn't have to forward the *QUERY*, because it has itself already issued a *QUERY* for the destination, but better discard it to prevent message overhead.

b. If the node has no downstream links and the route-required flag was not set, it sets its route-required flag and rebroadcasts the *QUERY* message.

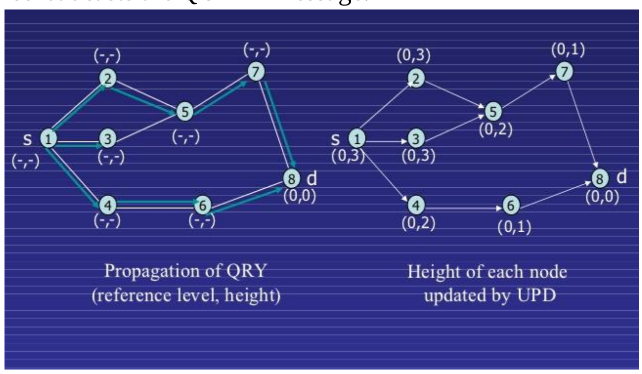

Fig. 6. Route Creation in TORA

A node receiving an update packet updates the height value of its neighbor in the table and takes one of the following actions:

a. If the reflection bit of the neighbors height is not set and its *route required flag* is set it sets its height for the destination to that of its neighbors but increments d by one. It then deletes the RR flag and sends an *UPDATE* message to the neighbors, so they may route through it.

b. If the neighbor's route is not valid (which is indicated by the reflection bit) or the RR flag was unset, the node only updates the entry of the neighbor's node in its table.

2) *Route Maintenance*

The availability of multiple paths is a result of how TORA models the entire network as a directed acyclic graph (DAG) rooted at the destination. Each node has a height associated with it and links between nodes flow from one with a higher height to one with a lower height. The collection of links formed between nodes forms the DAG and ultimately all nodes will have a route to the destination. For each possible destination required, a separate DAG needs to be constructed. Route maintenance occurs when a node loses all of outgoing links.

When the detection of a link failure causes a node to lose all of out-going links, the node propagates an update packet which reverses the links to all of its neighbouring nodes. Intermediate nodes that receive the update packet then reverse the links of their neighbouring nodes. Links are reversed only for neighbouring nodes that do not have any out-going links and have not performed link reversal recently. The link reversal needs to be repeated until each node has at least one out-going link. This entire process ensures that the DAG is maintained such that all nodes have routes to the destination.

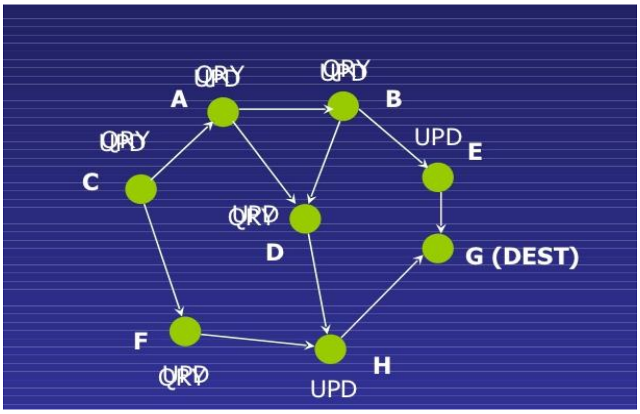

Fig. 7. Route Maintenance in TORA

3) *Route Erasure*

When a node has detected a partition it sets its height and the heights of all its neighbors for the destination in its table to *NULL* and it issues a *CLEAR* packet. The *CLEAR* packet consists of the reflected reference level and the destination id.

If a node receives a *CLEAR* packet and the reference level matches its own reference level it sets all heights of the neighbors and its own for the destination to *NULL* and broadcasts the *CLEAR* packet. If the reference level doesn't match its own it just sets the heights of the neighbors its table matching the reflected reference level to *NULL* and updates their link status.

B. *Advantages and Disadvantages*

The multiple routes between any source destination pair are supported by this protocol. Therefore, failure or removal of any of the nodes is quickly resolved without source intervention by switching to an alternate route. TORA is also not free from limitations. One of them is that it depends on synchronized clocks among nodes in the ad hoc network.

The dependence of this protocol on intermediate lower layers for certain functionality presumes that the link status sensing, neighbor discovery, in order packet delivery and address resolution are all readily available. The solution is to run the Internet MANET Encapsulation Protocol at the layer immediately below TORA.

Table 1: *Comparison of Reactive Routing Protocols*

Parameters	DSR	AODV	TORA
Route Selection	Shortest path	Shortest and updated path	Shortest path or next available
Routing Structure	Flat	Flat	Flat
Source Routing	Yes	No	No
Routes	Multiple	Single	Multiple
Topology Structure	Full	Full	Reduced
Broadcast	Full	Full	Local
Update Period	Event-driven	Event-driven	Table-driven
Update Information	Route Error	Route Error	Node's height
Update Destination	Source	Source	Neighbors
Method	Unicast	Unicast	Broadcast
Beacon	No	Yes	No
Route maintenance	Route Cache	Route Table	Route Table
Route reconfiguration	Erase route, Notify source	Erase route, Notify source	Route Repair
Route Metric Method	Shortest path	Shortest path	Shortest path or next available

VI. Conclusion

Mobile ad hoc networks are wireless networks that use multi-hop routing instead of static networks infrastructure to provide network connectivity. Therefore, there are new challenges for routing protocols in MANETs since traditional routing protocols may not be suitable for MANETs. This work is an attempt towards a comparison of three commonly used mobile ad hoc routing protocols (DSR, TORA and AODV).

Ad Hoc On-Demand Distance Vector (AODV) performance is the best considering its ability to maintain connection by periodic exchange of information, which is required for TCP, based traffic. AODV performs better than other protocols with large number of nodes. Hence for real time traffic AODV is preferred over DSR. AODV is based on route discovery and route maintenance mechanism. Flat

Routing Philosophy is used in DSR, AODV and TORA. Packet size is uniform for AODV and non uniform for DSR. DSR is suitable for networks with moderate mobility rate. Whereas TORA is suitable for operation in large mobile networks having dense population of nodes. The major benefit is its excellent support for multiple routes and multicasting.

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