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MANET Protocols Efficiency – Comparative Study

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ABSTRACT- MANETs is one of the faster growing new-generation wireless networks. It is a collection of wireless mobile nodes forming a temporary network without using any centralized access point, infrastructure, or centralized administration. To establish a data transmission between two nodes, typically multiple hops are required due to the limited transmission range. Packet delivery ratio, end to end connection, multicast efficiency and hops count are very challenging in MANET over a dynamic topology. We compare the various protocols and their analyses in earlier works on several parameters for the sake of completion of readability; we insert the investigation in chronological order.

Keywords: *Mobile Ad hoc Networks (MANET), Routing protocol, AODV, DSR, LAR, ZRP, ODMRP, AMRIS, MAODV*

1. INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a collection of mobile nodes (hosts) which communicate with each other via wireless links either directly or relying on other nodes as routers. The operation of MANETs does not depend on pre existing infrastructure or base stations. Network nodes in MANETs are free to move randomly. Therefore the network topology of a MANET may change rapidly and unpredictably. [12] This becomes challenging for the network research community and looking forward to have general standards in this context. In line with this objective we propose in this paper comparing various protocols and their analyses on several parameters.

Specifically, nodes may participate in the route discovery and maintenance process of forwarding the data packets. The network nodes are randomly distributed over the entire network area. The source and destination of each transaction are chosen randomly among all nodes.

Routing protocols also maintain connectivity when links on these paths break due to effects such as node movement, battery drainage, radio propagation, or wireless interference. In multi-hop networks, routing is one of the most important issues that have significant impact on the network's performance. [20]

This paper compare and analyses the various techniques of the multicast protocols like MAODV, ODMRP, AMRIS, AODV, DSR, LAR, and ZRP in MANET environment. The rest of the paper is organized as follows. In section 2, we discussed different types of protocols contributed by various authors and in section 3 we elaborate those protocols. In section 4 we make specific comparison and make conclusions in section-5 followed by the list of references in section-6.

2. ENUMERATION OF MANET RESEARCH CONTRIBUTIONS

We would like to discuss some relevant papers about simulation results and protocol comparison, although those experiments vary very much in their experimental setup. Almost always the network protocols were simulated as a function of pause time (i.e. as a function of mobility), but never as a function of network size.

We start with first paper [1] studies on was carried out by Broch, Maltz, Johnson, Hu and Jetcheva , who conducted experiments with DSDV8, TORA9, DSR and AODV. The *ns-2* simulator [15,18] was used for visualization of performance. They summarizes like DSDV performed well and delivered almost any packet in low mobility scenarios, i.e. when the node mobility rate and movement speed are low. But it failed as the mobility increased. TORA appeared as the worst performer in the routing packet overhead issues. DSR showed a very good performance at all mobility rates and speeds. At last, AODV performed almost as well as DSR in all scenarios.

We consider remarkable paper[15] where DSR and DSDV were simulated and compared to a newly developed Cluster-based Routing Protocol (CBRP) by Mingliang, Tay and Long. The simulations were performed with pause times from 0 to 600 seconds and with 25 to 150 mobile nodes. The focus of this presentation is set to CBRP, specially how it scales in larger networks and in situations with higher mobility. It can be seen that the packet delivery ratio of DSR falls to approximately 65% in a network of 150 nodes, which is good comparable to our results. CBRP performed much better with a delivery ratio always greater than 90 percent and made a lower routing overhead comparing that for DSR in larger networks.

Compact comparison in [19] by Das, Perkins, Royer and Marina presented performance analyses of the AODV and DSR protocol. In this paper, it was also concluded that AODV outperforms DSR in more stressful situations (i.e. larger network, higher mobility). In high mobility scenarios with low pause times, DSR performed badly due to the frequent use of stale routes and slow reaction to link changes. This leaded to poor delay and delivery ratio. DSR only showed advantage in the general lower routing overhead and in low mobility and small load scenarios.

Committing to better Qos the paper[21] Al-Karaki and Kamal published a detailed overview and the development trends in the field of QoS routing. They highlighted some areas such as security and multicast routing requiring further research attention. They were categorized the QoS routing solutions into various types of approaches: Flat, Hierarchical, Position-based and power aware QoS routing. eddy et al. provided a thorough overview of the more widely accepted MAC and routing solutions for providing better QoS in MANETs.

A different approach quoted in Aparnka.K [23] was presented a comparative performance of three multicast protocols for Mobile Ad hoc Networks – ODMRP, AMRIS and MAODV focusing on the effects of changes such as the increasing number of receivers or sources and increasing the number of nodes.

A systematic performance evaluation of these protocols is done by performing certain simulations under NS-2. [15,18]. The availability of alternate routes provided robustness to mobility. AMRIS was effective in a light traffic environment with no mobility, but its performance was susceptible to traffic load and mobility. ODMRP was very effective and efficient in most of our simulation scenarios. However, the protocol showed a trend of rapidly increasing overhead as the number of senders increased. [20,10,5]

Keeping interest in larger networks, David Oliver Jorg [17] was to test routing performance of four different routing protocols (AODV, DSR, LAR and ZRP) in variable network sizes up to thousand nodes. This paper analyses and summaries the four different routing protocols [19,12,16]

This article presented by Sanjeev Gangwar, Dr.Sauabh Pal and Dr.Krishnan Kumar [24]about overview of QoS routing metrics, resources and factors affecting performance of QoS routing protocols also considered the relative strength, weakness, and applicability of existing QoS routing protocols are also studied and compared. QoS routing protocols are classified according to the QoS metrics used type of QoS guarantee assured.

3.AD-HOC ROUTING PROTOCOLS

3.1. Ad Hoc On-Demand Distance Vector Routing (AODV)

The Ad Hoc On-Demand Distance Vector routing protocol (AODV) is an improvement of the Destination-Sequenced Distance vector routing protocol (DSDV). DSDV has its efficiency in creating smaller ad-hoc networks. Since it requires periodic advertisement and global dissemination of connectivity information for correct operation, it leads to frequent system-wide broadcasts. Therefore the size of DSDV ad-hoc networks is strongly limited. When using DSDV, every mobile node also needs to maintain a complete list of routes for each destination within the mobile network. The advantage of AODV is that it tries to minimize the number of required broadcasts. It creates the routes on a on-demand basis, as opposed to maintain a complete list of routes for each destination. Therefore, the authors of AODV classify it as a *pure on-demand route acquisition system*. [2,10,15]

3.2. Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) protocol is an on-demand routing protocol based on source routing. In the source routing technique, a sender determines the exact sequence of nodes through which to propagate a packet. The list of intermediate nodes for routing is explicitly contained in the packet's header. In DSR, every mobile node in the network needs to maintain a *route cache* where it caches source routes that it has learned. When a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet. Otherwise the source node initiates the route discovery process. Route discovery and route maintenance are the two major parts of the DSR protocol. [1,10,22]

3.3. Location-Aided Routing (LAR)

Hop-by-hop acknowledgement at the data link layer allows an early detection and retransmission of lost or corrupt packets. If the data link layer determines a fatal transmission error (for example, because the maximum number of retransmissions is exceeded), a *route error* packet is being sent back to the sender of the packet. The route error packet contains two parts of information: The address of the node detecting the error and the host's address which it was trying to transmit the packet to. Whenever a node receives a route error packet, the hop in error is removed from the route cache and all routes containing this hop are truncated at that point. End-to-end acknowledgement may be used, if wireless transmission between two hosts does not work equally well in both directions. As long as a route exists by which the two end hosts are able to communicate, route maintenance is possible. There may be different routes in both directions. In this case, replies or acknowledgements on the application or transport layer may be used to indicate the status of the route from one host to the other. However, with end-to-end acknowledgement it is not possible to find out the hop which has been in error.[10,23,17,3]

3.4. Zone Routing Protocol (ZRP)

In a mobile ad-hoc network, it can be assumed that most of the communication takes place between nodes close to each other. The Zone Routing Procol (ZRP) described in [4] takes advantage of this fact and divides the entire network into overlapping zones of variable size. It uses proactive protocols for finding zone neighbors (instantly sending *hello* messages) as well as reactive protocols for routing purposes between different zones (a route is only established if needed). Each node may define its own zone size, whereby the zone size is defined as number of hops to the zone perimeter. For instance, the zone size may depend on signal strength, available power, reliability of different nodes etc. While ZRP is not a very distinct protocol, it provides a framework for other protocols.

The detection process is usually accomplished by using the *Neighbor Discovery Protocol* (NDP). Every node periodically sends some *hello* messages to its neighbours. If it receives an answer, a point-to-point connection to this node exists. Nodes may be selected by different criteria, be it signals strength, radio frequency, delay etc. The discovery messages are repeated from time to time to keep the map of the neighbors updated.

The routing processes inside a zone are performed by the *Intrazone Routing Protocol* (IARP). This protocol is responsible for determing the routes to the peripheral nodes of a zone. generally a proactive protocol. Another type of protocol is used for the communication between different zones. It is called *Interzone Routing Protocol* (IERP) and is only responsible for routing between peripheral zones. A third protocol, the *Bordercast Resolution Protocol* (BRP) is used to optimize the routing process between perimeter nodes. Thus, it is not necessary to flood all peripheral nodes, what makes queries become more efficient. [14]

3.5.On-Demand Multicast Routing Protocol (ODMRP)

ODMRP [12], [19], [11] creates a mesh of nodes (the "forwarding group") which forward multicast packets via flooding (within the mesh), thus providing path redundancy. ODMRP is an on-demand protocol, thus it does not maintain route information permanently. It uses a soft state approach in group maintenance. Member nodes are refreshed as needed and do not send explicit leave messages. In ODMRP, group membership and multicast routes are established and updated by the source on demand. Similar to on-demand unicast routing protocols, a request phase and a reply phase comprise the protocol. When multicast sources have data to send, but do not have routing or membership information, they flood a JOIN DATA packet. When a node receives a non-duplicate JOIN DATA, it stores the upstream node ID (i.e., backward learning) and rebroadcasts the packet. When the JOIN DATA packet reaches a multicast receiver, the receiver creates a JOIN TABLE and broadcasts to the neighbors. When a node receives a JOIN TABLE, it checks if the next node ID of one of the entries matches its own ID. If it does, the node realizes that it is on the path to the source and thus is part of the forwarding group. It then broadcasts its own JOIN TABLE built upon matched entries. The JOIN TABLE is thus propagated by each forwarding group member until it reaches the multicast source via the shortest path. This process constructs (or updates) the routes from sources to receivers and builds a mesh of nodes, the *forwarding group*. Multicast senders refresh the membership information and update the routes by sending JOIN DATA periodically. Another unique property of ODMRP is its unicast capability. Not only can ODMRP coexist with any unicast routing protocol, it can also operate very efficiently as unicast routing protocol. Thus, a network equipped with ODMRP does not require a separate unicast protocol.[20,5,6]

3.6. Ad hoc Multicast Routing protocol utilizing Increasing idnumberS (AMRIS)

AMRIS is an on-demand protocol that constructs a shared multicast delivery tree to support multiple senders and receivers in a multicast session. AMRIS [2] establishes a shared tree for multicast data forwarding. Each node in the network is assigned a multicast session ID number. The ranking order of ID numbers is used to direct the flow of multicast data. Like ODMRP, AMRIS does not require a separate unicast routing protocol. Initially, a special node called Sid broadcasts a NEW-SESSION packet. The NEW-SESSION includes the Sid's msm-id (multicast session member id). Neighbor nodes, upon receiving the packet, calculate their own msm-ids which are larger than the one specified in the packet. The msm-ids thus increase as they radiate from the Sid. The nodes rebroadcast the NEW-SESSION message with the msm-id replaced by their own msm-ids. Each node is required to broadcast beacons to its neighbors. The beacon message contains the node id, msm-id, membership status, registered parent and child's ids and their msm-ids, and partition id. A node can join a multicast session by sending a JOIN-REQ. This JOIN-REQ is unicasted to a potential parent node with a smaller msm-id than the node's msm-id. The node receiving the JOIN-REQ sends back a JOIN-ACK if it already is a member of the multicast session. Otherwise, it sends a JOIN-REQ.PASSIVE to its potential parent. If a node fails to receive a JOIN-ACK or receives a JOIN-NAK after sending a JOIN-REQ, it performs "Branch Reconstruction (BR)." The BR process is executed in an expanding ring search until the node succeeds in joining the multicast session. AMRIS detects link disconnection by a beaconing mechanism. If no beacons are heard for a predefined interval of time, the node considers the neighbor to have moved out of radio range. If the former neighbor is a parent, the node must rejoin the tree by sending a JOIN-REQ to a new potential parent. If the node fails to join the session or no qualified neighbors exist, it performs the BR process. Data forwarding in done by the nodes in the tree. Only the packets from the registered parent or registered child are forwarded. Hence, if the tree link breaks, the packets are lost until the tree is reconfigured. Our AMRIS implementation followed the specification in [4]. BR consists of two subroutines. BR1 is executed when a node has a potential parent node for a group. If it does not find any potential parent node, BR2 is executed. In BR2, instead of sending a unicast JOIN-REQ to a potential parent node, the node broadcasts a JOIN-REQ that consists of a range field R to specify the nodes till R hops. Upon link breakage, the node with the larger msm-id tries to rejoin the tree by executing any of the BR mechanism. It is to be noted that AMRIS detects link disconnection by a beaconing mechanism. Hence, until the tree is reconstructed, packets could possibly be dropped.

3.7. Multicast Ad Hoc On-demand Distance Vector (MAODV)

MAODV routing protocol follows directly from unicast AODV, and discovers multicast routes on demand using a broadcast route discovery mechanism employing the same route request (RREQ) and route reply (RREP) messages that exist in the send to a multicast group but does not have a route to that group. Only a member of the desired multicast group may respond to a join RREQ.[5] If the RREQ is not a join request, it receives a RREQ and does not have a route to that group, it rebroadcasts the RREQ to its neighbors. As the RREQ is broadcast across the network, nodes set up pointers to establish the reverse route in their route tables. A node receiving an RREQ first updates its route table to record the sequence number and the next hop information for the source node. This reverse route entry may later be used to relay a response back to the source. For join RREQs, an additional entry is added to the multicast route table and is not activated unless the route is selected to be part of the multicast tree. If a node receives a join RREQ for a multicast group, it may reply if it is a member of the multicast group's tree and its recorded sequence number for the multicast group is at least as great as that contained in the RREQ. The responding node updates its route and multicast route tables by placing the requesting node's next hop information in the tables, and then unicasts an RREP back to the source. As nodes along the path to the source receive the RREP, they add both a route table and a multicast route table entry for the node from which they received the RREP, by creating the forward path. unicast AODV protocol. A mobile node originates an RREQ message when it wishes to join a multicast group, or has data to streams with jitters. [23,17,3]

4. METRICS

The following four metrics have been chosen to compare the protocols:

• *Packet delivery ratio*: Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source (i.e. CBR source). It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.

• *Routing overhead*: The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the CBR packets. It is an important measure for the scalability of a protocol. It for instance determines, if a protocol will function in congested or low-bandwidth situations, or how much node battery power it consumes. If a protocol requires to send many routing packets, it will most likely cause congestion, collision and data delay in larger networks.

• *End-to-end delay*: End-to-end delay indicates how long it took for a packet to travel from the CBR source to the application layer of the destination. It represents the average data delay an application or a user experiences when transmitting data.

• *Hop count*: Hop count is the number of hops a packet took to reach its destination.

To comparison among the different Ad-hoc Routing Protocols are described in a table. The metrics constrained, packet delivery radio, Routing overhead, End-to-end delay and Hop count.

The parameters of the different Ad-hoc Routing Protocols are described in a table. The parameter metrics are packet delivery ratio, Routing overhead, End-to-end delay and Hop count.

Table 1 : Ad-hoc Routing Protocol - Comparison

Protocol	Packet Delivery Radio	Routing overhead	End-to-End delay	Hop count
ODMRP	Medium	Medium	Medium	Medium
AMRIS	Low	Low	Low	Low
MAODV	Low	Low	Low	Low
AODV	High	Medium	Medium	High
DSR	Low	Low	Low	Low
LAR	Medium	High	High	Medium
ZRP	Low	Low	Low	Low

4.1 Packet Delivery Ratio

Here figure 4.1 shown comparing protocols when number of packets and number of senders increasing their efficiency are decreasing.

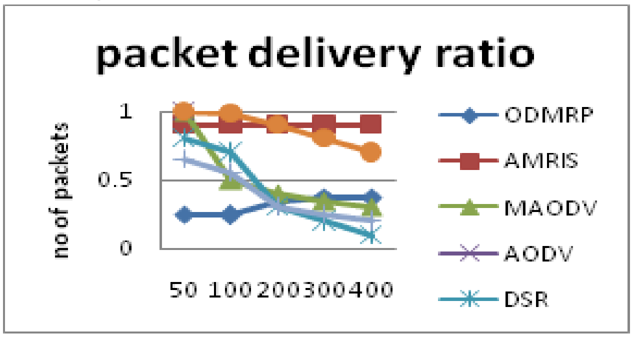

Fig 4.1: Packet Delivery ratio

Here AMRIS and ODMRP are working well compared to other protocols. DSR and ZRP shown poor performance fail for a network of 200 nodes, as they lose more than 70 percent of all CBR packets initiated by the source. The low delivery ratio when using DSR may be explained by the aggressive route caching built into this protocol. For a large number of nodes with higher mobility, the benefit of caching routes is completely lost. In contrary, stale routes are often chosen in DSR with higher loads. This often leads to route failures, retransmission and loss of packets. DSR reacts only slowly to route changes due to large amounts of routes in the cache. AODV and LAR show similar performance in networks up to 200 nodes with a delivery ratio of almost 100 percent. Because each sender of ODMRP floods control messages into the entire network periodically, the packet collision probability becomes higher when the number of senders increases. The senders in the AMRIS protocol must forward data packets to a rendezvous point; the rendezvous point is very busy when many senders are sending data. This situation may also increase the packet collision probability.

4.2 Routing Overhead

Figure 4.2 describes the routing efficiency for various protocols when number of nodes increases.

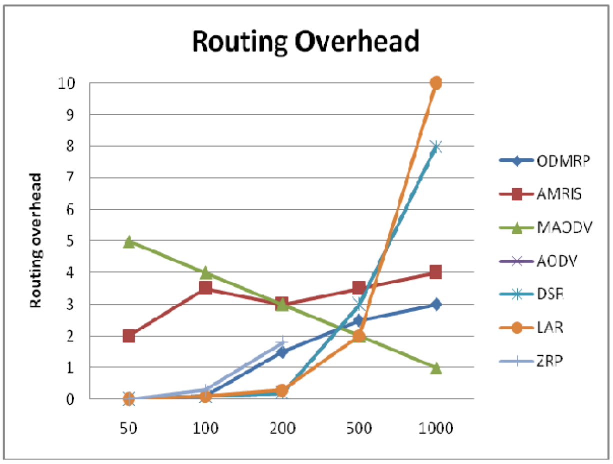

Fig 4.2 Routiong Overhead

On the whole, LAR performs a bit better than AODV by limiting the routing packets to the expected zone. The larger routing overhead for LAR in a network of 1000 nodes is explained by the less reliable position of the destination node in large networks and by the selection of a too small request zone. Additionally, this may also be a statistical error because LAR may have performed badly in this specific run. DSR always has a lower routing load than AODV: Due to aggressive caching, DSR will most often find a route in its cache and therefore rarely initiate a route discovery process unlike AODV. But because these routes are most often not valid anymore, a lot of packets get dropped. DSR's routing overhead is dominated by route replies (unicast packets), while AODV's routing load is dominated by route requests (broadcast packets). Therefore, DSR performs very well when looking at the routing overhead. MAODV has performs lower than AODV. AMRIS and ODMRP are performed better than AODV and MAODV.

4.3 Hop Count

Here figure 4.3 shown for various protocols when number of nodes increases and hop count also increased.

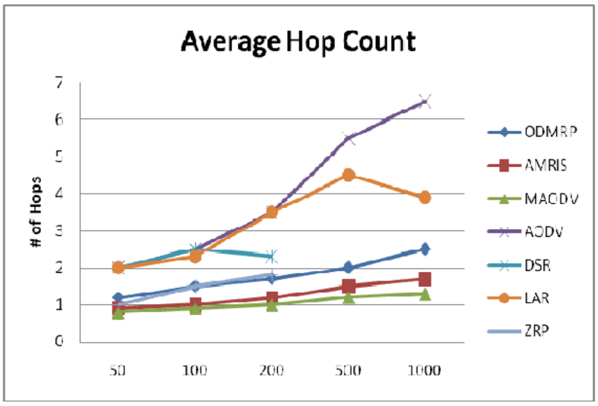

Fig 4.3 Average Hop Count

In a network of 1000 nodes, the delay for LAR is still below 1 second while AODV shows even better results below 0.1 seconds. The higher delay when using location aided routing may be explained as follows: When mobility is high, more packets may travel over non-optimal routes with larger hop counts, which may be stored in a route cache. Therefore, these packets will experience longer end-to-end delay than the ones travelling over the shortest path. Best performance is reached by the Zone Routing Protocol due to the regular updates of the routing table within the zone and due to the routing optimization by the bordercast resolution protocol. DSR performs very badly, with an average delay time of about 121 seconds in a network of 200 nodes. ODMRP has better than AMRIS and MAODV.

4.4 End to End Delay

Figure 4.4 shows end to end delay for various protocols.

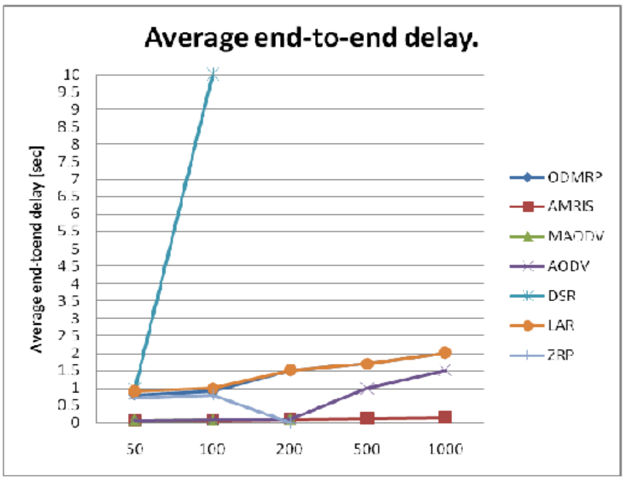

Fig 4.4 Average end to end delay

We compare the DSR graph to the average end-to-end delay; the delay heavily rises whilst the hop count decreases. We assume that these inconsistencies were produced in a particular simulation run, i.e. we expect a statistical error. The source and the destination node may have been in a relatively near position. The Zone Routing Protocol reaches the best average hop count due to the use of the Border cast Resolution Protocol. AMRIS shows better results comparing the other protocols.

5. CONCLUSION

In this paper, a performance comparison of the different mobile ad-hoc routing protocols (ODMRP, AMRIS, MAODV, AODV, DSR, LAR and ZRP) for the issues are packet delivery ratio, routing overhead, hop count, end to end delay. As a result of our studies, it can be said that DSR performs very poor in larger networks. The performance of AODV was very good in all network sizes. LAR is even better than AODV up to 200 nodes in terms of delivery ratio and routing overhead, but the delivery ratio then decreases to 70 percent. AMRIS, MADOV, DSR and ZRP are very low performance compared to other protocols. Hence the type of protocol is determined by the context and requirements in the studies.

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