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A Review of AODV Based Routing Protocols for Mobile Ad-hoc Network

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***Abstract*:** A Mobile ad-hoc network(MANET) is the cooperative engagement of collection of (typically wireless) mobile nodes without the required intervention of any centralized access point or existing infrastructure. To provide optimal communication ability, a routing protocol for such a dynamic self-starting network must be capable of unicast, broadcast, and multicast. This paper discuss about three Variants of AODV protocols Enhanced AODV- EAODV[1],Improved Multicast AODV- IMAODV[2],Mobility aware AODV -MAAODV[3].

EAODV[1]extends the original HELLO message in AODV with lower overhead and at the same time prevent the potential unidirectional links in the network to some extent. The protocol can reduce the route load and has a better performance than AODV in the network with potential unidirectional link. IMAODV[2] proposes an Improved Multicast Ad hoc On Demand Distance Vector (IMAODV) protocol based on Ad hoc On Demand Distance Vector (AODV) and Multicast AODV (MAODV) protocol to support reliability and multicasting for on-line routing of delivery-guaranteed multicasts. MAAODV[3] protocols perform periodic quantification of nodes mobility for the sake of establishing more stable paths between source/destination pairs, hence, avoiding the frequent link breakages associated with using unstable paths that contain high mobile nodes The paper aims at study of these three protocols and compare them on three metrics Routing Load, Reliability and Packet delivery Ratio and End to End Delay.

Keywords: Ad hoc Network, Multicasting, Routing load , Packet delivery ratio, AODV, MAODV.

I. INTRODUCTION

AODV [5] is uniform and destination based reactive routing protocol. It uses table driven routing framework and destination sequence numbers for an on demand protocol .AODV prepares loop free routes. It provides unicast, multicast and broadcast capabilities to all nodes AODV uses destination sequence numbers to ensure that all routes are loop-free and it contains the most recent information. Each node has its own sequence number and broadcast-id. The sequence number is used to indicate the freshness of routing information and to prevent routing loop.

Two issues about AODV are local connectivity and unidirectional link. The methods used by AODV to detect the local connectivity to a neighbor are Link layer feedback and Hello messages .Link layer feedback is a passive method to detect the connectivity. It can quickly identify the link failure during transmission of a data packet to another node. Disadvantage of this method is it needs the support of the underlying MAC protocol. Hello message is an active approach. It requires periodic locally broadcast messages that are utilized to indicate the link availability. This method has a long latency to detect the loss of connectivity to a neighbor also the periodical broadcast of hello messages increases the overhead of the network. While establishing routes AODV assumes that the routes are bidirectional, which is not always true in the real scenarios. A unidirectional link getting included in a route, incur unnecessary loss of data packets and network control overhead. This paper discuss about EAODV [1], an improvement of AODV, which not only reduces the control overhead incurred by Hello message prominently, but also ensures the bidirectional link in routes.

MAODV [4] is multicast extension of AODV. It discovers Multicast routes on demand. The multicast is similar to unicast route request and route reply propagates back from nodes that are members of multicast group. IMAODV (Improved Multicast Ad-hoc On Demand Distance Vector) [2] has multicasting and reliability capability in high mobility rate and large network area.

Mobility is a crucial factor in MANETs and it plays an important role in determining the overall performance of the network because the high mobility of nodes can cause frequent changes in network topology, leading to less reliable routes and frequent link breakages, hence, increasing the reinitiation of the route discovery process, resulting in more control packets overhead due to the extra use of Route Request Packets (RREQ), Route Reply Packets (RREP), and Route Error Packets (RERR) and increasing the average end-to-end delay. To alleviate such problems, nodes mobility should be taken into consideration when designing any routing protocol for MANETs. This paper discuss mobility aware routing protocol MAAODV [3] that periodically quantify nodes mobility based on neighboring knowledge and exploit the calculated mobility value to determine the best reliable route between source and destination during route discovery process.

II. REVIEW OF ALGORITHMS

A. *Enhanced AODV [1]:*

EAODV [1] solves a problem related to local connectivity by modifications mentioned in 1 and 2.

a. Control packets RREQ (Route Request), Route Reply (RREP) and Route Error (RERR) serve the same function as hello messages. Once a link is established, failure to receive a Hello message (or RREQ/RERR/RREP) for ALLOW_HELLO_LOSS * HELLO_INTERVAL time from a neighbor indicates a loss of connectivity to that neighbor. In order to use these control packets as Hello message, a node needs to get the address and sequence number of the previous node that sends out these packets. The address of the previous node is the source IP address in the IP header of the IP packet which contains those EAODV control packets. For the sequence number, author has changed the format of these EAODV packets to contain the sequence number of the previous node. So a field of "Previous Sequence Number" is added to each EAODV route packet.

b. Hello message may require as long as ALLOW_HELLO_LOSS * HELLO_INTERVAL time to detect the loss of connectivity to a neighbor. During this period all packets sent to that neighbor may be lost. Based on this consideration, author is taking a use of the link layer feedback in addition to the Hello message. Link layer feedback is able to identify link failures immediately during transmission of a data packet to another node. A data packet is first queued for transmission at the MAC layer. If the packet can't be transmitted after several MAC layer retries, an indication is given to the higher layers, and then a failure has occurred. This mechanism provides immediate notification of a broken link as soon as a packet fails to be transmitted. This approach has significantly lower latency in detecting link breaks than the use of Hello messages. As a consequence fewer data packets are lost and the route using that link can be repaired more quickly.

c. Neighbor Hello Message : To improve the performance of EAODV in the presence of unidirectional link, author has introduced a new kind of control packet: the Neighbor Hello message (NHello).

<table>
<tr><td>Type</td><td>Reserved</td><td>I</td><td>Neighbour Count</td></tr>
<tr><td colspan="4">Previous Sequence Number</td></tr>
<tr><td colspan="4">Neighbour Ip Address (1)</td></tr>
<tr><td colspan="4">Neighbour IP Address(if needed)</td></tr>
</table>

Figure 1 EAODV NHello message

Type: 0x20
Reserved: Sent as 0; ignored on reception.
I: Ignore the neighbor list, used when node reboot.
Neighbor Count: The number of neighbor IP Address included in the message.
Previous Sequence Number: The destination sequence number of the previous node.
Neighbor IP Address: A list of IP address of neighbor nodes.

The NHello message includes a list that contains all the neighbors of the source node. On receiving a NHello message, a node will check whether its own address is included in the neighbor list. If its address is found, it does nothing. Otherwise a link between it and the source node may be unidirectional. Then a link failure error is incurred, all the route use this link will be invalidated and a RERR packet will be originated. The unidirectional connectivity neighbor node will be added to a "black list". The RREQ packets from nodes in the black list will be ignored to avoid potential unidirectional link. Nodes in the black list will be deleted when it receives a NHello message with the current node included in the neighbor list or the current node doesn't receive any Hello messages from the node in ALLOW_HELLO_LOSS * HELLO_INTERVAL.

B. Improved Multicast AODV -IMAODV[2]:

a. Authors contribution for reducing End to End delay:

If a node wishes to send multicast data packets to its multicast group and this node is close to the existing shared-tree root node, it delivers its data packets along the original shared-tree; but if this node is far away from the existing shared-tree root node, it initiates a new route discovery. Forwarding table will be set up for the nodes that are involved in new route discovery and forwarding path establishment. The new forwarding table will contain Source Node IP Address; Next Hops; Group Leader IP Address; Hop Count to Source Node.

Source node- A node initiating a new send.

Next hops - List of both the upstream and downstream link nodes.

Each next hop contains two fields: next hop IP address and link direction.

Hop Count to Source Node-Number of hops away from source node.

In proposed protocol, to establish new forwarding path within the vicinity of the existing shared tree to reduce the average end-to-end delay the existing shared tree established by the group leader is maintained for use such as grafting a new branch, pruning an existing branch, forwarding data packets that originated from the group leader or nodes close to group leader, and repairing a broken link. When a link along the forwarding path breaks, the node downstream of the break is responsible for repairing the link.

b. Authors contribution for increasing Reliability:

To improve reliability (i.e. mechanism to ensure correct delivery of the data packets at the receiver node) author has used an Acknowledgement- Retransmit mechanism. If the data packet could not be delivered or get delayed, the sender node will not get the acknowledgement from the receiver within a pre specified time quantum and will be retransmitted again. In case of failure in the transmission, the data packet will be retransmitted once again and this approach improves the packet delivery ratio and reliability as compared with MAODV.

C. Mobility Aware AODV –MA-AODV[3]:

MAAODV proposes mobility aware routing protocols I) PH-MA-AODV II) Agg-AODV that periodically quantify nodes mobility based on neighboring knowledge and exploit the calculated mobility value to determine the best reliable route between source and destination during route discovery process.

a. Per Hop Mobility Aware AODV (PH-MA-AODV)

In the traditional AODV, the source node initiates a route discovery process for the sake of finding the intended destination node. The same RREQ packet may pass through several paths (routes) to find its way towards the destination. Upon receiving the RREQ, the destination node replies back choosing the first route it gets, and consequently, other routes with possibly better metrics and Quality of Service (QoS) are dropped.

In PH-MA-AODV, each node computes its own mobility periodically. Then, while initiating the Route Discovery process, each node decides to whether participate in the discovery process and thus relay the RREQ further or not.

Therefore, the overall selected route is stable and more reliable. Figure 2 illustrates the process of Route Discovery in PH-MA-AODV protocol. A node with high mobility values are dropped from root.

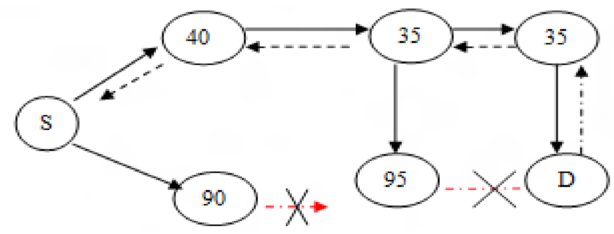

Figure 2 RREQ in PH-MA-AODV

b. Aggregate Mobility Aware AODV (Agg-AODV Protocol):

In Agg-AODV, upon receiving the RREQ packet, if the recipient node is not the intended destination, it adds its own mobility to the RREQ packet and forwards it further towards the destination. The destination node is responsible to store the aggregated value of mobility along the path from itself to the source, and to compare this value with future aggregated values that are obtained from other available paths towards the same source. If there are more than one active path between the source and the destination, the destination chooses the path whose aggregated mobility value is the least among all paths.

Upon receiving the RREQ packet for the first time through a specific path, the destination has no other choice but to select this path (regardless to its aggregated mobility value) to send RREP back to the source as in Figure 3-a. However, the decision to whether continue using this path depends on the aggregated mobility of the subsequent paths as in Figure 3-b and 3-c, where the initially used path is replaced by another stable one with less aggregated mobility value.

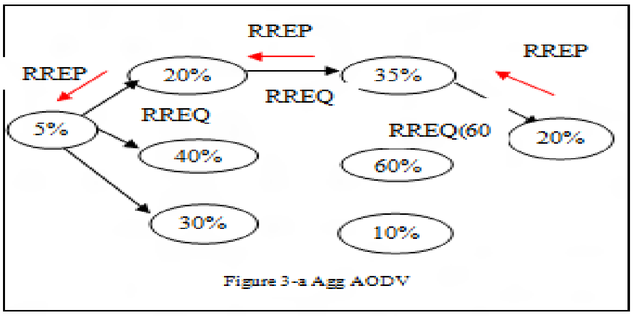

Figure 3-a Agg AODV

Figure 3-a Agg AODV

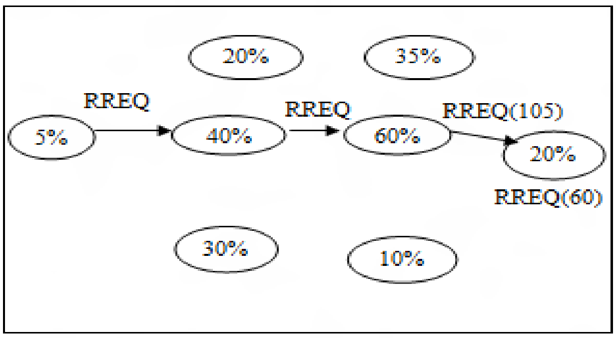

Figure 3-b Agg AODV

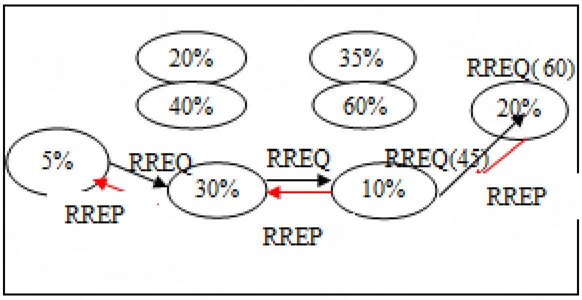

Figure 3-c Agg AODV

III. COMPARATIVE STUDY

Table I shows the comparative study of EAODV[1],IMAODV[2],MA-AODV[3] . Thses three papers are compared on the basis of Routing load, Reliability and Packet delivery ratio, End to end delay

Table: 1 Comparative study of three routing protocols

	EAODV	*IMAODV*	*MA-AODV*
Routing Load	It considers each control packet as hello message which reduces no of hello messages required to detect local connectivity and hence reduces routing load	Doesn't offer significant improvement in routing load.	The number of relayed RREQ packets by Intermediate nodes is reduced because each node selects candidates with low mobility hence reduces routing load.
Reliability and Packet delivery ratio	It uses NHello message to ensure that only bidirectional links are used in route establishment.	If the data packet is not correctly received, source Node retransmits the Same packet. By using this and potential communication link, reliability and packet delivery ratio is significantly improved.	Mobility awareness of protocols reduces the number of broken links by routing through the guaranteed stable links which increases reliability and hence packet delivery ratio
End to End Delay	Limitation :Doesn't offer significant improvement in end to end delay	A source node which is far away from multicast group leader initiates new route discovery and establishes forwarding path which reduces end to end delay.	Reduction in the use of REER packet by allowing a node that detect a broken link to choose alternative path reduces End to End Delay Limitation: Mobility Threshold value is fixed and doesn't change according to network density and nodes mobility.

IV. CONCLUSION

The first research line EAODV [1] is a scheme that can make mobile nodes more aware of the local connectivity to its neighbors. This protocol extends the original HELLO message in AODV but with lower overhead. The EAODV can also prevent the potential unidirectional link in the network. EAODV can reduce the route load and has a better performance in the network with potential unidirectional links.

Multicast protocol deals with number of receivers, due to which the end-to-end delay is expected to be more in comparison to simple unicast.

The second research line IMAODV [2] perform better than MAODV in terms of end-to-end delay as the new route discovery and forwarding path minimize the hop between source and root. The Protocol uses an Acknowledgement-Retransmit mechanism to ensure correct delivery of the data packets at the receiver node to increase reliability and packet delivery ratio.

The third research line MA-AODV [3] proposes mobility aware approaches that achieve significant improvements which touch in particular the three principal metrics: the Average Packets Overhead, the Average Delivery Ratio and the Average Link Reliability. The approaches consider the degree of node's mobility in order to assist in making a proper routing decision. The decision is either made by the destination to send a reply back through the stable route, as the case of Agg-AODV, or by the intermediate nodes through the route discovery process, as in PH-MA-AODV. Taking the mobility metric into consideration introduces clear enhancements that are evident in terms of decreased control packets overhead and the increased delivery ratio.

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