Performance Comparison on Path Establishment and Recovery algorithms in Wireless Ad-hoc Networks

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***Abstract*—Mobile Ad-hoc Networks (MANET) consists of wireless devices which are uses for the initiating and establish communication link between the sender and receiver nodes. Due to the unpredictable mobility of wireless nodes in MANET, node links can be break at any time. Paper has done the survey on different existing routing protocols which initiates the route between the sender and receiver. Different routing protocols have different way of route initialization process with single or multiple paths at the beginning which can be used for the link recovery when path gets breaks. We have also studied the path recovery mechanism when link gets breaks between any two nodes. Paper also contributes the study and the comparison between the various protocols involved.**

Keywords—MANET, Protocols, Routing, Link break prediction.

I. INTRODUCTION

Mobile host consists of routing which is also called as mobile IP technology. When mobile node changes its position from its own network to the foreign network, mobile node informs to own network agent, on the home network to which foreign agent it wants to communicate. With this mobile agent registers itself with new foreign agent on the foreign network. Then home agent forwards all the packets intended for mobile node which is in the foreign network. When mobile agent comes back to its home network, it restores the settings in the foreign as well as home network. But this is not the case with the Ad-hoc network. It does not have concept of home network. Address management as well as protocol interoperability is required to supports the mobile IP host.

Depending on the medium of communication, networks are classified into two categories such as wired and wireless network. Wired network consists of wire as a medium to communicate. In wired network, cable or wire is used to establish link between any two nodes in the network. In contrast, wireless networking uses the air as a medium of communication between any two nodes and a hardware device to support the wireless communication. Nodes are moving independently within the network. This type of network is used to establish the private network. Wireless networks are also known as ad-hoc network.

Ad-hoc networks differ in infrastructure like routers, switches, mobile nodes, routing protocols and supporting hardware. Wireless routing protocols face the challenges such as frequency, change in topologies, low power and asymmetric links. Number of protocols has defined to work in wireless network.

Protocols are classified into two categories:

1) Table Driven
2) Source Initiated On demand protocols

As the name suggests the table-driven protocols maintain the routing information in tabular form such as Next hop, IP address, Destination node etc. Routers in the network exchange the routing table with neighbor node in-case of addition of any node in the network or deletion of node from the network. With this information, nodes in the network nodes are able to send the data to the destination. Any change in the network reflects the change in the routers memory.

In source initiated routing scheme, paths are created as and when it requires. If any node wants o send the information to the any other node in the network, it initiates the process of path establishment. This process ends when the destination node found. This type of network called as Mobile Ad-hoc Network (MANET)[1].

In MANET routing in the network is very popular because it does not require any backbone infrastructure. Communication between the devices happens with the help of wireless protocol. This gives the advantages over the fixed network. MANET as wireless network consists of number of movable nodes. As the node moves from one place to another place topology keeps on changing frequently. In on-demand routing protocols only the nodes actually participating in the process of data transfer from source to destination store the information even-if many nodes get selected during path initialization process. Examples of these protocols are AODV [2], DSR [3] and TORA [4]. On other hand, Table driven protocols consists of routing tables inside nodes. An example of table-driven category is DARPA [5], DSDV [6] and WRP [7].

II. WIRELESS AD-HOC ROUTING ALGORITHMS

On-demand distance Vector(AODV) routing protocol is mostly used because of its advantages over other routing protocols. AODV establishes connection between wireless nodes quickly, efficiently and with minimum latency and reduced overhead through path accumulation technique.

AODV is extended version of DSDV i. e. Destination Sequenced Distance Vector protocol. It minimizes the number of broadcasts in the network while establishing the connection between source and destination node. It is pure on-demand routing protocol as it considers only those nodes in the path that are actually sending the data from source to destination. And only these nodes exchange the routing table with neighbor nodes before sending the data.

When source node wants to communicate with destination node, it starts the initialization process and it broadcasts the packets in the network with information of destination node. When these packets are received by the neighbor node if neighbor node has the destination node information it send the route reply packet back to the source else neighbor node again re-broadcasts the packet to find the destination node. This packet gets rebroadcasted till the destination node is reached.

Figure 1(a) shows the different paths to the destination node. Source node sends the Route Request Packet (RREQ) to initiate the path between sender and receiver. AODV uses the destination sequence number to maintain the path information during the every broad-casted RREQ packet. Broadcast ID is incremented by one in every broadcast. The source node consists of most recent RREQ for its destination. The intermediate node replies to the RREQ packet if it has the destination node as neighbor node.

During the process of forwarding the RREQ packet, node stores the routing information in its routing table. It helps to establish the reverse path from destination to source node. During this process if node finds the duplicate packet if discards the packet.

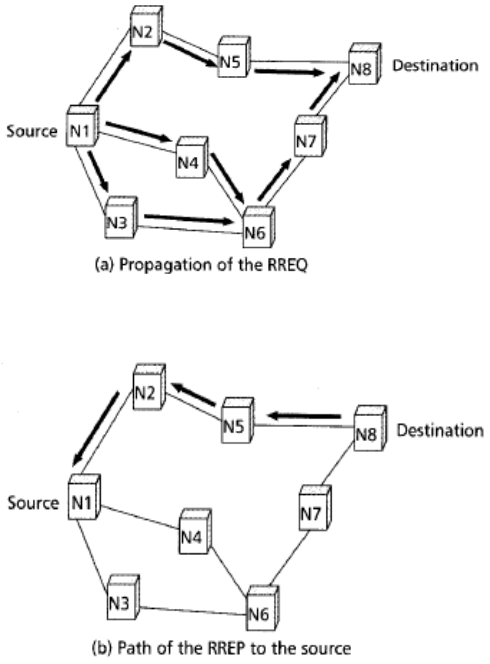

Figure 1. Path in the AODV

When RREQ packet reaches to the destination, node responds to the previous node by sending Route Reply packet (RREP). Figure 1(b) shows the RREP packet path from destination to the source node by tracking the broadcast ID which was saved during the path initialization process. Hence, destination node unicast the RREP packet with path information to the source node. Destination node chooses the path having minimal number of hops till source node.

In addition to this it maintains the network by sending "hello" packets at regular interval so as to check whether neighbor node is alive in the network or not. There are some other algorithms who work on path initialization. In MANET, node position changes frequently in the network so path maintenance and path recovery algorithms are also required.

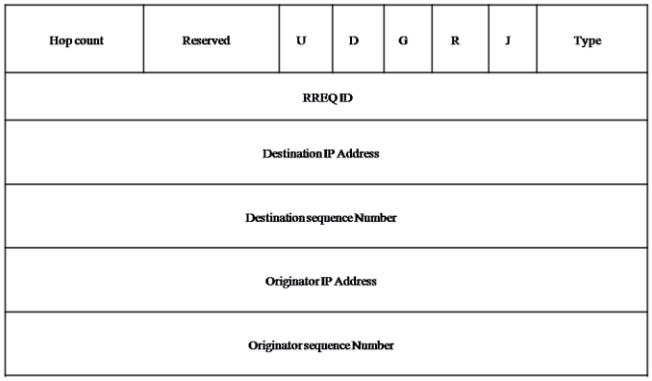

Figure 2. RREQ packet format

Figure 2 shows the block diagram of RREQ packet format in ad-hoc network. It consists of Hop count, Flag registers, Type of packet, RREQ ID, Destination IP address, Destination sequence number, Originator IP address and Originator sequence number. These fields are use during path initialization process.

III. PATH INITIALIZATION ALGORITHMS

Ilyas, M.[1], [2], [6], AODV is wireless protocol which is used for maintaining ad-hoc network. It initiates route between source and destination node. In initialization process source sends the RREQ packet to find destination node. RREP packet replies to route request if destination node exists from that node else it again rebroadcasts new packet. Once RREQ packet reaches to the destination, node sends RREP packet to the source node by uni-casting.

D. B. Johnson and D. A. Maltz [3], proposes Dynamic Source Routing (DSR) protocol. It is based on source routing. It maintains all the information on the mobile nodes only. DSR computes the route and also maintains the routing tables at every node. In this, sender identifies the entire sequence of path from source to destination. Packet header in the DSR consists of the route information in the header itself. So whenever packet travels from source to destination, node reads the next node from header list to which packet needs to forward and sends accordingly.

C. Perkins and P. Bhagwat [4], proposes Destination Sequence Distance Vector (DSDV) routing protocol. It is a table-driven routing protocol in ad-hoc network. It consists of routing table in each router which maintains the routing information. Every entry in the table consists of sequence number for each route. Sequence number is even if the node is active else it is odd. This number is generated by the destination node. Emitter node needs to send out the next update with the help of this number.

Po-Jen Chuang and Po-Hsun Yen [7], proposes an algorithm which overcomes the problem of flooding by the node during the path initialization process. It uses the two hop neighbor node concept. This limits the flooding during path initialization. Node sends the following messages to build 2-hop neighbor table.

1. **All Neighbors :** including all current 1- hop neighbors (based on it, a node will build its 2-hop neighbor table)

2. Neighbors **Deleted:** giving the disconnected neighbors detected by the sender

3. **Neighbors Unchanged:** indicating the current neighbor table for the sender remains unchanged (so the neighbor count is set as 0 and the neighbor IP address is null).

By using this type of messages, the routing table has built and is used for initiating the path between the different nodes. It is used for initialization process for finding out destination path.
In some cases even-if two next hop stored in the table real path may not be available because nodes are operational independent in the network. This results into wastage of memory. So rebuilding of the routing table frequently requires. As the number of nodes increases in the network routing because of 2 hop information storing in routing table overheads also increases. This technique is useful where nodes are not moving too much but if node movement is very high then 2-hop neighbor node concept may not useful. It requires more memory as compare to other algorithms.

Latif Ullah Khan, et.al. [8] proposed modification of AODVv2 algorithm to the routing metric and the route discovery mechanism. This method also called as Modified-AODV (M-AODV). The ad hoc On-demand Distance Vector (AODV) routing scheme is a widely used routing expertise in ad-hoc networks due to its low-laying routing traffic overhead. However, the performance of the less number of hops routing used by AODV reduces significantly when the underlying system has routes that have high throughput and hop count. The throughput of the bottleneck link (link with lowest throughput between all links in a particular path) is considered as a throughput of the particular route. The decision is made on maximizing the throughput. Route selection will be based on hop count if multiple routes has same throughput. Then the path with low hop count is considered.

IV. PATH RECOVERY ALGORITHM

Jin-Sun Kim and Jong-Won Choe, proposed [10] the concept of core-node in ad-hoc network. Algorithm finds more than one i.e. two paths between the source and destination while initialization phase. Each packet will contain these two paths namely as primary and secondary. The link between any two nodes of a path may break because of change of position of a mobile node or any other reason like low energy, upstream node validates that the link is broken and sends route error message to the core node which is situated in the upstream path. Then, this core node finds the alternative path to the destination without informing the path breakage to the source node as it has information of alternate path. Author also mentions that, AODV protocol finds the single path between the source and destination which has the shortest path. DSR and DSDV also do the same thing while initiating the path. Ad-hoc On-demand Multi-path Distance Vector (AOMDV) is the protocol which finds more than two paths between the same source and destination. Source node keeps both path information with it. Firstly it uses the primary path. If primary path fails due to link failure in between intermediate node it sends the Route Error (RERR) message to the source node, then it sends next packets by secondary path.

When any node in the ad-hoc network wants to send the data to the destination, it find the paths which gives the shortest distance in terms of the number of intermediate nodes between them. Energy requires is more in the ad-hoc wireless network as they are moving in space independently and continuously they are senescing messages and transferring data without any external battery backup. Intermediate node of a path replies to RREQ packet only if they have valid route to the destination.

Muhammad Khalil Afzal and Hyun-Ho Shin [11], proposes a concept which states that each node stores the IP address and Medium Access Control (MAC) id of the neighbor node while initializing the path between sender and receiver. Proposed Enhanced Local Repair AODV (ELRAODV) algorithm repairs when the link between any two nodes breaks.

Link break prediction is based on physical distance between respective node has been proposed by Madhumita Chatterjee [12]. This algorithm calculates the threshold value (i.e. time taken for the message to travel between any two nodes) between all the neighboring nodes. Each router maintains the routing table for each path independently. Each router is maintaining the path information for each path separately. So as the number of path increases it also increases the overhead of a router. If the threshold value is the physical distance between any two nodes, then it will work only for the straight and visible distances.
Junwei Jin and Sanghyun Ahn's [13] have proposed algorithm, while initiating the path between the sender and the receiver source finds an alternate path too. It also finds the two paths from each intermediate node up to the destination. Use of these alternate paths comes into operation by each intermediate node when link break happens. While transmitting the data from sender to receiver, source node is taking the decision about sending the data by alternative path using node disjoint concept. In node disjoint path, nodes are not common except sender and receiver node. Alternate paths that are already found by all intermediate nodes may be unusable because maximum paths from intermediate nodes to the destination get broken due to the independent movement of nodes in the network. So it increases the time to rebuild the alternate path again.

Kokula Krishna Hari. K [14], proposes a method in which if a link gets broken between the intermediate nodes, intermediate node takes a decision to find the alternate path to the destination. Till that time the intermediate node buffers the packet in its memory. But in this case as the node having the limited buffer size it may get overflow and packet can be drop.

The packets which are traveling to other destinations through the same node will also get dropped due to this type of algorithmic concept and this will increase congestion in the network.

V. EXISTING APPORACH LIMITATIONS

A review of existing literature divulge that most of the authors focused on the development of algorithms for route initialization, route maintenance and route recovery area. Some limitations of these algorithms are in order.

As an intermediate node stores information of the next 2-hops in memory routing overhead increases drastically as the movement of mobile node increases. It also has additional route maintenance messages for tracking the next 2-hop information in path. Time required for processing each packet for router should be considered while initializing the path between sender and receiver. When data flow maximizes in the node due to multiple path goes through from same node, some amount of buffer size needs to maintain to avoid packet drop.

Authors also proposed the core node concept where core node needs to store the alternate path information so that this can be used during link failure. If link break happens very frequently in the network then algorithm spends time to repair and maintain path instead of sending data to the destination. This leads to increased delay and reduced the throughput.

Some algorithm stores the IP address and the MAC address for maintaining the routing path. These use the router memory for searching IP and MAC address of a node. Number of entries increases in routing table if the number of nodes increases in the network. Due to this, routing overhead (searching time in the router's table) also get increase and it wastes router memory too which is limited.

Some algorithm is proposed where physical distance between two neighboring node is calculated. Herein, this distance is contemplated as a threshold value. The algorithm predicts that the link may break if the distance between the nodes is constantly getting increase. If the threshold value is the physical distance between any two nodes then it will work only for the sprightliness distances otherwise algorithm is of no use.

Comparative study on different routing protocols used in ad-hoc wireless protocol has shown in Table.1.

In this some protocol uses multiple paths during initialization of path between the sender and receiver node. Some protocol finds the alternative path to receiver when link break happens. But due to the incalculable movement of the node in the ad-hoc network no other node can predict the exact place of other node. So different mechanism like link break prediction algorithm or the path selection by the source node must be healthier in terms of processing speed, amount of data to be send to the destination energy, etc. can be consider while initialization of path. Link breakage also can be predicted on the basis of time require to get the acknowledgement from the receiver in different situation.

VI. COMPARETIVE ANALYSIS

Comparison between various algorithms in wireless ad-hoc network is shown in the figure below.

Figure shows the comparison between AODV, DSR, AOMDV and MAODV with core node. We compared these protocols by two ways, one during the path establishment i.e. time require initializing the path between the sender and receiver. Second, comparative study shows that how much time require to each protocol to reset the path and sends the remaining data over path in-order to reach the data to the destination node.

TABLE 1 COMPARISON BETWEEN DIFFERENT ROUTING ALGORITHMS

Algorithm	Routing Overhead	Multi - Route	Delay	Recovery Time	Remark	Disadvantage
AODV	Medium	NO	Low	More	Repair by Source	Time to repair path is More
DSR	Low	NO	Medium	More	Repair by Source	Time to repair path is More
DSDV	Medium	NO	More	More	Repair by Source	Time to repair path is More
TORA	Medium	NO	More	More	Repair by Source	Time to repair path is More
Multipoint Relaying	More	NO	More	More	Repair by Source	Need 2-hop to store
Modified AODV	Low	NO	Low	More	Repair by Source	Time to repair path is More
AOMDV	Medium	YES	Medium	Medium	Repair by Source	Time to repair path is More
AOMDV with Core Node	Low	YES	Low	Low	Repair by Intermediate Node(Core)	Multiple core node require if link fails
EAODV	More	NO	More	Low	Repair by Intermediate Node(MAC)	Extra field is requiring in router.
Node Disjoint Multi-path	Medium	YES	More	Low	Repair by Intermediate Node not require	Stored link may not use as nodes are moving

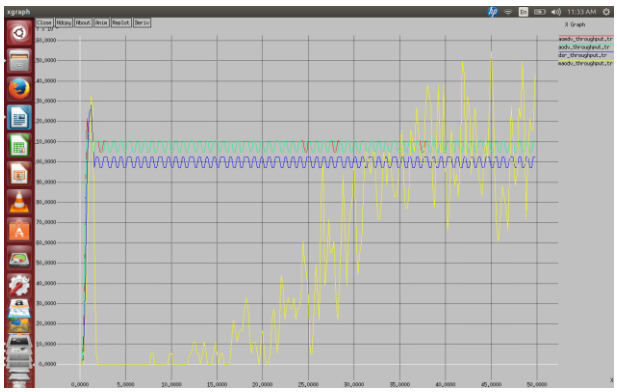

Figure. 3 Throughput without link break

Above Figure-3 shows that the different routing algorithm in wireless ad-hoc network. With respect to throughput. It finds that the AODV, AOMDV and DSR algorithm does bettter if no link breakage happen during data transfer. Wheras the MAODV gives the better throughput after some time than other algorithms.

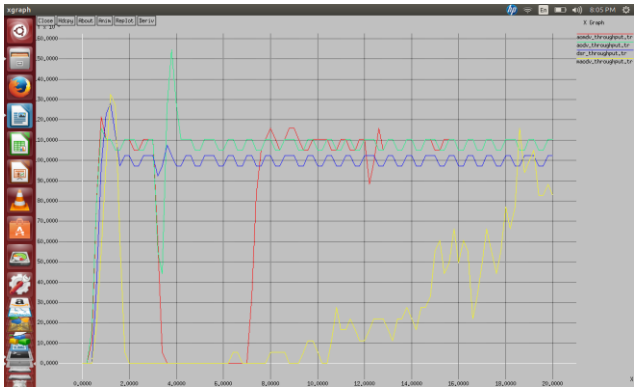

Figure. 4 Throughput with link break

Above figure-4 shows the throughput between different algorithm when link gets break between any two node then, it shows the time difference when link gets break. We can analyze that AODV and DSR algorithms are taking lesser time.

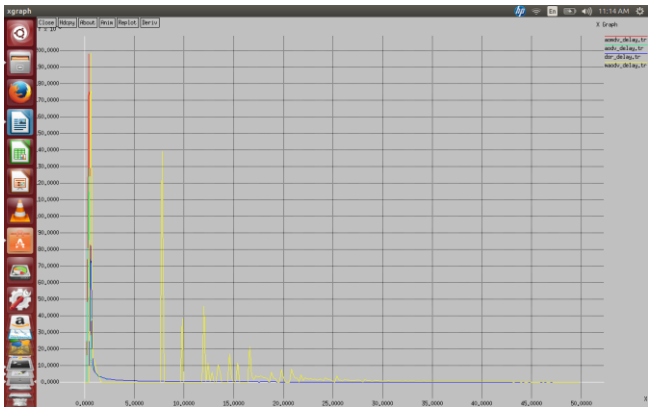

Figure. 5 Delay without link break

Above figure-5 shows the analysis between different routing algorithm in wireless ad-hoc network with respect to delay. It finds that the AODV and AOMDV algorithm does better if no link breakage happen during data transfer. Whereas the MAODV gives the equivalent delay as that of above algorithms.

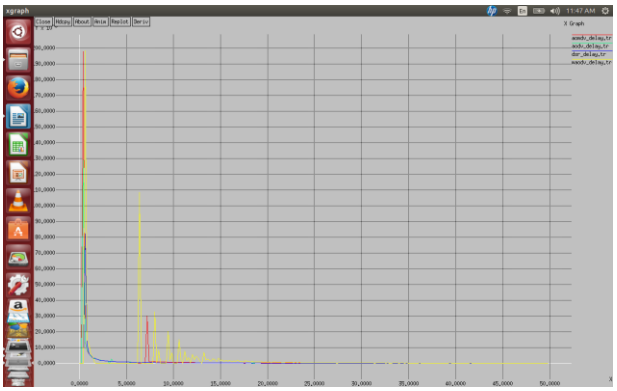

Figure. 6 Delay with link break

Above figure-6 shows the delay between different algorithm when link gets break between any two node then, it shows the time difference when link gets break. We can analyze that AODV, DSR, AOMDV and MAODV ascending respectively in terms of delay.

VII. CONCLUSION

Due to the incalculable maneuvers of each node in the ad-hoc wireless network, not any other node can predict the exact maneuver of every other node. Paper survey shows the different routing algorithm i.e. AODV, AOMDV, DSR, MAODV with core code. in terms of throughput and delay. These study will require to develop new routing algorithms by using some advantageous features in dynamic routing algorithm. This can be useful for solving the nearest upcoming IoT problems too.

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