An Analysis of Multi-Hop Wireless Network Routing Protocols for Mobile Nodes

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***Abstract* — In Wireless Configuration, multiple nodes are distributed through out the Network and the nodes have mobile characteristics. The network topology changes time to time because the nodes do not have any static set up. That is wireless mobile networks are infrastructure less distributed system. Depending upon the requirement, the mobile nodes are dynamically organized itself to make a temporary routing between a sender and receiver for an effective communication. An important task of the wireless routing protocol is to face the dynamically changing topology in an ad hoc mobile network environment with minimum routing overhead in order to establish a path between two nodes. There are many protocols to meet the above goals, to provide an effective communication between the source and the destination. But in between the source and destination nodes there may be many mobile nodes exist. There are various categories of routing protocols are in use. In this paper, the various routing protocols in Proactive, Reactive and Hybrid categories are surveyed and analyzed. The analysis is done in contrast to parameters such as packet delivery fraction, average end to end delay and number of packets dropped.**

***Keywords*- Proactive; Reactive; Hybrid; Ad Hoc network; Wireless routing; Packet Delivery Fraction; Average End to End Delay; Number of packets dropped.**

I. INTRODUCTION

Now a day's communication is an essential part in human life. We can say without communication nothing can be done, this situation is reached due to the rapid development in the field of computer and wireless mobile networks. Routing is a major issue in wireless mobile network due to their highly dynamic and distributed structure. Recently the mobile networks are growing tremendously to tackle the huge population. So the scalability of the network is reaching its peak position. Hence the technical people are much concentrating and researching on wireless mobile network to meet the present situation. There is much scope in this field to do research about the routing techniques and how to improve the performance when the network is enormously growing and it becomes very huge. The study of various protocols have to be done for the mobile ad hoc networks to satisfy various properties like distributed implementation, efficient utilization of bandwidth and minimum power utility, metrics optimization, fast route convergence and freedom from loops. Wireless mobile networks are applicable in several fields some of them are listed below:[4]

- Automated battlefield
- Special operations
- Homeland defense
- Soldiers, tanks, plants
- Disaster Recovery (flood, fire, earthquakes etc)
- Law enforcement (crowd control)
- Search and rescue in remote areas
- Environment monitoring (sensors)
- Space/planet exploration
- Boats, small aircraft

- Sports stadiums
- Taxi cab network
- Sport events, festivals, conventions
- Patient monitoring
- Ad hoc collaborative computing (Bluetooth)
- Sensors on cars (car navigation safety)
- Vehicle to vehicle communications
- Video games at amusement parks, etc

II. PROPERTIES OF WIRELESS AD HOC NETWORK

- Dynamic Topology: The structure of the network is varying due to the mobility of the nodes which produces a dynamic topology rather than a static topology. This is a challenging issue in mobile networks.
- Power constrains: Almost all the mobile nodes are basically a battery operated nature because the nodes may be Practically a Laptop or a thin client or a PDA. It may exist in the routing if the battery power is sufficient which leads to Power constrain and it needs some modes like stand by mode or sleep mode to save the power. Therefore it is important that the routing protocol has to support also for these sleep-modes. That is a routing protocol should be able handle such situations without overly unfavorable consequences.
- Bandwidth: Nodes are moving from one place to other place, so we could not provide physical links but it uses wireless radio links. The radio links used have lower capacity than physical links.
- Security issues: When we are using wireless radio network rather than a physical network then it highly needed to face threats to information security. Because of this wireless network protocols are very much exposed to attackers. Most of the wireless protocol does not address the security issues.
- Unpredictability: Compare with fixed network the wireless ad hoc network the problems are unpredictable nature. Packet collision is more and randomly occurring. Some of the other problems faced are signal fading, signal interference; multi-path cancellation, propagation delay etc are also unpredictable.
- Route Existence: In mobile network finding the shortest route with available active nodes at that time for communication can be used once again when the source and destination are same provided no nodes in the path are dropped. But we can not expect that all the mobile nodes are present in the same point between any time intervals, since mobile nodes have the property of moving from one point to another point. That is if the routing algorithm find out a shortest route then the existence of the same route is a cumbersome issue in wireless mobile ad hoc network.
- Node Failure: If a node in a path is failed due to some reason then the packet should be delivered to the destination through another node which provides an alternate path of communication. Hence a multiple path finding is essential for uninterrupted transfer of packets.
- Wireless Environment: Wireless network is a distributed environment. Hence the protocol should support distributed operation than a centralized operation.
- Multicasting: The concept of sending the same packets to more than one node (i.e. multiple destinations) at the same time is called Multicasting. This concept is similar to broadcasting but the difference is broadcasting means all the nodes and multicasting means multiple nodes, not all the nodes of the network. The advantage of multicasting is that it takes short time to transfer the data to multiple destinations.
- Loop less: Packet will not be allowed to travel twice in between the same nodes while it is transferring in a route. Hence it provides a loop less transfer to a node when the route is found out. This phenomenon of loop – less will improve the routing performance of a routing algorithm.
- Unidirectional and Bidirectional Links: Unidirectional links are used in broadcasting and Multicasting but using only this links will not improve the routing performance. Thus Routing protocol uses both Unidirectional and bidirectional links in order to improve routing Performance.
- Transmission Range: The wireless network Transmission range is limited to short area only. This is one of the drawbacks of wireless ad hoc network.

- Packet Losses: Due some error in transmission, there may be a chance of packet loss in wireless communication. Packet losses may occur because of the mobility of the nodes. Mobility also induces route change in the network which is tolerable but packet loss is not tolerable for effective communication in wireless networks.

III. ROUTING PROTOCOLS

A. A. Types of Routing Protocols

The Major classification of Routing Protocols are given below:

- Proactive Routing Protocol (PRP)
- Reactive Routing Protocol (RRP)
- Hybrid Routing Protocol (HRP)

Under these major classifications, there are sub classifications of Protocols as shown in figure 1.

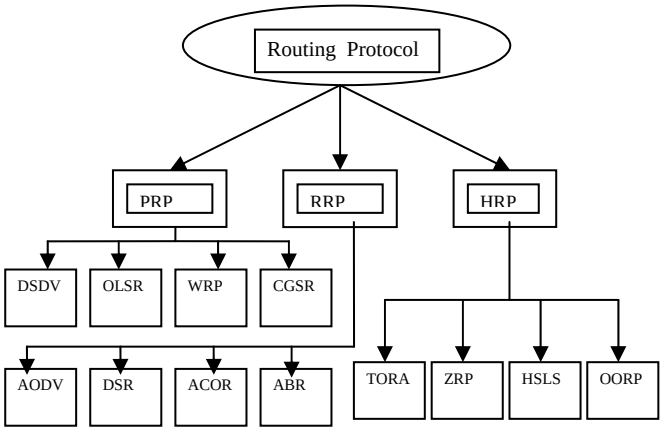

Figure 1 Different Routing Protocols

B. Proactive Routing Protocol (PRP) Proactive Routing protocol is also called as Table Driven Routing Protocol (TDRP). Every node has the complete routing details in the form of table. All the routing will be known to the node before the actual packet is propagated. The maintenance of up to date routing node information in each node is a critical issue in PRP. Packets are transferred over the predefined route specified in the routing table. In this scheme, the packet forwarding is done faster but the routing overhead is greater because all the routes have to be defined before transferring the packets. Proactive protocols have lower latency because all the routes are maintained at all the times. In PRP the route discovery overhead is larger since all the possible routes are to be identified and kept ready as a table form before the actual sending of packets. This becomes more complicated to keep track of all the node information in every node when the network is growing more and more. This is the major drawback of this scheme. Example of PRP: DSDV (Destination Sequenced Distance Vector), OLSR (Optimized Link State Routing) [2].

1) Destination Sequenced Distance Vector (DSDV): DSDV is a routing protocol which maintains a routing table in each node. It is a hop by hop distance vector Protocol. Here each node routing table has the next-hop for and number of hops to, all reachable destinations. Routing tables are periodically updated through broadcasting the changes time to time. Routing table should maintain consistency in all nodes because the network has dynamic topology. To maintain so each station periodically transmits the updates to other nodes immediately any changes took place in the path. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently [10]. Routing information is advertised by broadcasting or multicasting the packets which are transmitted periodically and incrementally as topological changes are detected – for instance, when stations move within the network [4]. A sequence number is generated to show the freshness of the route which provides this algorithm free from loops.

2) Optimized Link State Routing (OLSR): An optimization version of a pure link state protocol in which the topological changes cause the flooding of the topological information to all available hosts in the network. This protocol is called as Optimized Link State Routing Protocol (OLSR) and coming under the category of Table Driven (Proactive) Protocol. The exchange of the topology information with the other node is done regularly. Furthermore, as OLSR continuously maintains routes to all destinations in the network, the protocol is beneficial for traffic patterns where a large subset of nodes are communicating with another large subset of nodes, and where the [source, destination] pairs are changing over time. OLSR is very much suited for dense networks and where the network does not allow long transmission delay for the packets.

C. Reactive Routing Protocol (RRP) Unlike Proactive Routing Protocol, Reactive Routing Protocol does not maintain any table of information in each node. Reactive Routing Protocol will find for the path when the source demanded the destination. The main advantage in this category is elimination of overhead for the route detection in advance only to prepare the table, when it is not actually required. So here the routs are not predefined already as in the case of PRP. If a source node demands for route detection then the shortest route will be calculated. Thus the route finding is based on demand only, hence it is also called as On – Demand Routing Protocol (ODRP). Rout finding is done by spreading a request packet in the network like broadcasting until it gets the feedback from the respective destination node. For this flooding Algorithm is used. Examples of RRP: DSR (Dynamic Source Routing) Protocol and AODV (Ad hoc On demand Distance Vector) Protocol.

1) Ad-Hoc On Demand Vector Protocol (AODV): This is a Reactive (On-Demand) Routing protocol suited mostly for Ad-Hoc mobile Networks. AODV takes also some properties from DSDV, but it does not maintain any route table. It keeps the route information of the active paths. 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[2]. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers maintained at each destination to determine freshness of routing. AODV handles route discovery process with Route Request(RREQ) messages. RREQ message is broadcasted to neighbor nodes. The message floods through the network until the desired destination or a node knowing fresh route is reached. Sequence numbers are used to guarantee loop freedom. RREQ message cause bypassed node to allocate route table entries for reverse route. The destination node sends a Route Reply (RREP) back to the source node. Node transmitting a RREP message creates routing table entries for forward route [3]. For route maintenance nodes periodically send HELLO messages to neighbor nodes. If a node fails to receive three consecutive HELLO messages from a neighbor, it concludes that link to that specific node is down. A node that detects a broken link sends a Route Error (RERR) message to any upstream node. When a node receives a RERR message it will indicate a new source discovery process [1, 3].

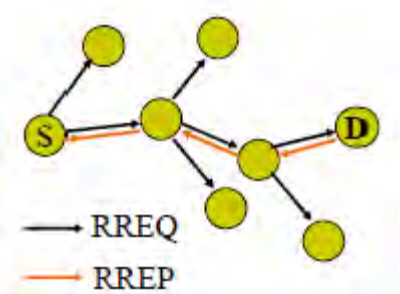

Figure 2 AODV routing protocol with RREQ. And RERR message

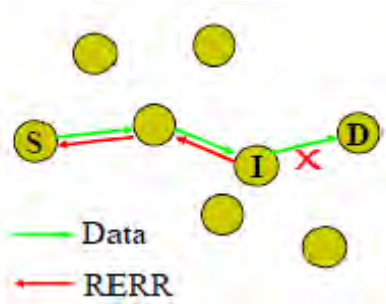

Figure 3 AODV routing protocol with RREP message.

2) Associativity Based Routing Protocol (ABR): Associativity Based Routing Protocol (ABR) will not supports time to time updates of routing information. Based on temporal stability of the links the routes are selected between the nodes. It is beacon based protocol, hence each node sends hello message as beacon message periodically to neighbor nodes. This message indicates the other nodes that the node is active in the network. The main aim of this ABS is to identify the longer lived routes and it has three phases as Route Discovery, Route Reconstruction if it is broken and route Delete.

3) Dynamic Source Routing Protocol (DSR): The Dynamic Source Routing (DSR) is a reactive unicast routing protocol that utilizes source routing algorithm [8]. In DSR, each node uses cache technology to maintain route information of all the nodes. There are two major phases in DSR such as:[1]

- Route discovery
- Route maintenance

When a source node wants to send a packet, it first consults its route cache [6]. If the required route is available, the source node sends the packet along the path. Otherwise, the source node initiates a route discovery process by broadcasting route request packets. 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. 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. Whenever the data link layer detects a link disconnection, a OUTE_ERROR packet is sent backward to the source in order to maintain the route information 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. The advantage of this protocol is reduction of route discovery control overheads with the use of route cache and the disadvantage is the increasing size of packet header with route length due to source routing.

D. Hybrid Routing Protocol (HRP) The advantages of Reactive and Proactive protocols are combined and a new protocol is created. This routing scenario is known as Hybrid Routing Protocol (HRP). Thus in this the performance is improved by finding the rout faster. Zone Routing Protocol (ZRP) and Temporally- Ordered Routing Algorithm (TORA) are coming under this category.

1) *Temporally-Ordered Routing Algorithm (TORA):* TORA is a Hybrid Protocol which has the good characteristics of Proactive and Reactive protocols. TORA also maintains a DAG by means of an ordered quintuple with the following information

    - t time of a link failure
    - oid originator id
    - r reflection bit indicates 0=original level 1=reflected level
    - d integer to order nodes relative to reference level
    - i the nodes id

The triplet (t,oid,r) is called the reference level. And the tuple (d,i) is said to be an offset within that reference level. The heights of the nodes for a given destination to each other determine the direction of the edges of the directed acyclic graph. The DAG is destination oriented (routed at the destination) when the quintuples which represent the heights are maintained in lexicographical order, the destination having the smallest height, traffic always flowing down streams. Heights are however not needed for route discovery, instead a mechanism as in LMR is used. Also nodes which do not currently need to maintain a route for themselves or for others won't change a height value. Each node has a Route required flag for that purpose , additionally the time since the last UPD (update) packet was sent is recorded. Each node maintains a neighbor table containing the height of the neighbor nodes. Initially the height of all the nodes is NULL. (This is not zero "0" but NULL "-") so their quintuple is (-,-,-,-,i). The height of a destination neighbor is (0,0,0,0,dest). g. Zone Routing Protocol (ZRP): The Zone Routing Protocol (ZRP) is either a proactive or reactive protocol. It is a hybrid routing protocol. It combines the advantages from proactive (for example AODV) and reactive routing (OLSR). It takes the advantage of pro-active discovery within a node's local neighborhood (Inter zone Routing Protocol (IARP)), and using a reactive protocol for communication between these neighborhoods (Inter zone Routing Protocol (IERP)). The Broadcast Resolution Protocol (BRP) is responsible for the forwarding of a route request. ZRP divides its network in different zones. That's the nodes local neighborhood. Each node may be within multiple overlapping zones, and each zone may be of a different size. The size of a zone is not determined by geographical measurement. It is given by a radius of length, where the number of hops is the perimeter of the zone. Each node has its own zone [1].

IV. ANALYSIS OF ROUTING PROTOCOLS

Some of the parameters like Packet delivery fraction, Average End to End Delay, Packets dropped are considered in this paper and analyzed to understand the performance of these routing algorithms.

A. Packet Delivery Fraction (PDR) Result It is the ratio between the numbers of packets originated by the sources and the number of packets received by the at the final destination. PDF will depict the loss rate that will be seen by the transport protocols, which in turn affects the maximum throughput that the network can support. The performance of AODV is consistently uniform According to packet delivery ratio, DSR performs well when the number of nodes is less and the loads of the network also less. However its performance declines with increased number of nodes due to more traffic in the network. The performance of DSDV is better with more numbers of nodes than in comparison with the other two protocols.

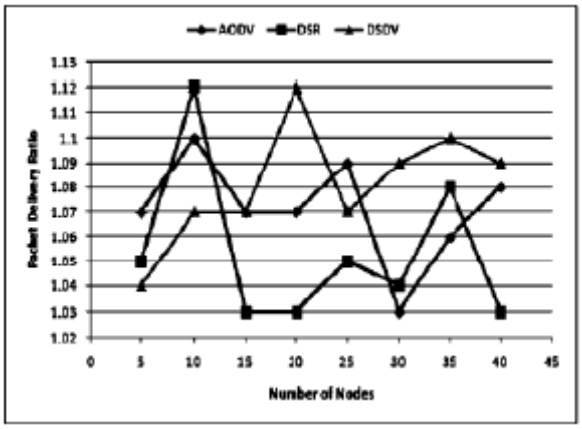

Figure 4 Graphical Representation of PDR- AODV, DSR, DSDV

B. Average End to End Delay Result ***The delay is affected by high rate of CBR packets as well. The buffers become full much quicker, so the packets have to stay in the buffers a much longer period of time before they are sent. This can be seen at the DSR routing protocol when it was reach around 2400 packets at the 0 mobility. For average end-to-end delay, the performance of DSR and AODV are almost uniform. However, the performance of DSDV is degrading due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes***

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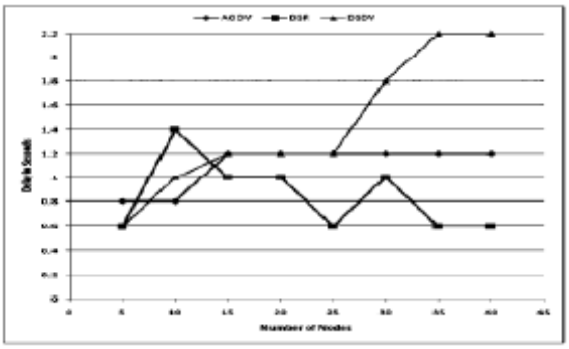

Figure 5 Graphical Representation of Average end to end delay

C. Number of Packets Dropped The number of data packets that are not successfully sent to the destination. In terms of dropped packets, DSDV's performance is the worst. The performance degrades with the increase in the number of nodes. AODV and DSR performs consistently well with increase in the number of nodes.

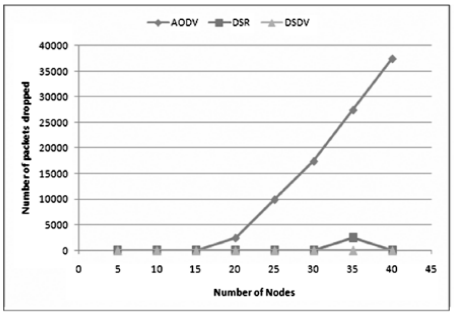

Figure 6 Number of nodes Vs Number of Packets Dropped

V. CONCLUSION

In this article we have analyzed three routing protocols and also provided a classification of these Schemes according to the Routing Methods (Reactive and Proactive) with respect to Packet Delivery Fraction, Average End to End Delay and Number of Packets Dropped. The significant observation result is that AODV (reactive routing protocol) performance is the best, considering its ability to maintain connection by periodic exchange if information, which is required for TCP, based on traffic consideration. Delivered virtually all packets at low node mobility, and failing to coverage as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs almost as well as DSR, but still requires the transmission of many routing overhead packets. At higher rates of node mobility it's actually more expensive than DSR. Compared the On- Demand (DSR and AODV) and Table-Driven (DSDV) routing protocols by varying the number of nodes and measured the metrics like end-end-delay, dropped packets, As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. Hence for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DSDV's performance is very good.

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