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# A STUDY ON MUTIPATH ROUTING PROTOCOLS IN AD HOC NETWORKS

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**Abstract:** A Mobile Ad Hoc Networks (MANET) is a collection of mobile nodes that can communicate with each other using multihop wireless links without utilizing any fixed based-station infrastructure and centralized management. Each mobile node in the network acts as both a host generating flows or being destination of flows and a router forwarding flows directed to other nodes. Routing is a fundamental problem in mobile ad hoc networks. Multipath routing is a routing technique that is used to find multiple paths between a single source and a single destination. This paper presents an overview of several multipath routing protocols that have been proposed by researchers.

***Keywords: Mobile Ad Hoc Network, Routing Protocols, AODV, SMR, MSR***

## I.INTRODUCTION

Recently, network researchers are studying networks based on new communication techniques, especially wireless communication. Mobile networks have been of significant interest in the past ten years because of their improved flexibility and reduced costs. Compared to wired networks, mobile networks have unique characteristics and differ in the way of communication. Wired networks transfer data packets through physical cables; whereas, in mobile networks, the communication between different devices can be either wireless or wired.

In mobile networks, node mobility makes the network topology change frequently, which is rare in wired networks. Mobile networks have a high error rate, bandwidth limitations and power restrictions. Due to the impacts from transmission power, receiver sensitivity, noise, fading and interference, wireless link capacity continually varies. Wireless networks can be deployed quickly and easily, and users stay connected to the network while they are moving around. Also, they play an important role in both civilian and military fields. We have seen great developments in Wireless networks infrastructure, availability of wireless applications, and proliferation of Wireless devices everywhere such as laptops, PDAs, and cell phones. According to the deployment of network infrastructure, Wireless networks can be divided into two types [1]. The first types are Infrastructure-based wireless networks and the second are infrastructure-less mobile networks, commonly known as ad-hoc networks. Infrastructure networks are those networks with fixed and wired gateways. The bridges for this type of networks are known as base stations. A mobile node connects to the nearest base station which is within its communication radius. As the mobile travels out of range of one base station and into the range of another, a "handoff" occurs from the old base station to the new, and the mobile is able to continue communication seamlessly throughout the network.

A mobile ad-hoc network (MANET) is a group of wireless mobile nodes dynamically establishing a short live network without any use of network infrastructure or centralized administration. In addition to the high degree of mobility, MANET nodes are distinguished by their limited resources such as power, bandwidth, processing, and memory. If two mobile nodes need to communicate with each other, they can communicate directly if they are within the transmission range of each other, otherwise intermediate nodes (nodes in between) should forward the packet from one of them to the other. Thus, each node in the network acts both as a host and router and must therefore be willing to forward packets to other nodes. All nodes in mobile ad hoc networks are free to move, and the link between two nodes is broken when one of them moves out of other's transmission range, and hence the network topology may change frequently.

### 1.2 Characteristics

Compared to other wired or infrastructure-based wireless networks and according to [2], Mobile ad hoc networks have the following characteristics.

- **Dynamic topology:** All nodes of mobile ad hoc network are free to move causing network topology changes rapidly at unpredictable times. Links between nodes are expected to break much more frequently than with wired and infrastructure based wireless networks.
- **Self-organization:** Due to the lack of infrastructure or central administration, nodes should be able to form themselves into a network.
- Multi-hopping: In a mobile ad hoc network, nodes use a wireless channel to transmit data, and due to the limited number of a node's neighbors, intermediate nodes are used to relay the packets.
- **Resource conservation:** In mobile ad hoc networks, the nodes are limited in both energy supply and processing power. Power conservation becomes a very important factor to be considered when

designing a network. Therefore, optimizing all operations may minimize the energy consumption.

- **Limited security:** Mobile ad hoc networks are more prone to security threats than wired networks or infrastructure-based wireless networks because of their unique characteristics. Each mobile node in an ad hoc network can function as a router or packet forwarder for other nodes, both legitimate users and malicious attackers can access the wireless channel, and there is no well place where access control mechanisms can be deployed. As a result, separating the inside of the network from the outside world becomes imprecise.
- **Scalability:** In some applications (e.g., battlefield deployments), mobile ad hoc networks may grow up to several thousand nodes. Mobile ad hoc networks suffer from scalability problems in channel capacity, because channel capacities are very limited and maximum use of channel capacity can be reached faster. Due to the multihoping nature of mobile ad hoc networks, their scalability is related to the routing protocols they employ.

## II.ROUTING CLASSIFICATION IN AD HOC NETWORKS

Routing in wireless ad hoc networks is clearly different from routing found in traditional infrastructure networks. Routing in ad hoc networks needs to take into account many factors including topology, selection of routing path and routing overhead, and it must find a path quickly and efficiently.

Ad hoc networks generally have lower available resources compared with infrastructure networks and hence there is a need for optimal routing. Also, the highly dynamic nature of these networks means that routing protocols have to be specifically designed for them, thus motivating the study of protocols that aim at achieving routing stability.

Designing a routing protocol for ad hoc networks is challenging because of the need to take into account two contradictory factors:

- A node needs to know at least the "reachability" information to its neighbors' for determining a packet route; and
- The network topology can change quite often.

Furthermore, as the number of network nodes can be large, finding a route to the destinations also requires large and frequent exchange of routing control information among the nodes. Thus, the amount of update traffic can be quite high, and it is even higher when the network includes high mobility nodes, which can impact the route overhead of routing protocols in such a way that there might be no bandwidth leftover for the transmission of data packets. In wireless ad hoc networks, the communication range of a node is often limited and not all nodes can directly communicate with one another.

Nodes are required to relay packets on behalf of other nodes to allow communication across the network. Since there is no pre-determined topology or configuration of fixed routes, an ad hoc routing protocol is used to dynamically discover and maintain up-to-date routes between communicating nodes.

### 2.1 Multipath Routing Protocols

Multipath routing is a routing technique that is used to find multiple paths between a single source and a single destination. It is one of the ways to improve the reliability of the transmitted information. Multiple paths can be used to provide load balancing, fault tolerance, and bandwidth aggregation [3]. Recently, several multipath routing protocols have been proposed, and many of them are based on the popular on-demand routing protocols, DSR and AODV [4]. In the case of using a reactive routing protocol, maintaining multiple routes for each destination increases the reliability of the protocol by selecting an alternative route without initiating a route discovery procedure. Numerous of the proposed multipath routing protocols produce disjoint paths which have the desirable property that they are more likely to fail independently. Thus they have a better utility. There are two types of disjoint paths: node disjoint paths and link disjoint paths. Node disjoint paths do not have any nodes in common, except for the source and the destination. Whereas, link disjoint paths do not have any common links, but may have common nodes. Multipath routing protocols can be categorized into two types according to how they use multiple routes: as backup routes for fault tolerance [5][6], and as data transfer routes for load balancing [7][8].

### 2.1.1 AD HOC ON-DEMAND MULTIPATH DISTANCE VECTOR (AOMDV)

Ad hoc On-demand Multipath Distance Vector (AOMDV) [9] is an extension to the AODV protocol for computing multiple loop-free and link-disjoint paths. The protocol computes multiple loop-free and link-disjoint paths. Loop-freedom is guaranteed by using a notion of "advertised hopcount". Link-disjointness of multiple paths is achieved by using a particular property of flooding. To keep track of multiple routes, the routing entries for each destination contain a list of the next-hops together with the corresponding hop counts. All the next hops have the same sequence number. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths. This is the hop count used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternative path to the destination. To ensure loop freedom, a node only accepts an alternative path to the destination if it has a lower hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and advertised hop count are reinitialized.

AOMDV can be used to find link-disjoint routes. To find disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQ carries an additional field called firsthop to indicate the first hop (neighbour of the source) taken by it. Also, each node maintains a first hop list for each RREQ to keep track of the list of neighbours of the source through which a copy of the RREQ has been received.

In an attempt to get multiple link-disjoint routes, the destination replies to duplicate RREQs regardless of their first hop. To ensure link-disjointness in the first hop of the RREP, the destination only replies to RREQs arriving via unique neighbours. The trajectories of each RREP may intersect at an intermediate node, but each takes a different reverse path to the source to ensure link-disjointness.

**2.1.2 SPLIT MULTIPATH ROUTING (SMR)**

Split Multipath Routing (SMR) proposed in [10] is an on-demand multipath source routing protocol that builds multiple routes using a request/reply cycle. SMR can find an alternative route that is maximally disjoint from the source to the destination. When the source needs a route to the destination but no route information is known, it floods the Route Request (RREQs) message to the entire network in order to find maximally disjoint paths, so the approach has a disadvantage of transmitting more RREQ packets. Because this packet is flooded, several duplicates that traversed through different routes reach the destination. The destination node selects multiple maximally disjoint routes and sends Route Reply (RREP) packets back to the source via the chosen routes. In order to choose proper maximally disjoint route paths, the destination must know the entire path of all available routes. Therefore, SMR uses the source routing approach where the information of the nodes that comprise the route is included in the RREQ packet.SMR is similar to DSR, and is used to construct maximally disjoint paths. Unlike DSR, intermediate nodes do not keep a route cache, and therefore, do not reply to RREQs. This is to allow the destination to receive all the routes so that it can select the maximally disjoint paths. Maximally disjoint paths have as few links or nodes in common as possible. Duplicate RREQs are not necessarily discarded. The algorithm only selects two routes. In the algorithm, the destination sends a RREP for the first RREQ it receives, which represents the shortest delay path. The destination then waits to receive more RREQs. From the received RREQs, the path that is maximally disjoint from the shortest delay path is selected. If more than one maximally disjoint path exists, the shortest hop path is selected. If more than one shortest hop path exists, the path whose RREQ was received first is selected. The destination then sends an RREP for the selected RREQ.

**2.1.3 MULTIPATH SOURCE ROUTING (MSR)**

Multipath Source Routing (MSR) [11, 12] is an extension of the on-demand DSR protocol. It consists of a scheme to distribute traffic among multiple routes in a network. MSR uses the same route discovery process as DSR with the exception that multiple paths can be returned, instead of only one. When a source requires a route to a destination but no route is known (in the cache), it will initiate a route discovery process by flooding a RREQ packet throughout the network. A route record in the header of each RREQ records the sequence of hops that the packet passes. An intermediate node contributes to the route discovery by appending its own address to the route record. Once the RREQ reaches the destination, a RREP will reverse the route in the route record of the RREQ and traverse back through this route. Each route is given a unique index and stored in the cache, so it is easy to pick multiple paths from there. Independence between paths is very important in multipath routing; therefore disjoint paths are preferred in MSR. As MSR uses the same route discovery process as DSR, where the complete routes are in the packet headers, looping will not occur. When a loop is detected, it will be immediately eliminated.

Since source routing is used in MSR, intermediate nodes do nothing but forward the packet according to the route in the packet-header. The routes are all calculated at the source. A multiple-path table is used for the information of each different route to a destination. This table contains for each route to the destination: the index of the path in the route cache, the destination ID, the delay and the calculated load distribution weight of a route. The traffic to a destination is distributed among multiple routes. The weight of a route simply represents the number of packets sent consecutively on that path.

**2.1.4 AD HOC ON-DEMAND DISTANCE VECTOR MULTIPATH ROUTING**

Ad hoc On-demand Distance Vector Multipath Routing (AODVM) [13] is an extension to AODV for finding multiple node disjoint paths. Instead of discarding the duplicate RREQ packets, intermediate nodes are required to record the information contained in these packets in the RREQ table. For each received copy of an RREQ message, the receiving intermediate node records the source that generated the RREQ, the destination for which the RREQ is intended, the neighbour that transmitted the RREQ, and some additional information in the RREQ table. Furthermore, intermediate relay nodes are precluded from sending an RREP message directly to the source. When the destination receives the first RREQ packet from one of its neighbours, it updates its sequence number and generates an RREP packet. The RREP packet contains an additional field called "*last hop ID*" to indicate the neighbour from which the particular copy of RREQ packet was received. This RREP packet is sent back to the source via the path traversed by the RREQ. When the destination receives duplicate copies of the RREQ packet from other neighbours, it updates its sequence number and generates RREP packets for each of them. Like the first RREP packet, these RREP packets also contain their respective last hop nodes' IDs. When an intermediate node receives an RREP packet from one of its neighbours, it deletes the entry corresponding to this neighbour from its RREQ table and adds a routing entry to its routing table to indicate the discovered route to the originator of the RREP packet (the destination). The node, then, identifies the neighbour in the RREQ table via which, the path to the source is the shortest, and forwards the RREP message to that neighbour. The entry corresponding to this neighbour is then deleted from the RREQ table. In order to ensure that a node does not participate in multiple paths, when nodes overhear any node broadcasting an RREP message, they delete the entry corresponding to the transmitting node from their RREQ tables.

Intermediate nodes make decisions on where to forward the RREP messages (unlike in source routing) and the destination, which is in fact the originator of these messages, is unaware as to how many of these RREP messages that it generated actually made it back to the source. Thus, it is necessary for the source to confirm each received RREP message by means of a Route Confirmation message (RRCM). The RRCM message can, in fact, be added to the first data packet sent on the corresponding route and will also contain information with regards to the hop count of the route, and the first and last hop relays on that route.

**2.1.5 AODV-BR: BACKUP ROUTING IN AD HOC NETWORKS**

AODV-BR (AODV with Backup Routes) [6] is an AODV-based protocol. It creates a mesh and provides multiple alternate routes for each desired destination, without transmitting extra control messages. AODV-BR has two phases: Route Construction, and Route Maintenance and Mesh Routes. Route Construction: As mentioned, AODV-BR is based on the AODV routing protocol. AODV-BR builds routes on demand via a query and reply procedure. The protocol uses the AODV's RREQ (Route Request) process with no modification. The mesh structure and alternate paths are established during the route reply phase. Thus, a slight modification has been made to the route reply process. Route Maintenance and Mesh Routes: Nodes use the primary route to deliver data packets unless a link failure is encountered. When a node detects a link break, it performs a one hop data broadcast to its current neighbors. The node identifies in the data header that the link is disconnected and that the packet is a candidate for alternate routing. When a neighbour receives this packet and has an entry belonging to the destination in its alternate route table, it uncast the packet to its next hop node. Thus, data packets are delivered using one or more alternate routes.

**2.1.6 SCALABLE MULTIPATH ON-DEMAND ROUTING FOR MOBILE AD HOC NETWORKS (SMORT)**

Scalable multipath on-demand routing protocol (SMORT) [14] is a multipath extension to the AODV routing protocol. The main objective of SMORT is to reduce the amount of routing overhead using multipath routing. Reduction in the control overhead allows the protocol to scale to larger networks. SMORT uses the idea of Fail-safe multiple paths. The path between the source and the destination is considered as a Fail-safe to the primary path, if it bypasses one or more intermediate nodes on the primary path. Multiple paths between a source and a destination nodes can be divided into two types, namely node-disjoint and link-disjoint multiple paths. Node-disjoint paths are the paths that do not have any common nodes, except the source and destination nodes. In contrast, Link-disjoint paths do not have common links, but may have common nodes. Fail-safe multiple paths are different from node-disjoint and link disjoint multiple paths, where the Fail-safe multiple paths can have nodes and links in common. The Fail-safe path is used to send data packets when the bypassed node(s) on the primary path leave the network or move away.

**2.1.7 DISJOINT MULTI-PATH SOURCE ROUTING IN AD HOC NETWORKS: TRANSPORT CAPACITY (DMPSR))**

The Disjoint Multi-Path Source Routing (DMPSR) [7] is a protocol that allows packets originating from the same source to be statistically multiplexed onto multiple disjoint routes. DMPSR consists of three phases: Route Discovery, Route Maintenance, and Route Destruction. When a source node needs to start the communication, it initiates the Route Discovery process, by broadcasting a Route Request (RREQ) packet. To minimize the routing overhead, the source node broadcasts the RREQ packet with probability $p = 1$, while the other nodes broadcast the packet with probability $p < 1$. This probability is referred to as the critical probability below which the network lacks connectivity (i.e., the network is in sub-critical mode). When an intermediate node that knows how to reach the destination or the destination itself receives a RREQ packet, it generates and sends a Route Reply (RREP) packet back to the source node. The source node gathers information from all RREP packets and selects as many disjoint routes as possible. The purpose of choosing multiple routes is to increase the connectivity of the network (i.e., the source stays connected to the destination for a longer time).When a link failure occurs, the source node continues sending packets over alternative routes and only reinitiates the Route Discovery process if all the routes are invalid. In the sub-critical mode, the method increases the chance of delivering the message to the destination, because DMPSR is designed to utilize all possible routes simultaneously.

At the end of the communication session, the source node informs the destination node and all the relay nodes about closing the connection to release the resources. The informed nodes either choose to erase the route information from their caches or wait for a timer to expire before doing so. The authors in [7] present an analytical framework to derive the transport capacity of the network with DMPSR both with and without load balancing. They concluded that if no load balancing is used, the DMPSR's transport capacity is more than that of traditional source routing, where the spatial density of the network is below some critical threshold.

**2.1.8 NODE-DISJOINT MULTIPATH ROUTING WITH ZONING METHOD IN MANETS**

Wang et al. propose Multiple Zones-based routing protocols (M-Zone) [15], to discover node-disjoint paths in large scale MANETs. M-Zone uses a multiple zoning method based on location to guarantee that the paths between the source and the destination have no common nodes. M-Zone combines the advantages of topology-based routing and location-based routing and can be used in large scale MANETs using segment-by-segment route discovery. The proposed protocol divides the region between the source and the destination into multiple zones to find node-disjoint multiple paths, and uses two approaches to maintain the routes: local route maintenance and global route maintenance. The local route maintenance ensures that the broken path is repaired quickly, and global route maintenance initializes route discovery periodically. Compared to GZRP [14], the authors conclude that the average path length of M-Zone is close to that of GZRP, and the average packet delivery ratio is significantly improved.

## III.CONCLUSION

Routing is an important and challenging issue in mobile ad hoc networks (MANETs). Since the transmission is wireless and nodes are free to move, MANETs challenge the design of routing protocols. Routes frequently break due to interference and node mobility, and nodes have limited resources such bandwidth, energy, and processing power. These problems make multipath routing an interesting possibility. Multiple paths can be used to provide load balancing, fault tolerance, minimizing end-to-end delay, enhancing reliability and bandwidth aggregation.

## IV.REFERENCES

[1]. E.M Royer and C.K. Toh. A review of current routing protocols for ad hoc mobile wireless networks. IEEE Personal Communications, 6(2):46–55, 1999.

[2]. S. Corson and J. Macker. RFC2501: Mobile ad hoc networking (MANET): Routing protocol performance issues and evaluation considerations. http://www.ietf.org/rfc/rfc2501.txt, January 1999.

[3]. J. Tsai and T. Moors. A review of multipath routing protocols: from wireless ad hoc to mesh networks. In Proceedings of ACoRN Early Career Researcher Workshop on Wireless Multihop Networking, pages 17–18, Australia, July 2006.

[4]. M. Abolhasan, T. Wysocki, and E. Dutkiewicz. A review of routing protocols for mobile ad hoc networks. Ad Hoc Networks, 2(1):1–22, 2004.

[5]. M. Khazaei and R. Berangi. A multi-path routing protocol with fault tolerance in mobile ad hoc networks. In Proceedings of the 14th International CSI Computer Conference (CSICC 2009), pages 77–82, Tehran, Iran, October 2009.

[6]. S.J. Lee and M. Gerla. AODV-BR: Backup routing in ad hoc networks. In Proceedings of IEEE Wireless Communications and Networking Conference (WCNC 2000), volume 3, pages 1311–1316, Chicago, IL, USA, September 2000.

[7]. L. Wang, Y. Shu, M. Dong, L. Zhang, and O.W.W. Yang. Adaptive multipath source routing in ad hoc networks. In Proceedings of IEEE International Conference on Communications (ICC01), volume 3, pages 867–871, Finland, June 2001.

[8]. N. Wisitpongphan and OK Tonguz. Disjoint Multi-Path Source Routing in ad hoc networks: transport capacity. In Proceedings of the IEEE 58th Vehicular Technology Conference (VTC 2003), volume 4, pages 2207–2211, Orlando, Florida USA, October 2003.

[9]. Mahesh K. Marina, and Samir R. Das, On-demand Multipath Distance Vector Routing in Ad Hoc Networks. In *Proceedings of the 9th IEEE International Conference on Network Protocols (ICNP)*, Page(s):14 – 23, November 2001.

[10]. S.J.Lee and M.Gerla, Split Multipath Routing with Maximally Disjoint Paths in Ad Hoc Networks, In *Proceedings of the IEEE ICC*, pages 3201-3205, 2001.

[11]. L. Wang, Y. Shu, M. Dong, L. Zhang and O. Yang, "Adaptive Multipath Source Routing in Ad hoc Networks", *IEEE ICC 2001*, Page: 867-871 vol.3, June 2001.

[12]. L. Wang, Y. Shu, Z. Zhao, L. Zhang and O. Yang, "Load Balancing of Multipath Source Routing in Ad hoc Networks", in *Proceedings of IEEE ICCC'02,* Page(s):3197 - 3201 vol.5 April 2002.

[13]. Ye, Z., Krishnamurthy, S. V., Tripathi, S.K., A Framework for Reliable Routing in Mobile Ad Hoc Networks. *IEEE INFOCOM (2003),* 30 March-3 April 2003 Page(s):270 - 280 vol.1.

[14]. L. Reddeppa Reddy and SV Raghavan. SMORT: Scalable multipath ondemand routing for mobile ad hoc networks. Ad Hoc Networks, 5(2):162–188, 2007.

[15]. Y. Ge, G. Wang, W. Jia, and Y. Xie. Node-disjoint multipath routing with zoning method in manets. In Proceedings of 10th IEEE International Conference on High Performance Computing and Communications (HPCC'08), pages 456–462, Dalian, China, September 2008.