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Survey of Different Routing Protocols for Mobile Ad Hoc Networks

Ishaq Ahmad[1], Shakeel Ahmad[2], and Dr. Sher Afzal Khan[1]

[1]Department of Computer Science, Abdul Wali Khan University Mardan
[2]Faculty of computing and information technology in Rabigh, King Abdul Aziz University Jeddah, Saudi Arabia

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ABSTRACT

Communication between nodes in Mobile Ad-hoc Networks (MANETs) is one of the challenging tasks because there are no fixed routes among different nodes in mobile ad-hoc network. Routes change continuously due to node mobility in MANET. Communication process is achieved through routing algorithms. Routing algorithms perform best path selection among the available paths in MANET. There are two routing algorithms used for communication which are called flooding and broadcasting. Flooding and broadcasting are the only options available for route discovery between unknown nodes in MANET which create network congestion, delay and reliability problems. Routing algorithms use different approaches to perform efficient communication in MANET which include Proactive Approach, Reactive Approach and Hybrid Approach. In this paper, all those Proactive, Reactive and Hybrid routing protocols that contribute towards the route discovery among different nodes of ad hoc network will be reviewed and critically analyzed to evaluate the performance of different routing protocols that could enable the researchers to keep them under consideration when conducting research.

KEYWORDS: MANET, Routing, Flooding, Proactive, Reactive, Hybrid

1. INTRODUCTION

Information and communication technologies play a vital role in our society and the world becomes a global village in which people are connected from all over the world for sharing different valuable information and other services through different communication devices and equipment including cell phones, laptops, handheld devices and PDA (Personal Digital Assistants). People don't like to be restricted or bounded to some limited area for its use. Their desire is to use these services everywhere without any pre-existing infrastructure limitations. Mobile ad hoc network is one of the best solutions to all these services. Mobile ad hoc network facilitates users on different platforms for different types of communication like internet surfing, checking emails, guidance maps for tourists, ticket reservation and confirmation without the need of physical infrastructure (Imrich Chlamtac, 2003)[1]. Mobile ad hoc network offers several advantages over fixed and cellular networks. First of all mobile means something in motion, means node in mobility; ad hoc means temporary and network means collection of two or more than two devices connected through some physical medium so that they can send and receive messages or share information with each other. It is a self-organizing network where nodes communicate with each other by storing and forwarding the packet by itself in a dynamic fashion. In mobile ad hoc networks, nodes have the ability to forward packets to other nodes because they act as routers and routers have a very clear objective to route the packets in a network. There is no central administration in mobile ad hoc network because it is a temporary network where each node acts independently from other nodes. Nodes in mobile ad hoc networks use RF transceivers as a network interface for communication with each other. Mobile ad hoc network is a temporary communication network in which nodes are connected through wireless links without any pre-existing infrastructure. One of the advantages of mobile ad hoc network over traditional wired networks is the easier setup, installation and deployment. These networks are specifically useful and have high impact in special circumstances like search and rescue operation, hostile operation, recovery during disaster (earth quack, flood), automated battlefield in which tanks and other devices need communication, and during national crises. In all of these situations we don't need and may have no time to build an infrastructure first and then connect nodes within that infrastructure because it can happen in such areas where we don't have the facility of already available infrastructure. Therefore mobile ad hoc network is ideal for such type of environment and saves our time and resources. Mobile ad hoc network is equally important in such an environment where people want to connect with each other despite of constant movement like to get connected with conference rooms, attending classes in electronic classrooms, and to control home appliances while traveling (Giordano, 2002)[2]. When nodes in mobile ad hoc networks are connected with each other, the next step is the communication among them. Routing is the process of best path selection in a network from source node to destination node among

*** Corresponding Author**: Ishaq Ahmad, Department of Computer Science, Abdul Wali Khan University Mardan

available routes. Routing is one of the challenging tasks in mobile ad hoc networks because of the dynamic topology, limited bandwidth of the links, energy consumption of nodes and node mobility. Several nodes are entering and leaving the network continuously due to which routes among nodes are changing accordingly and becomes invalid most of the time.

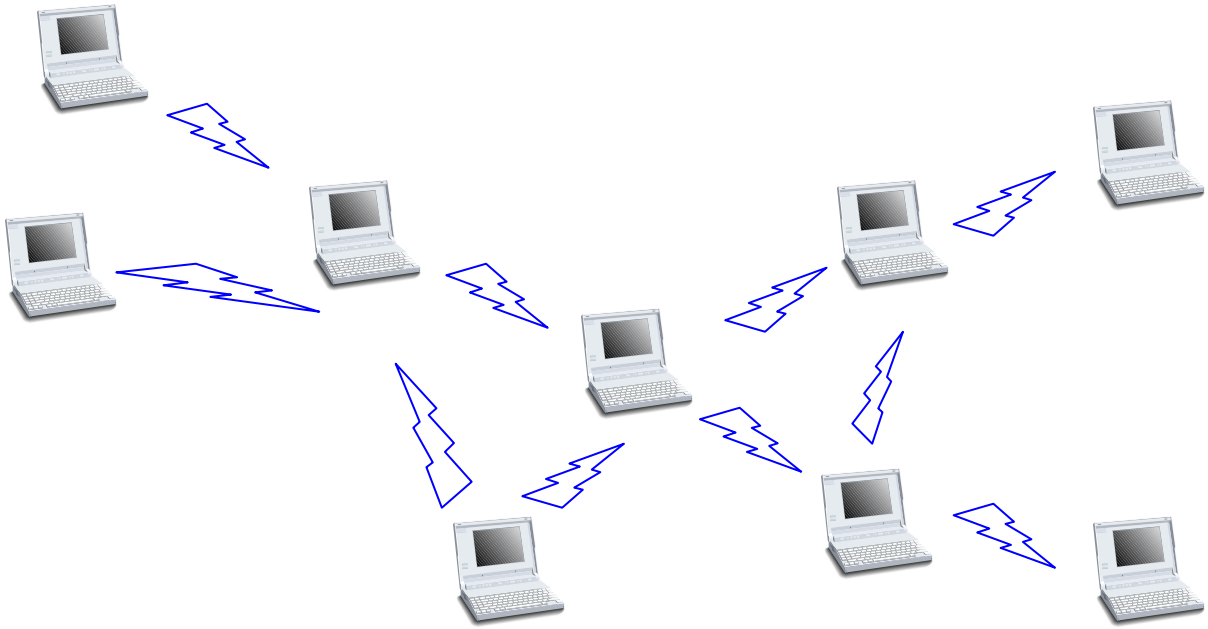

Figure 1. Mobile ad hoc network routing diagram

There are two types of protocols on a network layer one is called routing protocols and the other is called routed protocols. Routing protocols perform best path selection among the available paths in the network while routed protocols deliver the packets on that selected bet path. Routing in wired networks is performed by two types of protocols in which one is called distance vector protocols and other is called link state protocol. Distance means the distance of the source node from destination node and vector means the direction. In distance vector protocols nodes only know about its neighbors and communicated with each other on regular intervals that create routing overhead in wired networks. Nodes using distance vector protocols are sending their routing information to each other after specific amount of time whether change occurred or not in that duration. Link state routing protocols perform best routing than distance vector because in this category a node knows about the complete routes in a network. In link state protocols first neighbors table is created after this topology table is constructed and at the end routing table is created.

Link state protocols use a shortest path algorithm for maintaining up to date routes between nodes. The convergence time of link state protocols is lower than distance vector protocols. These protocols do not suit well in mobile ad hoc networks. Limitations of these routing protocols are tried to overcome in mobile ad hoc networks. In mobile ad hoc network for efficient communication between nodes in a dynamic topology routing protocols are divided into three main categories. First category is called reactive routing protocols, second category is called proactive routing protocols and third category is called hybrid routing protocols (Anuj, 2009) [3].

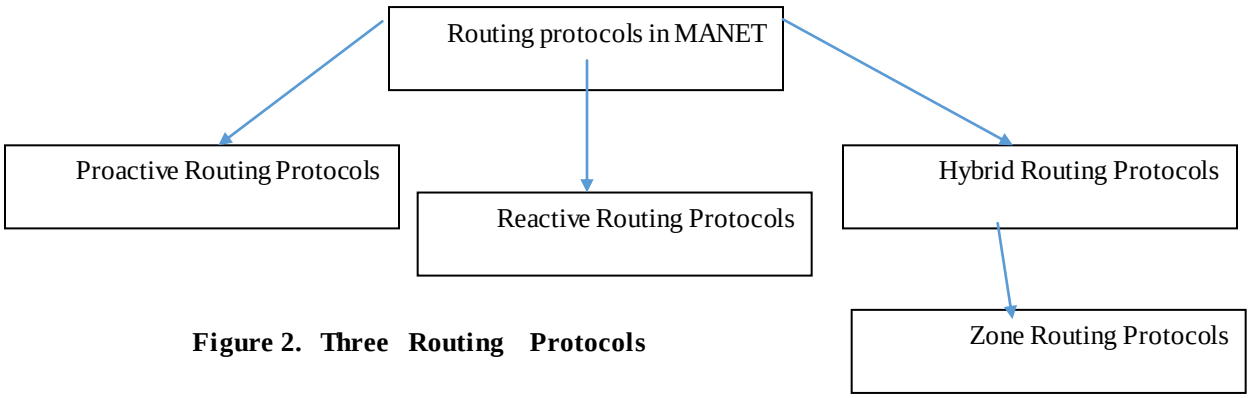

Figure 2. Three Routing Protocols

Protocols' efficiency is measured by using different parameters like energy consumption of nodes, delay, and bandwidth utilization of links, throughput and controlling routing traffic between nodes. Mobile ad hoc networks have limited resources and best utilization of these resources is only possible in the presence of efficient routing protocols. Reactive protocols are also called on demand protocols because they only perform route searching process for destination node when there is a need for the route means when node requests for that route. It starts a discovery request for the route and finishes its job when either it finds the required route or fails when there is no route exists. Proactive protocols are also called table driven or pre-calculated protocols that contain route information of all nodes and maintains that routes all the time through regular periodic intervals. Hybrid routing protocols is dual in nature because it is the composite of both reactive and proactive routing protocols. It combines best features of reactive and proactive protocols. Challenging task for these routing protocols is that when a node tries to send packets for unknown destination. For route discovery process every protocol has its own mechanism, some protocols using flooding, some using broadcasting and some using bordercasting algorithms. Routing protocols must have the capability to respond quickly in timely fashion and adopt efficiently according to the changes in the topology and converge the network in less amount of time (Anuj, 2009) [4] (Conti, 2014) [5].

2. **Literature Review.** Study has shown that routing protocols for Mobile Ad Hoc Networks are divided into different categories in which most of them are discussed by researchers in (Ayash & Yim, 2012) [6] (Deepadasarathan, 2013) [7] (Malarkodi & Venkataramani, 2009) [8] (Bellur, 1999) [9] and (Lee, Hong, Breyer & Gerla) [10] as

- Proactive routing protocols
- Reactive routing protocols
- Hybrid routing protocols

2.1. Pro-active Routing Protocols. These protocols are also called table driven protocols. Proactive or table driven routing protocols maintain consistent and up to date routes information in their routing table on each node through regular periodic updates (Shah, 2002) [11]. It is also called pre-calculated routing protocols because routes to different destinations are already calculated using link state algorithm whether a node requested that route or not. Nodes in mobile ad hoc networks using proactive protocols floods link states information of their all outgoing links to their neighbors periodically. Upon receiving this latest information neighbor nodes update route information in their routing tables. When a sudden change occurs in the routes due to the joining or leaving of node from the network then this change is propagated and every node receives consistent route information. When the size of the mobile ad hoc network is small then it is an efficient method for finding out paths in advance but it has some limitations when the size of the network is large and node mobility is high. The following protocols belong to the proactive routing scheme.

2.1.1. Destination-Sequenced Distance-Vector Routing Protocol (DSDV) (Charles E. Perkins, 1994) [12]. It is highly dynamic proactive table driven routing protocol in which every node has a labeled sequence number for each entry that is originated by destination node. Every node has the ability to distribute its distance vector by using broadcast method but broadcast for route discovery is restricted to only one hop in this protocol. New sequence number for each entry in the sender is represented by +1. DSDV consider those paths more preferable that have most recent sequence number.

2.1.2. Optimized Link-State Routing (OLSR) (Jacquet, Clausen, & Laouiti, 2001) [13] (Bow-Nan Cheng, 2012) [14]. It is a proactive routing protocol which broadcasts its routing table after regular periodic intervals to its neighbors so that neighbors can list up to date routes in their routing tables but this creates a large overhead on a network. Therefore this protocol uses a technique which is called multi point relay (MPRs) for reducing overhead of routing and flooding in the network. In MPRs technique only selected nodes have the permission to perform packet forwarding and flooding. OLSR does not immediately broken links information to the source rather they come to know this in next periodic updates. OLSR gives best results in dense networks and perform routing in minimum delay. Bandwidth utilization of OLSR is high but it is reduced up to some extent by MPRs.

2.1.3. Wireless Routing Protocols (WRS) (Zygmunt, 2001) [15]. Wireless routing protocol uses proactive approach for finding shortest path from source to destination with minimum delay. WRP convergence time is low and has solved the problem of count to infinity. WRP only forward routing information to its neighbors when it detects a change in the topology or receives an update packet from its neighbor. Each node maintains link cost table, distance table and routing table

2.2. Reactive Routing Protocols. Reactive routing protocols (S. R. Biradar, 2008) [23] (Park, 1997) [31] (Jing Feng, 2006) [32] are also called on demand routing protocols which have the benefit of reducing traffic overhead. It performs route discovery on the same time when requested which means that it does not maintain routes in advance to request. Reactive routing protocols perform best utilization of the network bandwidth where links have limited bandwidth and nodes have limited energy. Reactive Protocols take some time by finding the path from

source node to destination node upon request before forwarding the packet which is referred to as high latency. Paths are not already available to nodes for immediate transmission. Following are some of the well known reactive protocols

2.2.1. Ad-hoc On- Demand Distance Vector Routing (AODV) (Thabotharan Kathiravelu, 2011) [16] (Perkins, 1999) [17]. AODV performs next hop routing which is pure on demand reactive routing protocol. Every node maintains a routing table in which only next hop information is stored. It uses flooding for route discovery and route maintenance. AODV does not need to keep the information about neighbor nodes until it is communicated with him. Discovery packets are broadcasted on demand only. It maintains a very clear identification of the local connectivity, neighborhood detection and maintenance of the general topology. AODV has the capability to unicast as well as multicast routing. Sequence numbers are used by AODV for keeping fresh list of routes in the routing table. AODV uses Route Request (RREQ) message for route discovery, Route Reply (RREP) message for sending route response to the source and Route Error (RERR) message for route maintenance. In large network AODV faces some problems due to decrease in some characteristics.

2.2.2. Dynamic Source Routing (DSR) (kumar, 2013) [18] (Yingii Zhong, 2003) [19] (David B. Johson, 1996) [20] (Josh Broch, 1998) [21]. DSR is on demand routing protocol of Mobile Ad hoc network in which routes of the source is constructed in the header of the packet. There is a concept of cache which is maintained by each host. Route cache is updated when there is a change in the routes information. When a node wants to communicate with some other nodes then source node first checks destination route in its cache if it is available then send the packet on that path and if it is not available then it broadcast the route discovery request along with source node address, destination node address and a unique number for identification in a network. DSR has access to more routing information as compared to AODV. DSR does not have any mechanism for deleting stale route as compared to AODV. There is no load balancing in DSR and it has less routing load than AODV.

2.2.3. Associativity-Based Routing (ABR) (Toh, 1996) [22] (S. R. Biradar, 2008) [23]**.** ABR is also on demand reactive protocol which considers the link stability by measuring received number of beacons from the other side link which is in general referred to as degree of association stability. When ABR detects that the degree of the link stability is high on one end then on the other end of the link node mobility is lower. ABR discovers the route in the same manner as DSR but it also gets information about association stability in route request packet. It is the responsibility of the destination node to choose best path in the form of association stability. ABR performs local search on receiving route error packet in order to perform repairing. But it sends a route error message to the source if the local search is not successful.

2.3. Hybrid Routing Protocols. Hybrid routing protocol is the composite of proactive and reactive protocols (Huda, 2013) [24]. Hybrid protocol combines best features of both proactive protocols and reactive protocols. In hybrid routing protocols each node creates a neighborhood individually for itself which is called routing zone of the node. Hybrid protocol uses proactive part for communication within the neighborhood zone of the nodes and reactive part is used for communication across the zone. Zone actually specifies the premises of nodes within which they can communicate by using proactive part of the hybrid protocols. Proactive part of the hybrid protocols is restricted for communication within the zone. Nodes can only maintain list of routes consistently of the zone to which it belongs. It does not keep route information of the node which is outside of the node zone. Reactive part of the hybrid protocol is responsible for routing outside of node zone when it is required. These two approaches in one protocol gives outstanding benefits in routing process. It reduces the latency of route discovery process and also minimizes the control messages overhead and gives best utilization of the link bandwidth. Hybrid routing protocols provide up to date route information within zone and also provide scalability with minimum searching cost. Hybrid routing protocol form the basis of most common protocol which is called zone routing protocol (ZRP) (Haas, Pearlman & Samar, 2002) [25].

2.3.1. Zone Routing Protocol (ZRP). Zone routing protocol is a hybrid routing protocol which acts in proactive manner in the local neighborhood (node routing zone) maintaining consistent and up to date fresh route information on each node while behave reactively when the destination requested by the node is outside the routing zone of the node (Rave Nayak, 2010) [26] (Natasha Dhiman, 2013) [27]. ZRP is invented at Cornell University by Zygmunt Haas in 1997 for mobile ad hoc networks. Structure of the ZRP is flat rather than hierarchical because flat structure reduces congestion localization. Neighbor nodes are those nodes which lie inside the area of the routing zone of the source node. Neighbor nodes are at a distance of one hop from the source node. Hope count of the neighbor nodes is normally less than the radius of the routing zone. When the distance of the neighbor nodes is equal to the radius of the source node routing zone then it means that they are lying on the border of this routing node. Zone Routing Protocol first of all performs network division into different sizes of overlapping zones. ZRP provides table driven as well as on demand services to the routing process. Table driven services is applied to the nodes which belongs to routing zone of the node while on demand services is used when the destination node lies outside

the routing zone of the requested node. ZRP gives loop free routing to the destination and its structure in flat not hierarchical. In zone routing protocol first a node defines zone size which is specified as number of hops reachable to the node. Actually routing zone is the local neighborhood of the node. For routing zone creation first a node is required to know or find out neighbor nodes in its locality. A node in ZRP (Shafiq, Khan, Sayyed, & Al-Raweshidy, 2012) [28] (Hass, 2001) [29] is said to be the neighbor node if it is one hop away from the zone creating node and direct communication is possible with it. ZRP protocol has divided the routing process into the following two parts.

2.3.1.1 Intrazone routing (IARP) (Sulaiman, 2006) [33]. Intrazone routing protocol is that part of the ZRP which is used by nodes for local communication within the zone. It has the capability of supporting unidirectional links without symmetric links because it happens most often when one node X sends data to other node Y but node Y due to low transmission power and interference cannot reach to node X. Responsibility of IARP protocol is only limited to the routing zone size. To limit the route discovery packet to within the zone IARP uses TTL (Time to Live) field set which is decremented by each node for forwarding the packet and the field value reaches to 0 then it is discarded. In IARP each node in the zone has complete route information in their routing table of the zone. There are two methods used for finding out neighbors of the zone first one is by MAC protocol and the second one is by Neighbor Discovery Protocol (NDP). Zone notification message is the broadcast message of every node inside the routing zone. Zone notification message reaches to every neighbors inside the zone and it is terminated after specific hop count K where $K > 1$. Each node decrements the hop counts by one after receiving and before forwarding to other neighbors. Forwarding of zone notification message is stopped by each node when the value of hop count reaches to zero. Each node stores routes information in the link state table. Each node broadcast this information after specific periodic intervals to its neighbors and they update their routing table accordingly. IARP gives proactive services of ZRP inside the zone which reduces the latency for finding paths because it always maintains paths inside the zone and when a route is requested by any node then it is immediately provided without delay. It uses same mechanism used by DSDV.

2.3.1.2 Inter-zone Routing Protocol (IERP) (Loutfi, 2011) [34]**.** Inter-zone routing protocol is that part of the ZRP which performs routing when the distances of nodes are greater than zone radius. When the destination node lies outside the routing zone of the source node then IARP is unable to route the packet; for this purpose IERP performs on demand routing and can route packets outside the routing zone of the source node. Route discovery is enhanced using IERP which uses the benefits of local connectivity provided by IARP. Routes are discovered by IERP using a technique which is called bordercasting. When node knows that the destination lies outside its routing zone then it forwards the broadcast discovery packet to the border nodes. For bordercasting, IERP uses bordercast resolution protocol (BRP) (Jaiswal, 2010) [35]. Bordercast routing protocols only sends route request messages to the peripheral nodes flooded by IERP. BRP constructs bordercast tree from topological information obtained from IARP. Route Request message is sent to the peripheral nodes by IERP using bordercasting techniques. Route Reply is forwarded by the node which contains complete path of the destination to the source node. Route request process of IERP is similar to DSR. There is also an alternate technique available for route reply which is similar to AODV in which information about forward and backward links are stored on each node routing table.

2.4. Query control mechanism in ZRP. When routing zone node does not find the destination node in its zone then it broadcasts query to the peripheral nodes, these peripheral nodes set their own routing zone and broadcast the same query message to some of those nodes which already have received the same query and usually every node receives the same query message so many time, this creates big problem in network, to eliminate such problems ZRP used three different mechanisms (Zygmunt, 2001) [36].

2.4.1. Query detection. In MANETs every node broadcasts the query massage. There are two methods i.e. direct scheme which is called Query Detection 1 (QD1) and indirect scheme which is known as Query Detection 2 (QD2) for detection. The direct scheme QD1 is used for broadcast relay, these nodes have the ability to discard the duplicate query while the indirect scheme QD2 is used for Eavesdropping in which existing query node listen the query and discard the duplicate copy of queries which prevents it from reappearing in the existing zone (Zygmunt, 2001) [36].

2.4.2. Early termination. The nodes which already have received the requested query massage see that same message again then it terminates such query or ignores because this request already exists in the routing table of this node (Zygmunt, 2001) [36].

2.4.3. Random query-processing delay. In MANETs there are number of nodes which broadcast the same request query massage to their respective nodes. If two nodes send the same massage at the same time then they create problems in the network. In order to reduce this probability of problem a Random Query Processing Delay (RQPD) mechanism is used in which each node waits for a random time to construct the broadcasting tree and early termination in the node. It avoids the additional route discovery delay (Zygmunt, 2001) [36]

3. Conclusion and Future Work. Mobile Ad Hoc network performance is mainly dependent on routing. Delay, overhead of the control messages, traffic overhead, utilization of the link's bandwidth, energy consumption of nodes, delivery ratio of packets and convergence time in Mobile Ad hoc networks are those parameters on which it strongly relies. Ups and downs in these parameters increase and decrease network performance. Routing is one the key factor for efficient communication in Mobile Ad Hoc Networks. Different routing algorithms (Proactive, Reactive and Hybrid) have been used by different researchers to achieve this goal which is discussed in this review paper. Hybrid approach can be considered efficient approach as compared to other traditional routing approaches. Hybrid approach combines best characteristics of proactive approach and reactive routing approach in one place. Best characteristic of proactive routing approach is minimum latency in routing while reactive routing approach has the advantage of minimizing control messages overhead which is combined by hybrid routing in one protocol called zone routing protocol (ZRP). ZRP restricts the scope of proactive routing protocols to the local neighborhood of the node which has tremendously reduced cost. Proactive task of routing is achieved through IARP (Intra Zone Routing Protocol) of the ZRP and reactive task of routing is accomplished through IERP (Inter Zone Routing Protocol). Hybrid routing algorithms brought enhancement in routing for efficient communication in MANET's but still needs special attention of the research community for perfection. Main objectives of this review are to evaluate three routing approaches in MANETs and to select best one approach which is efficient in communication. There are still some open problems that needs to be addressed in future for best routing in Mobile Ad hoc networks that includes: Removing of unwanted flooding in the overlapping routing zones of ZRP, maintenance of the routes by using IARP & IERP of zone routing protocol with best convergence time, improved Query – control mechanisms to remove or reduce broadcasting and enhancement in detection query method of BRP such as (DQ1 & DQ2) and avoid same query message by using early termination and random query-processing delay in MANET.

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