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A COMPREHENSIVE AND PROPORTIONAL ANALYSIS OF COURSE-PLOTTING ALGORITHMS IN MANETs

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ABSTRACT

Mobile Ad hoc Networks (MANETs) are self constructive multihop unguided network in which the configuration of network varies. This is primarily due to movability of nodes. The node behaves like host as well as routers in the network. MANETs do not have a specific framework as the source node is not the extent of the goal node to transfer the packets. Therefore a directing technique is needed to assist the source node to advance the packets across the hops to reach the goal node. There are several routing algorithms like topology-based, Hierarchical, position-based routing algorithms are available in the literature. In this paper, we present a comprehensive and proportional analysis of these algorithms to help the researchers for the development of new routing algorithms.

Keywords: MANETs, routing protocols, ZRP, ARP, DREAM, MFR, NFP.

1. INTRODUCTION

The nodes in the ad hoc networks exchange information with other nodes by utilizing multi-hop links [38]. MANETs provides the foundation for nodes (movable gadgets) dispersed at different places in different times [40]. An ad hoc system comprises of movable gadgets without any predefined framework [26, 35]. Therefore gadgets itself serve as routers in restricted scope for the transmission of the packets [28]. Many devices are needed to route the packets before it actually reaches the final destination [24, 39]. Since the topology of a system can change rapidly and uncertainly, it ought to be versatile to changes, for example, when a connection breaks, a hub leaves the system, or a another hub is appended to the system [25, 37]. In the last few decades, there has been a big concern in ad hoc networks as they have incredible applications in military, commercial and social fields [36].

1.1 Differences between MANETs and cell phone networks

An ad hoc system is a scattered sort of remote systems [1&7]. It doesn't trust upon a prior setup. Rather, every node takes part in directing and sending information to other hubs [8 & 9]. It also discovers the successive hubs for the transmission of the packets with available framework [24]. The framework's remote topology may change quickly and erratically [28]. The Figure-1 shows a sample framework of MANETs in military applications.
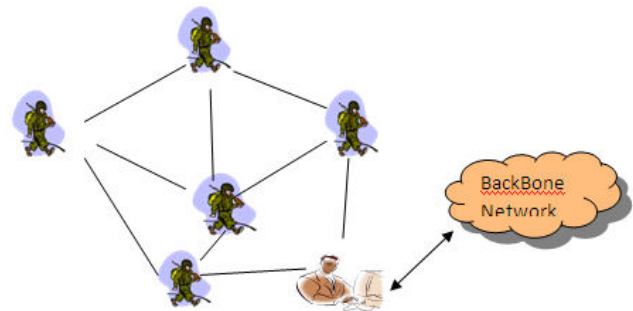
Figure-1. Overview of MANETs.

A Cell Phone is a communication network distributed over land areas called cells [63]. Each cell provides radio coverage over a wide geographic area when joined together [63]. Every cell is supported by at most one settled area transceiver, known as cell tower or base station [63]. The cell phone communicates with each other with fixed transceivers through base station. The coverage area of a cell depends on many factors including the transmission power of the base station, obstructing buildings in the cell and the height of base station antennae. Increased capacity, low power usage, large coverage area, reduced interfering from other signals are the advantages of cell phone network. A sample diagram that depicts the connectivity of cells in cell phone network is shown in Figure-2.
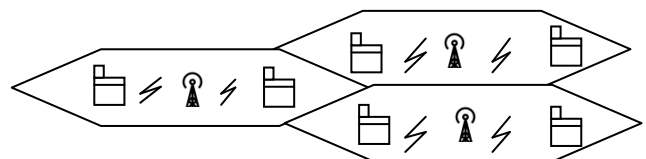
Figure-2. Cell connectivity in cellular networks.

1.2 Applications of MANETs

In this section, we describe the applications of MANETs.

1.2.1 Armed forces application

Ad hoc system is extremely helpful in building a correspondence among a group of officers for strategic operations. Setting up of a settled framework for correspondence among group of soldiers in adversary regions may not be possible. In such a case, MANETs provide a solution for communication quickly. The essential way of the correspondence required in a military domain is Reliable, Efficient, Secure correspondence and Support for multicasting.

1.2.2 Collaborative & distributed computing

In collaborative and distributed computing we establish a momentary base for fast connection with nominal arrangement among the cluster of community. File sharing reliability has huge attention in ad hoc networks. Gadgets utilized for such applications could commonly be laptops having remote interface cards, enhanced personal digital assistants (PDAs) or mobile devices with high processing power.

1.2.3 Emergency Operations

Ad hoc networks are exceptionally useful in crisis operations like inquiry, protect, swarm control and commando operations. The self-arrangement of framework with less overhead is the main consideration for supporting in the adhoc networks. Adhoc remote system is a solution for Co-Organizing the salvage exercises when traditional framework based networks are failed due to war or natural disasters. Instant exploitation of MANETs is a superior resolution in crisis activities.

1.3 Challenges in MANETs

The key threat that affects the routing protocol in MANETs is movability of nodes, Bandwidth constraints, link-Breakdown and Power Constraint. A detailed discussion on each of the following is given below.

1.3.1 Movability

Mobility of nodes dynamically changes the framework structure of MANETs. Interruption happens either because of the mobility of the intermediate nodes in the path. Such circumstances don't emerge on account of dependable connections in guided media where all the nodes are fixed. Therefore network reconfiguration is very slow. So the algorithms which are used in guided networks can't be utilized in ad hoc systems, where the movability of nodes leads to continuous modification of topologies.
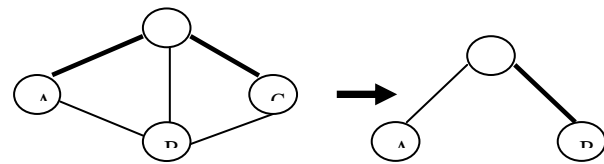

Figure-3. Mobility of nodes.

1.3.2 Bandwidth constraint

More bandwidth is consumed by wired networks due to fiber optics and wavelength division multiplexing. In case of unguided media, the radio signals are restricted, and subsequently the information amounts are not good as that of wired system can offer. So routing algorithms utilizes the bandwidth cleverly by keeping the overhead as less as possible. But the successive changes in topology, keeping up steady topological data at every node which include more control overhead causes bandwidth wastage.

1.3.3 Link breakdown

The links in the wireless networks have time-differing attributes in terms of link capacity and failure. The transmissions in ad hoc networks lead to collisions of packets. This leads to the hidden terminal problem.

1.3.4 Resource Constraints

Two basic and restricted assets that shape the real requirement for the hubs in remote systems are battery life and handling power. In ad hoc systems devices are portable, and henceforth they additionally have size and weight imperatives alongside the impediments on the power source. Expanding the battery life and handling limit makes the hubs bulky and less versatile. Subsequently ad hoc systems should ideally deal with these assets.

1.4 Routing in a MANETs

The method of electing a way in a system to route the packets is called as routing [41, 42]. Routing algorithms keep up routing tables that contains routing information for finding the paths to transfer the packets [29]. Various routing algorithms are proposed under categories in MANETs. Survey papers [1-22] describe about Proactive, Reactive, Hybrid and some of the Position Based Protocols. It is noted that these survey papers did not focus on the broad classification and detailed analysis of all routing protocols in MANETs. Therefore in this paper we present the comprehensive and proportion analysis of different routing algorithms in MANETS. The rest of the paper is organized as follows. In the second section we present the classification of routing protocols, third section describes the comparative analysis of the routing protocols. Section four will present conclusion and summary of routing protocols in MANETs.

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2. CLASSIFICATION OF ROUTING PROTOCOLS IN MANETS

The Figure-4 depicts the broad classification of various routing algorithms in MANETs.
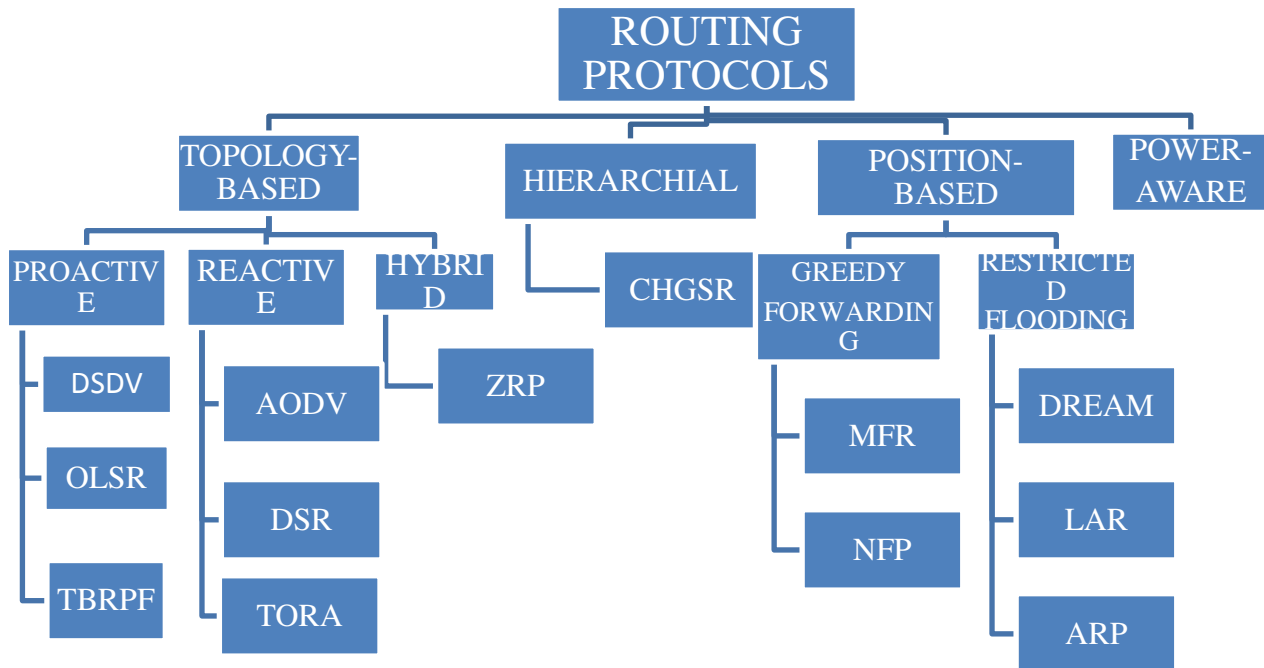
Figure-4. Classification of routing algorithms.

2.1 Topology-based protocols

In Topology-based protocols, all nodes in a system preserve their neighbour topology information. Based on this information, source node can forward the packets to its adjacent nodes [7].

### 2.1.1 Proactive routing protocols

In proactive routing each router keeps up the precise data in their routing tables [25]. Therefore, when a user sends a packet, route is identified and utilized quickly. This implies the protocol; dynamically keep track of the routes by periodic updating of routing tables [25]. Once the routing tables are established, forwarding of packets will be as quick and simple like guided media.

The proactive protocols have the accompanying common drawbacks: Separate measure of information for keeping up routing data and moderate response on rebuilding system.

Some of the Proactive routing protocols are:

a) Destination Sequenced Distance Vector (DSDV)

Destination-Sequenced Distance-Vector is a table-driven routing algorithm [22]. It is planned with the help of Bellman-Ford algorithm [44]. It was designed to solve the looping and Count-to-Infinity problems [25, 40]. Every passage in the routing table encompasses a sequence num. The sequence num is created by the goal node, and the source wants to convey the later amend by this sequence num [29, 44]. Routing info is spread by transferring *complete dumps* rarely and smaller updates more periodically [29, 44].
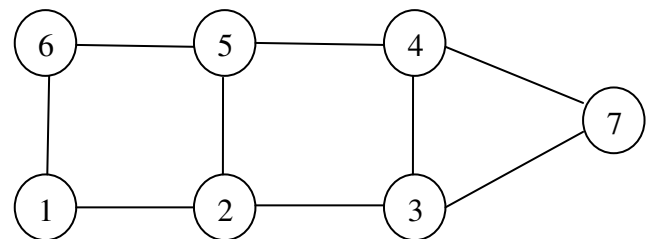
Destination	Next node	HOP	Sequenceno
2	2	1	22
3	2	2	26
4	5	2	32
5	5	1	138
6	6	1	145
7	2	3	268

Figure-5. Destination sequence distance vector.

In the event that a router gets new info, then it utilizes the most sequence num. In case that sequence num is same then it utilizes the path with prominent metric. Stale selections are indicated passages that are not updated for some time. Such sections and also the paths utilizing those hubs as next hops are erased at that point new destination come [21]. This is manner by which it works. It is very appropriate for making impromptu systems with little number of nodes, so less latency in finding the routes [43]. But it exhausts the battery power and a little quantity of bandwidth although when the framework is inactive

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[41, 43]. In addition to this, the system changes the sequence num before reconfiguration. It is not at all fit for active systems [41].

b) Optimized Link State Routing (OLSR)

OLSR is a link-state protocol, which utilizes Hello and Topology Control (TC) messages to find and propagate the connection state data all over the network [46, 47]. Each node utilizes this information to figure next hop for all hubs in the system utilizing the shortest paths. Each node has to select its multipoint relays (MPR) depends on the one hop node so that it attempts the best routes to the two hop nodes [45-47]. Every node has likewise a MPR selector set, which specify the nodes that have chosen it as a MPR node. OLSR utilizes TC & Host and Network Association messages to propagate route advertisements in the system [33].
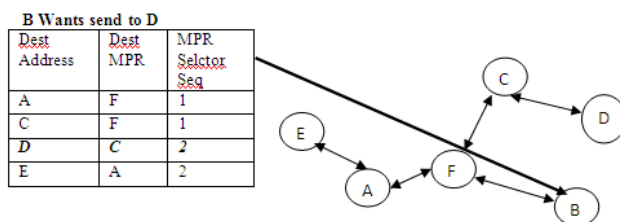

Figure-6. OLSR

Every node maintains its own routing table up-to-date, so it is helpful for frameworks and systems having huge battery power as there are no route disclosure delay [46]. With the help of HNA, messages store default path of the framework in the system. Therefore the path for all destinations within the subnet is identified in prior [2, 8]. Hence the latency is less for sending a packet. OLSR needs a sensibly huge measure of bandwidth & processing power to figure ideal ways in the system [41, 47]. MPRs are utilized to flood the data; OLSR discards a portion of the repetition of the flooding procedure, which might be an issue in systems. Yet the MPR procedure is self-pruning [41].

c) Topology broadcast based on reverse-path forwarding

Topology broadcast based on reverse-path forwarding (TBRPF) is a link state protocol [10]. It calculates the route with the help of broadcast trees information [60]. TBRPF convey the past and present network state information [48]. It need not to be restarted when a topology changes, But a node recognizes a new min hop path and chooses its new parent for the new source node. It can easily reconfigure the network with small amount of communication cost [60].

2.1.2 Reactive routing protocols

Although the Proactive routing protocols have several advantages, but it exhaust the battery power and a little quantity of bandwidth even when the framework is in idle. So Reactive routing protocols came into existence. Reactive protocols don't maintain the records of routes,

until a request is initiated by source node [49]. It discovers a path with the help of flooding in the system by sending Route Request packets [44, 49]. Compare to proactive protocols keep up of routing tables is not a burden in reactive protocols [25, 47]. Although the reactive protocols have the favorable circumstance, it will suffer from tremendous delay in the case of route discovery process and Unnecessary flooding can prompt to system blockage [43, 44].

A. Ad hoc On-demand Distance Vector (AODV)

In this protocol, it set up a route on request whenever the source node desires to send [26]. AODV is an improvement of DSDV [38]. It keeps away from the looping problem by utilizing proper sequence numbers [25, 37]. AODV do not consume more memory though it is a successor of distance vector routing algorithm [25].

In AODV, each node keep-up the next-hop data regarding to every stream for packet transferring [25, 47]. The source node initiates the *RREQ* packets in the system when a path is not accessible in the system [25, 26]. It might acquire various paths to distant destination nodes from a solitary *RREQ*.
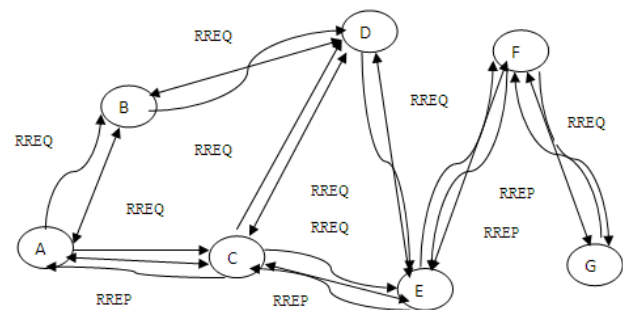

Figure-7. Route discovery & route reply in AODV.

A RREQ conveys the source identifier, the destination identifier, the source sequence number, the destination sequence number, the broadcast identifier, and the *time to live* field [25, 26]. If any adjacent node acquires a RREQ, then it forwards a RREP if it had. Every adjacent node in the system keep-up legitimacy path to the goal nodes then only it sends the RREP packets back to the desired source node [25, 26]. The legitimacy of a path at the intermediary node is dictated with the help of looking at the sequence number.

In the mean while of flooding the RREQ packet by the adjacent node in the system it appends its own address and its BCASTID. A clock is utilized to erase this passage in event that a RREP is not got before the clock terminates. Finally if a node gets a RREP packet, data about the past node from which the packet was gotten is additionally put away and forward to source node.

B. Dynamic source routing

Dynamic source routing protocol (DSR) is an on-demand protocol intended to confine the transmission capacity by periodic update of messages [40, 41]. The significant distinction amongst DSR and existed on-

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request protocols is, infrequently exchange of hello packets to identify its neighbors by a node which prompt to proper bandwidth utilization [43].

DSR divides the task of routing into two separate phases they are Route Discovery and Route Maintaince phases [46, 51]. In Route Discovery Phase, a source node just shot to detect a path to a goal node, if and only if it needs to convey the packets to goal node. In Route Maintaince phase, progressively observation of path is required to detect any connection failures between the adjacent nodes in the system. When a node detects problems with the current route, it has to find an alternative. If the adjacent node identifies its particular address as a goal node then it gives RREP back to the source node [46]. Otherwise, the adjacent node affix its particular address and forwards the updated route RREQ packet to remaining nodes in the system [46]. The adjacent nodes use the cache info of routes to eliminate the problem of routing. Once a path is identified, progressively observation of path is required to detect any connection failures. To ensure this, the adjacent node utilizes the implicit ack and explicit ack to smoothen the packet transmission.
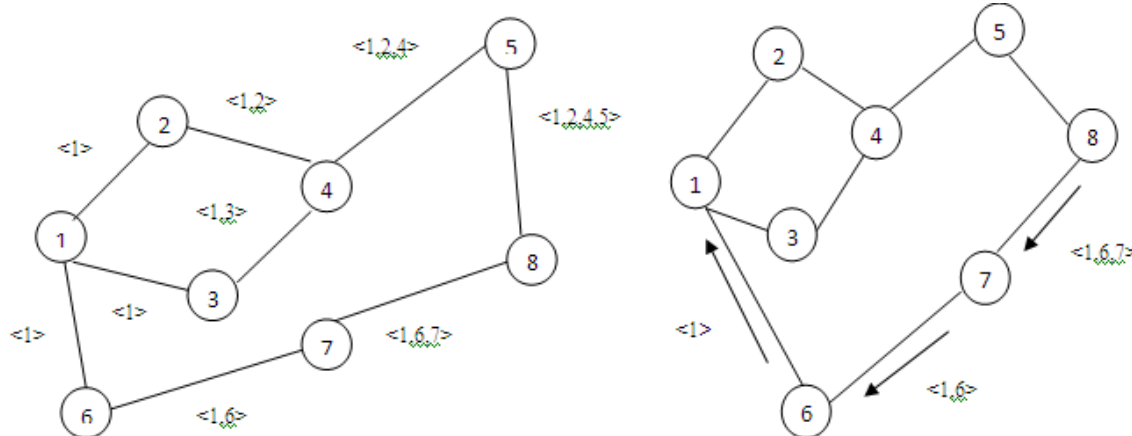
Figure-8. Route discovery & route reply in DSR.

Even though it is good in low versatility situations but it is not fit for huge count of nodes in the system [50]. Old route store data could also brings the irregularities during the route recreation phase [43]. The connection establishing latency is high when compared to other protocols [40].

C. Temporally ordered routing algorithm

Temporary ordered routing protocol is an on-demand protocol [41, 48]. It implies that it responds to the changes and connection reversals [41]. It is utilized for profoundly dynamic MANETs [41]. This protocol finds the system portions demonstrating the link reversals [47]. In other words, system demonstrates a directed acrylic graph topology [19, 47]. TORA has system potential so that huge number of packets is send to a given destination. It ensures loop-free paths [8, 19]. It doesn't trade hello messages intermittently. TORA uses three phases: route creation, route maintaince and route deletion [47].

2.1.3 Hybrid routing protocols

This protocol unites the benefits of proactive and reactive mechanisms [15]. That means routes are established with some proactive perspective and after that it utilizes the concept of reactive mechanism.

Zone routing protocol

Zone Routing Protocol (ZRP) was the primary hybrid protocol which combines the best features of table-driven and on-request constituent [26, 34]. ZRP is designed to weaken the difficulty of maintaining the routing tables in table-driven approach and delay in finding the routes of on-request protocols [26]. Every node in the ZRP specifies a zone for its k-neighborhood [26]. Specifically, every node inside the k-hop resides to the particular routing zone. ZRP is shaped by two inner protocols using Intra Zone routing Protocol & Inter-zone Routing Protocol [54].

A path to a goal node inside the neighborhood zone is established proactively with the help of keep up of routing tables. If the source and goal nodes are in the same zone, packets are conveyed instantly with the help of proactive mechanism like Intra Zone Routing Protocol [26].

If a path is ahead of zone then it follows the Inter Zone Routing Protocol, route discovery process is initiated with the help of RREQ packet by attaching various parameters and forwards to the border nodes in the system [26]. The border nodes check their nearby zone of the goal node. If the goal node is not an individual from close-by zone, the node appends its own deliver and process to its next border nodes. If the goal node is individual from the close-by zone, it sends a RREP return to the source node. The source node utilizes the saved for further transmission.

2.2 Hierarchical routing protocol

This protocol utilizes cluster at various levels with effective membership administration at each level of

clustering. The utilization of clustering improves resource allocation and management.

Cluster-head gateway switch routing protocol

The way toward isolating the system into interconnected substructures is called clusters [61]. The gathering of system nodes into various covering clusters is the primary thought behind clustering [14]. The cluster head of every cluster go about as a coordinator inside the substructure [61]. It also is in touch with different cluster heads [61]. A hierarchical routing is conceivable by clustering in which, ways are recorded between clusters. It expands the routes lifetime, along these lines diminishing the measure of routing control overhead [14]. The cluster head organizes the cluster activities inside the cluster [14]. Nodes that can listen more than two CHs are called gateways [62].
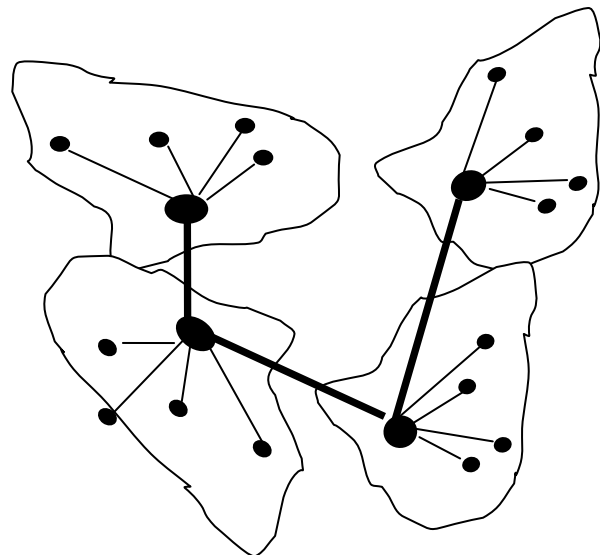
Figure-9. Cluster-head gateway switch routing protocol.

Table-1. Comparison summary for topology-based protocols.

Protocol name	Type	Advantages	Disadvantages	Proposed by
DSDV	Proactive	Loop free[25],Count to Infinity is reduced[4]	Exhaust battery power,bandwidth and not support multipath[40]	Perkins& Bhagawat[8]
OLSR	Proactive	OLSR is apt for high density networks[47]	Consumes more bandwidth by sending topology information[47]	Clausen & Jacquet[8]
TBRPF	Proactive	Compare to flooding it produces less traffic[60]	TBRPF is highly independent and correctness is not guaranteed[60]	
AODV	Reactive	Ensures Loop free[25]	Not supports asymmetric links[29]	C.E.Perkins &E.M.Royer[8]
DSR	Reactive	It does not require routing table for periodic updates[40]	It does not repair a broken link[40]	D.B.Johnson, Maltz & Broch[8]
TORA	Reactive	Bandwidth is properly utilized [47]	Packet delivery ratio is low[47]	Park & Corson[8]
ZRP	Hybrid	Reduces the amount of communication overhead[10]	It does not supports multiple routes	
CHGSR	Hierarchical	It decreases transmission overhead of routing table updates[14]	Few nodes consume more power when compared to other nodes[14]	Chiang[8]

2.3 Position-based routing protocol

Position-based protocol shortens the constraints of location-based routing by utilizing supplementary info. It keeps up the knowledge regarding the geographical location of the nodes [52, 53]. Usually; every hub decides its own position using GPS or some other sort of positioning service [36, 52]. Position based protocol is mostly engaged in light of two concern. A location service is utilized by the source to find the location of the goal node and to incorporate the goal node address two. A forwarding strategy is utilized to advance the packets with the help of protocols such as Greedy forwarding and restricted directional flooding [28, 48].

Position-based routing doesn't require the foundation or keep up of routes. The nodes neither need to store routing tables nor do they have to transmit messages to stay up with the updates [27].
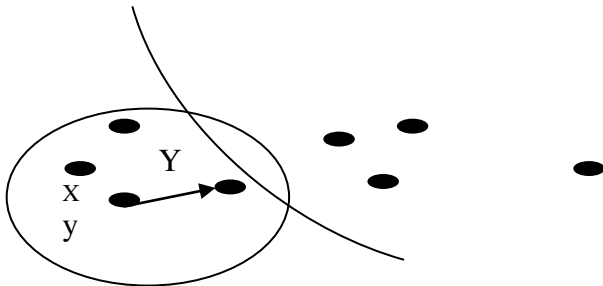
2.3.1Greedy forwarding

It shots to convey the info nearer to final node in every progression by utilizing the knowledge of neighbors [48]. Accordingly, every node advances the message to the neighbors who are appropriate from a nearby perspective. The most appropriate neighbor is diminish the separation of goal node in every progression.

Greedy forwarding rule

In this, by utilizing the greedy perimeter stateless routing the node shots to forward the packet to the next node until it reaches to the goal node [27, 55]. Sending in this administration takes progressively nearer geographic hops, as far as the goal is attained [28]. An example of greedy next-hop choice


Figure-10. Greedy forwarding example. y is x's closest neighbor to D.

In this event the source x gets a packet bound for D. The radio coverage of x is spotted by circle about x, and the circular segment with radius equivalent to separation amongst adjacent node y and goal node D is appeared as the arc about D. If a source x desire to sends the packet to goal D it first forwards to closest node y based on radio coverage of x. This process continues until the packet reaches D. On the off chance that more than one neighboring node exists, and then unique decisions are conceivable to choose the best neighboring node. Instances of greedy routing are: Most Forward progress within Radius (MFR) and nearest with Forwarding Progress (NFP).

a) Most Forward within Radius algorithm (MFR)

It is based on greedy routing algorithm; a message is forwarded based on minimal count of hops to attain the final hub [28, 32]. The separation between a source S and ridge A^1 of a adjacent node A onto the line joining the S and D is defined as movement shown in below figure.
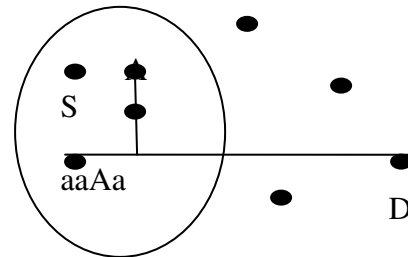
Figure-11. Message is received from S to D.

MFR routing algorithm advances the communication to a neighbor node that gains the most advance towards the destination D, while neighbors with negative advance are disregarded. In above figure node A is recognize as the perfect nearest for node S to additionally forward the message to destination D.

b) Nearest with Forwarding Progress (NFP)

It is an energy-aware protocol which shots to reduce the energy discharge by sending the information to the adjoining node towards the sink [28]. The best feature of NFP is that avoids collisions by adjusting its transmission power to reach the closest adjacent node which will bring about forward advance [28].

Table-2. Comparison summary for position-based greedy forwarding protocols.

Protocol Name	Type	Advantages	Disadvantages	Proposed by
MFR	Greedy forwarding	Minimizes the number of hops for reaching the goal node[28]	It does not avoid looping problem[28]	Takagi & Kleinrock[28]
NFP	Greedy forwarding	Changing its transmission power to avoid collision[28]	No guarantee delivery of message[28]	Hou & Li[28]

2.3.2 Restricted flooding protocols

Restricted Flooding protocol restricts the broadcast region will decrease the packet collisions and lowers the latency. The fundamental approach in restricted flooding is to confine the flooding region [28, 48]. Restriction relies on distance, angle and separation secured by the later adjacent node.

a) Distance Routing Effect Algorithm for Mobility (DREAM)

In this protocol, every node consists of information about geographical coordinates with the help of GPS [38, 56]. These coordinates are systematically trade and kept in routing table to keep updates of location

information [38, 42]. The benefit of switching the location info is, it uses up altogether less bandwidth than distance vector info, which implies that it is more versatile [56].

b) Location-aided Routing (LAR)

It is designed with the help of flooding algorithms like DSR [42]. LAR tries to decrease the routing overheads exhibit in the conventional flooding algorithm by utilizing location info. In this, every node recognizes its location with the help of GPS [58]. LAR consists of two parameters; first method determines a request zone which gives information about the boundaries for forwarding the packets to the final node, next method expected zone holds the coordinates of the final node it

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wants [57-59]. Both techniques confine the control over head transmitted through the system and henceforth save the bandwidth [42, 58].

c) Angular routing protocol

ARP is another position-based routing protocol that utilizes enhanced geographic forwarding to route the packets. In case of geographical sending fails, an angle-based methodology is preferred to avoid issues in scattered systems [28, 35]. Based on an adaptive beaconing protocol every node consists of one-hop information [35].

Table-3. Comparison summary for position-based restricted flooding protocols.

Protocol name	Type	Advantages	Disadvantages	Proposed by
DREAM	Restricted Flooding	Bandwidth & Energy efficient, ensures loop free[56]	Care is needed to reduce the expense of disseminating location information through network[56]	Basagani,1998[28]
LAR	Restricted Flooding	Limits the scope of route request flooding[42]	In some cases the source does not able to recognize the expected zone[53]	Ko&Vaidya 2000[8]
ARP	Restricted Flooding	Minimize spatial distance for travelling[28]	Less scalable[28]	

2.4 Power aware routing

This protocol mainly focus on lessen the power utilization while routing the packets in the system. This is possible by diminishing the aggregate power utilization of the hubs in the system and expanding the life expectancy of the system by proper utilizing. Power Aware Routing Protocols concentrates on four power considerations. They are: (1) Idle Power (2) Transmission Power (3) Acquisition Power and (4) Wiretap Power.

3. COMPARATIVE ANALYSIS OF DIFFERENT ROUTING PROTOCOLS

The below table indicates the performance of different routing algorithms which was used in Mobile Ad hoc Networks.

Table-4. Comparison summary of different routing protocols of various parameters.

Parameters	DSDV	OLSR	AODV	DSR	TORA	ZRP	CHGSR	MFR	NFP	DREAM	LAR	ARP
Topology Structure	Flat	Flat	Flat	Flat	Flat	Flat	Hierarchical	Location	Location	Location	Location	Location
Routes	Single	Single	Single	Multiple	Multiple	Single	Multiple	Multiple	Multiple	Multiple	Multiple	Single
Loop free	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Periodic Broadcast	Yes	Yes	No	No	No	Yes	Yes	No	No	Yes	Yes	NO
Power consumption	High	High	Moderate	Less	Moderate	High	High	Less	Less	Moderate	High	Less
Routing Overhead	High	Moderate	High	High	High	Less	Less	Less	Less	Moderate	High	Less
Route Metric	Link-State	Link-State	Shortest path	Shortest path	Shortest path	Shortest path	Cluster	radius	Closest node	GPS	Shortest path	One hop
Latency	Very Low	Low	Moderate	High	High	Less	Less	Less	Less	Less	Less	Less
Wastage of Bandwidth	High	High	Moderate	Less	Less	Less	Moderate	Less	Less	Moderate	Moderate	Less

4. CONCLUSIONS

A comprehensive survey of different routing algorithms is discussed in previous section. The main intention of this paper is to exhibits several types of routing algorithms in MANETS. It is learnt that, routing in MANETs will be a challenging task and it depends on various parameters. While routing the packets in MANETs network traffic, size, topology structure, battery power, bandwidth are major issues. The presented literature shows the merits and demerits of each routing algorithm in various aspects. The efficiency of the surveyed method can be measured in terms of routing, computational time,

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power consumption, Routing overhead and Bandwidth Topology Structure, Route metric respectively. Therefore this paper can be helpful for further researchers on bettering the current routing protocols and/or to create a new routing protocol to meet the challenges of MANETs for future trends.

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