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A Survey on Routing Protocols for Mobile Ad-hoc Networks (MANETs)

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Abstract

Mobile ad hoc networks (MANETs) are autonomous and self-organized networks which requires almost zero infrastructure support. In MANET, nodes move randomly and then the network may go through rapid and unpredictable topology changes. Because nodes within a MANET as a rule have a very limited transmission ranges, therefore some of the nodes cannot communicate directly with one another. Hence, the routing paths in mobile ad hoc networks potentially contains a number of hops, and each node in MANET gets the responsibility to behave as being a router to complete the communication. This paper is a review of existing research work on routing protocols used in Mobile ad hoc networks (MANETs).

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Keywords

MANET, Routing Protocols, Review, Survey.

Introduction

A large number of studies have been conducted and documented mainly in the fields of Medium Access Control (MAC), routing, power control, security and resource management within Mobile and Ad hoc Networks (MANETs) [1]-[33]. Routing protocols being one of the most important topic of research in dynamic multi-hop networks, many MANET routing protocols are actually proposed, discussed and documented during last decade. Keeping all special properties of MANETs planned, any routing protocol, on the whole are hoped for being distributed making sure that to possess increased reliability, need to be designed considering unidirectional links to check physical factors, must be power-efficient, should think about challenges in connection with security, must be a lot more reactive than proactive to avoid overhead, should become aware of Service quality (QoS) requirements.

Routing Protocols for MANETs

In MANET, Routing protocols can be classified into three major categories: Proactive, Reactive and Hybrid routing protocols. Proactive routing protocols continuously learn the changes in the topology within a network by exchanging real-time topological information among the neighbouring network nodes. Therefore, whenever there is a requirement arises for a route from source to destination node, such routing information is available immediately to the source node. Frequently changing network topology could increase the overall cost of maintaining the network. But, if the network topology changes are slow, the information about change in topology might even not be used, reducing the overall cost of maintaining the network. The reactive routing protocols are basically based on query-reply based communication between nodes. Whenever there is a requirement arises for a route from source to destination node, reactive protocols start the process of establishing route from source to the destination. They do not share or transmit periodic information about topological changes in the network. Hybrid Routing Protocols are the combination of reactive and proactive protocols to yield better solution for routing. Hence, in the recent years, several hybrid protocols are also proposed and documented [1, 2, 3, 4].

Good method of delivery of data packets through the source to destination,

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classification of MANET routing protocols might be done the following:

1. `Unicast Routing Protocols`: The routing protocols that consider sending information packets with a single destination from the single source.

2. `Multicast Routing Protocols`: Multicast may be the delivery of knowledge to your list of destinations simultaneously, while using well organized technique to deliver the messages over each link with the network just once, creating copies as long as the links for the destinations split.

In MANET, Multicast routing protocols uses both multicast as well as unicast routing for data transmission.

Multicast routing protocols for MANET might be classified again into two categories:

1. Tree-based multicast protocol and

2. Mesh-based multicast protocol.

Mesh-based routing protocols use several routes to arrive at a destination while tree-based protocols maintain only one path.

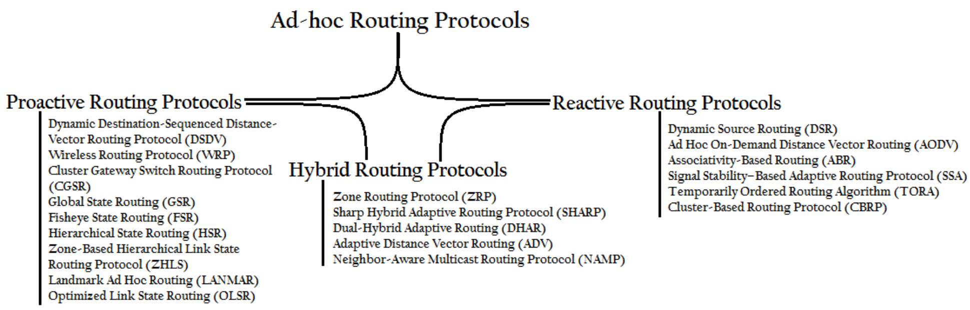

Figure 1: *Classification of Ad-hoc Routing Protocols*

Some of the challenges in the field of MANET are as follows [3]:

1. Dynamic network topology,

2. Speed,

3. Frequency of updates or Network overhead,

4. Scalability,

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5. Mobile agent based routing,
6. Quality of Service,
7. Energy efficient/Power aware routing,
8. Secured routing.

MANETs: Proactive Routing Protocols

Proactive routing protocols may also be called as table driven routing protocols. With this every node maintain routing table which contains details about the topology even without requiring it [5]. This useful feature for datagram traffic, brings significant signalling traffic and consumption of power [6]. The routing tables are updated periodically whenever the topology changes. Proactive protocols are not suited to large networks as they need to maintain node entries for every single node within the routing table of any node [7]. These protocols maintain different amount of routing tables varying from protocol to protocol. There are several popular proactive routing protocols. Example: DSDV, OLSR, WRP etc.

Dynamic Destination-Sequenced Distance-Vector Routing Protocol (DSDV)

DSDV [8] is developed by Bellman-Ford routing [9]. algorithm by modifications. Therein routing protocol, each mobile node within the network keeps a routing table. Each one of the routing table provides the directory all available destinations and the number of hops to every. Each table entry is tagged which has a sequence number, which can be originated because of the destination node. Periodic transmissions of updates on the routing tables help maintaining the topology information with the network. If you experience any new significant change for that routing information, the updates are transmitted immediately. So, the information of routes are updates either as periodic or as event driven. DSDV protocol requires each mobile node within the network advertising its routing table to its current neighbours. The advertisement is finished either by broadcasting or by multicasting. Advertisements can make neighbouring nodes learn about changes that occurred in the network due to the activities of nodes. The route update can possibly be submitted in two ways, one is called as full dump and other as incremental. In the case of full dump, the full routing table is delivered to the neighbours, when in case there is incremental update, exactly the entries which need changes are sent [1, 2, 3, 4].

Wireless Routing Protocol (WRP)

WRP [9] is among the general class of path-finding algorithms [8, 10, 11], looked as the number of distributed shortest path algorithms that calculate the paths using information regarding the length and second-to-last hop with the shortest road to each node maintains four things:

1. A distance table
2. A routing table
3. A link-cost table
4. A message retransmission list (MRL).

WRP uses periodic update message transmissions to the neighbours of a node. The nodes within the response report on update message (that is formed using MRL) should send acknowledgements. If there is no change since the past update, the nodes should send an idle Hello message to guarantee connectivity from the previous list. After receiving updated message from the neighbouring node, a node can decide whether or not to update its route information and try to find an alternative path when using this new routing table. If the node gets a much better path, it relays back that information to the original nodes to enable them to update their tables. After receiving the acknowledgement, the original node updates its MRL. Therefore, every time the regularity on the routing details are checked by every node in this protocol, which helps to reduce routing loops and try to find the very best optimal solutions for routing within a network [1, 2, 3, 4].

Cluster Gateway Switch Routing Protocol (CGSR)

CGSR [12] considers a clustered mobile wireless network rather than "flat" network. Cluster heads are chosen by using a cluster head selection algorithm in order to structure the network into split but interrelated groups. This protocol achieves a dispersed processing method from the network by forming several clusters. However, one disadvantage to this protocol is that, frequent change or number of cluster heads may very well be resource hungry plus it might affect the routing performance. CGSR uses DSDV protocol since the underlying routing scheme and, hence, it's exactly the same overhead as DSDV. However, it modifies DSDV with a hierarchical cluster-head-to-gateway routing procedure for route traffic from source to destination. Gateway nodes are nodes that are in the communication ranges of two or more cluster heads. A packet sent with

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a node is first provided for its cluster head, so the packet is sent through the cluster visit a gateway to another cluster head, and many others before the cluster head in the destination node is reached. The packet will be transmitted on the destination by reviewing the own cluster head [1, 2, 3, 4].

Global State Routing (GSR)

In Global State routing (GSR) protocol [13], nodes during routing information exchange, share their vectors of link states among their neighbouring nodes. Nodes maintain their global information depending on their link state vectors; this gives them information about their topologies so that they can locally optimize their routing decisions. Functionally, this protocol resembles DSDV, but it really improves DSDV from the sense which it avoids flooding of routing messages [1, 2, 3, 4].

Fisheye State Routing (FSR)

FSR [14] was made along with GSR. The novelty of FSR is that it works on the special structure with the network referred to as “fisheye”. This protocol cuts down on the quantity of traffic for transmitting the update messages. The fundamental idea is always that each update message does not contain information regarding all nodes. Instead, it contains update specifics of the nearer nodes more often in contrast to the farther nodes. Hence, each node can offer accurate and exact details about its neighbouring nodes [1, 2, 3, 4].

Hierarchical State Routing (HSR)

HSR [15] combines dynamic, distributed multilevel hierarchical clustering technique through an efficient location management scheme. In this protocol, a partition of the network is done into several clusters having a cluster head in the lower level in the hierarchy. Each cluster heads becomes person in the following to the higher-level. To get the principle understanding of the HSR protocol, it is important to understand that each cluster head summarizes distinctive cluster information and using gateways they pass it to the neighbouring cluster heads. This algorithm makes a node flood the obtained information to its lower level nodes at any time. The hierarchical data structure found in this protocol is efficient enough to provide data successfully to any kind with the network [1, 2, 3, 4].

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Zone-Based Hierarchical Link State (ZHLS)

In Zone-Based Hierarchical Link State routing protocol [16], the network is divided into non-overlapping zones similar to the cellular networks. Each node contains the information about the node connectivity within its zone and the connectivity information of the complete network. The links state routing is carried out using two levels: node level and global zone level. ZHLS does not have any cluster head inside network like other hierarchical routing protocols. The zone level topological facts are distributed to every node. As only zone and node IDs of a destination node is required for routing, the pathway from source to final destination is adaptable to varying topology. The zone ID of the destination is located by sending one location request to each and every zone [1, 2, 3, 4].

Landmark Ad Hoc Routing (LANMAR)

LANMAR [16] combines the characteristics of Fish-eye State Routing (FSR) and Landmark Routing [17]. It uses the technique of landmark from Landmark Routing, that has been originally developed for fixed wide area networks. A landmark is defined as a router whose neighbour routers inside a certain quantity of hops contain routing entries for that router. By using this concept LANMAR divides the network into several pre-defined logical sub networks, each using a pre-selected landmark information. All nodes within a subnet are assumed to relocate en masse, plus they remain connected to the other person via Fisheye State Routing (FSR).The routes towards the landmarks, so because of this the corresponding subnets, are pro actively maintained by all nodes in the network from the exchange of distance-vectors. LANMAR might be regarded as an extension box of FSR, which exploits group mobility by summarizing the routes to the group members which has a single path to a landmark [1, 2, 3, 4].

Optimized Link State Routing (OLSR)

OLSR [18] protocol inherits the stability of link state algorithm. This protocol performs hop-by-hop routing; that's, each node inside the network uses its most current information to route a packet. Hence, no matter if a node is moving, its packets is usually successfully delivered to it, whether speed is such that it is movements could at-least be followed in its neighbourhood. The main optimization in this routing protocol is done twice. Firstly, OLSR reduces the height and width of the control packets for just a particular node by declaring just a subset of links with the node's neighbours who're its multipoint relay selectors, as opposed to all links in the network. Secondly, it reduces the flooding with

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control traffic by utilizing exactly the required nodes, called multipoint relays to broadcast information into the network. As only multipoint relays of any node can retransmit its broadcast messages, this protocol significantly reduces the volume of retransmissions inside a flooding or broadcast procedure [1, 2, 3, 4].

MANETs: Reactive Routing Protocols

Reactive routing protocol is also referred to as at the moment routing protocol. In this protocol, route information is discovered when it's needed. Nodes initiate route discovery on the need basis. Source node sees its route cache for your available route from source to destination if the route seriously isn't available then it initiates route discovery process. The on-demand routing protocols have two main mechanisms [19]:

1. `Route discovery`: In this phase source node initiates route discovery when needed basis. Source nodes consults its route cache memory for the already existing route from source to the final destination, otherwise incase the route isn't present it initiates its discovery. The foundation node, in the packet, includes the destination address from the node likewise address with the intermediate nodes towards destination.

2. `Route maintenance`: On account of dynamic topology in the network cases from the route failure relating to the nodes arises on account of link breakage etc, so route maintenance is completed. Reactive protocols have acknowledgement mechanism with the result that route maintenance can be done.

Reactive protocols add latency to the network as a result of route discovery mechanism. Each intermediate node active in the route discovery process adds latency. These protocols decrease the routing overhead but at the expense of increased latency in the network. Hence these protocols are suitable inside the situations where low routing overhead becomes necessary. There are numerous recognized reactive routing protocols seen in MANET for example DSR, AODV, TORA, LMR, etc [1, 2, 3, 4].

Dynamic Source Routing (DSR)

DSR protocol is a type of reactive protocol and it is based on the source route approach [20]. In DSR protocol, it is based on the link state algorithm through which source node starts the route discovery on-demand basis. The sender node determines the route from source to the final destination and it includes the address information of the intermediate nodes for the route record into its packet. DSR principal purpose is for multi hop networks for small Diameters. This can be a beacon-less protocol during which no HELLO messages are exchanged between nodes to inform them of their neighbours inside the network [1, 2, 3, 4, 21].

Ad Hoc On-Demand Distance Vector Routing Protocol (AODV)

AODV [22] is basically a marked improvement of DSDV. But, AODV is usually a reactive routing protocol as an alternative to proactive. It reduces the number of transmissions by creating routes established on demand, which isn't the case for DSDV. When any source node requires sending a packet to the destination node, it transmits a route request (RREQ) packet to the entire network. The neighbouring nodes consequently broadcast the packet on their neighbours as well as the process continues before packet reaches the destination. During the procedure of forwarding the route request, in-between nodes records the address from the neighbouring node where the first copy of the broadcast packet is received. This record is saved in their route tables, which supports for establishing a reverse path. If additional copies of the same RREQ packets are received later, are of no use and thereby discarded. The solution is sent with all of the reverse path. For route maintenance, every time a source node moves, it could re-initiate a route discovery process. If any intermediate node moves with a particular route, the neighbour with the drifted node can detect the link failure and sends a keyword rich link failure notification to its upstream neighbour. This process continues before the failure notification reaches the source node. On the basis of received information, the source node can decide to re-start the route discovery process [1, 2, 3, 4].

Associativity-Based Routing (ABR)

ABR [23] protocol defines a whole new kind of routing metric "a higher level association stability" for mobile random networks. Therein routing protocol, a route is selected in line with the higher level association stability of mobile nodes. Periodic beacons are generated by individual nodes to announce their existence. Upon receiving the beacon message, a neighbour node updates its associativity table. For each and every beacon received, the associativity tick on the receiving node with the entire beaconing node is increased. Unparalleled combination of associativity tick for just about any particular beaconing node ensures that the node is fairly static. Associativity tick is reset when any neighbouring node moves out of the neighbourhood of any other node [1, 2, 3, 4].

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Signal Stability-Based Adaptive Routing Protocol (SSA)

SSA [24] protocol concentrates on receiving the most stable routes with an ad hoc network. The protocol performs at will route discovery depending on signal strength and placement stability. SSA detects weak and strong links/channels within a network, using signal strengths. SSA may be split up into two cooperative protocols: the Dynamic Routing Protocol (DRP) as well as the Static Routing Protocol (SRP). DRP uses two tables: Signal Stability Table (SST) & Routing Table (RT). SST saves the signal strengths from the surrounding nodes by monitoring periodic beacons from the link layer of every neighbouring node. These signal strengths are saved and classified as weak or strong. DRP receives every one of the transmissions and, after processing, it passes those to the SRP. SRP passes the packet towards the nodes upper layer stack whether it is the destination. Otherwise, it searches for the destination in routing table and forwards the packet. If you find no entry from the routing table for your destination, it initiates the path-finding process. Route-request packets are forwarded on the neighbours with all the strong channels. The destination, after having the request, chooses the primary arriving request packet and sends back the reply. The DRP sends a route-reply RR message time to the originating node of route request and reverses the selected route. The DRPs on the nodes on the path update their routing tables accordingly. In the event of a link failure, the intermediate nodes send a blunder message to the source indicating which channel has failed. The source node in turn transmits an erase message to see all nodes with the broken link and re-initiates a new route-search procedure to discover a new way to the destination node [1, 2, 3, 4].

Temporarily Ordered Routing Algorithm (TORA)

TORA [26] is usually a reactive routing protocol by proactive enhancements when a link between nodes is established making a Directed Acyclic Graph (DAG) on the route on the source node towards the destination. This protocol relies on a “link reversal” model on how discovery. A route discovery query is broadcasted and propagated over the network until it reaches the destination or maybe a node that has information regarding how you can get to the destination. TORA defines a parameter, termed height. Height is frequently considered a way of measuring the distance between the responding nodes to the required destination node. Inside the route discovery phase, this parameter is returned towards the querying node. Each intermediate node updates their route and height information to the destination node, in its TORA table because query response travels back. The source node then uses the peak to select the best route

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toward the destination. This protocol possesses an interesting property that it frequently chooses probably the most convenient route, instead of the shortest route. TORA tries to reduce the route management traffic overheads [1, 2, 3, 4].

Cluster-Based Routing Protocol (CBRP)

Cluster-Based CBRP [25] is regarded as a clustered mobile wireless network. For structuring the network into distinct but interrelated groups, they elects cluster heads using cluster head selection algorithm. This protocol achieves a distributed processing method by forming several clusters within a network. However, one drawback of this protocol is the fact that, frequent change or number of cluster heads might be resource hungry plus it might affect the routing performance. CGSR uses DSDV protocol since the underlying routing scheme and, hence, it offers the identical overhead as DSDV. It modifies DSDV algorithm by adding a hierarchical cluster-head-to-gateway based routing method for routing from source to the final destination. Gateway nodes are nodes which are from the communication ranges of 2 or more cluster heads. A packet sent with a node is first sent to its cluster head, and the packet is sent from the cluster head over to a gateway completely to another cluster head, etc until the cluster head in the destination node is reached. The packet is then transmitted on the destination looking at the own cluster head [1, 2, 3, 4].

MANETs: Hybrid Routing Protocols

You will find there's trade-off between proactive and reactive protocols. Proactive protocols have wide operating cost and less latency, on the other hand reactive protocols have less operating cost and much more latency. So a Hybrid protocol is presented to get over the shortcomings of both proactive and reactive routing protocols. Hybrid routing protocol is mixture of both proactive and reactive routing protocol. It uses the road discovery mechanism of reactive protocol and also the table maintenance mechanism of proactive protocol in order to avoid latency and overhead problems from the network. Hybrid protocol works for big networks where large numbers of nodes are mixed together. Therein large network is divided into list of zones where routing inside the zone is carried out by employing reactive approach and outside of the zone routing is completed using reactive approach [1, 2, 3, 4].

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Zone Routing Protocol (ZRP)

Zone Routing Protocol [27] is acceptable for wide selection of MANETs, particularly for the networks with large coverage and diverse mobility patterns. Within this protocol, each node pro-actively maintains routes with a local region, and that is known as routing zone. Route creation is performed by using a query-reply mechanism. For creating different zones inside network, a node first has to know who its neighbours are. A neighbour means a node with whom direct communication is usually established, which is within one hop transmission array of a node. Neighbour discovery facts are used as being a basis for Intra-zone Routing Protocol (IARP), which can be described in more detail in [28]. As an alternative to blind broadcasting, ZRP runs on the query control mechanism to cut back route query traffic by directing query messages outward from your query source and away from covered routing zones. A covered node is really a node which belongs to the routing zone of any node which has received a route query. During the forwarding with the query packet, a node identifies be it via its neighbour or not. If yes, then it marks most of its known neighbouring nodes in the same zone as covered. Therefore query is relayed until it reaches its final destination. The destination in turn sends back a response message through the reverse path and helps to create the path [1, 2, 3, 4].

Sharp Hybrid Adaptive Routing Protocol (SHARP)

SHARP [29] adapts between reactive and proactive routing by dynamically varying the quantity of routing information shared proactively. This protocol defines the active zones around some of the nodes. The quantity of nodes in a particular proactive zone depends on the node-specific zone radius. All nodes in the zone radius of the particular node end up being the member of that particular proactive zone for your node. If to get a given destination a node is just not present in just a particular proactive zone, reactive routing mechanism (query-reply)is employed to ascertain the route to that node. Proactive routing mechanism is employed from the proactive zone. Nodes in the active zones maintain routes actively with respect to the central node. Therein protocol, proactive zones are made automatically if some destinations are likely to be addressed or sought within the network. The active zones work as collectors of data packets, which forward these packets efficiently to final destination, if the packets reaches any terminal node at the zone vicinity [1, 2, 3, 4].

Dual-Hybrid Adaptive Routing (DHAR)

DHAR [30] uses the Distributed Dynamic Cluster Algorithm (DDCA) presented in [31]. The concept of DDCA is to partition the network in real-time, into some non-overlapping clusters of nodes. In DHAR, routing is completed using a dynamic two-level hierarchical process, including optimal and less-complicated table-driven algorithms operating at every level. DHAR implements a proactive less-complicated level-2 routing protocol. This is in combination with another dynamic binding protocol to obtain its hybrid distinctiveness. The exact level-2 protocol in DHAR mandates that one node generates an update regarding its cluster. If a level-2 update is generated, it should be flooded to every nodes in each neighbouring cluster. Level-2 updates usually are not transmitted beyond the neighbouring clusters. The node while using lowest node ID in each cluster is designated to come up with level-2 updates. The binding process is just like a reactive route discovery process; however, a priori knowledge of clustered topology can make it significantly more efficient and simpler to accomplish the routing. To send packets towards desired destination, a source node uses the dynamic binding protocol to find out the actual cluster ID associated with the destination. Once determined, this post is maintained from the dynamic cluster binding cache for the source node. The dynamic binding protocol utilizes the data packets from the level-2 topology to proficiently transmit a binding request to all of the nodes in a cluster. This is accomplished using reverse path forwarding depending on source cluster [1, 2, 3, 4].

Adaptive Distance Vector Routing (ADV)

ADV [31] routing protocol is really a distance-vector routing algorithm that exhibits some on-demand features by varying the frequency along with the size of routing updates responding to the network load and mobility patterns. ADV uses an adaptive mechanism to mitigate the issue of periodic transmissions of the routing updates, which basically relies upon the network load and mobility conditions. To reduce the length of routing updates, ADV advertises and maintains routes for your active receivers only. A node is regarded active if it's the receiver of any currently active connection. There's a receiver flag from the routing entry, which keeps the info regarding the status of your receiver whether it is active or inactive. To deliver data packet, a source node transmits a network-wide initial connection control packet. All of those other nodes trip the related receiver flag in their own individual routing tables and initiate advertising the routes to the receiver later on updates. When the target node gets the init-connection packet, it replies with it by transmitting a receiver-alert

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packet and becomes active. To close a network connection, the source node transmits a network-wide conclusion connection control packet, representing that this connection will be stopped. If the destination node doesn't have additional active connection, it broadcasts a non-receiver-alert message. Should the initial connection packet and receiver-alert message packets are lost; the source node advertises the receiver's entry by placing a receiver flag in all future updates. ADV also defines another parameters like trigger meter, trigger threshold, and buffer threshold. These include used for limiting the network traffic using the network' s mobility pattern and network speed [1, 2, 3, 4].

Neighbour-Aware Multicast Routing Protocol (NAMP)

NAMP [32] can be a tree-based hybrid routing protocol, which utilizes neighbourhood information. The routes within the network are planned and maintained via traditional request and reply messages or based-on demand. This hybrid protocol uses neighbour information of two-hops away for transmitting the packets towards the receiver. If your receiver isn't within this range, it searches the receiver using dominant pruning flooding method [33] and forms a multicast tree when using the replies down the reverse path. Even though mesh structure is proven to be more robust against topological changes, the tree structure is much better regarding packet transmission. As NAMP targets to obtain less end-to-end delay of packets, it uses the tree structure. You will find mainly three operations addressed in NAMP: Multicast tree creation, tree maintenance & Joining and leaving of nodes through the multicast cluster. Every one of the nodes from the network keep neighbourhood information as high as two-hop away nodes. This neighbourhood info is maintained using a proactive mechanism. Periodic hello packet issued because of this. To generate the multicast tree, the source node sends a flood request packet towards the destination with data payload attached. This packet is flooded inside the network using dominant pruning method, which actually minimizes the volume of transmissions inside the network for any particular flood request packet. Over the forwarding procedure for the packet, each node selects a forwarder and helps to create an extra forwarder list (SFL). The secondary forwarder list (SFL) contains the information regarding the nodes that had been primarily thought to be possible forwarders but finally just weren't selected for the purpose. Each middle node uses the selected forwarder to forward the data packet, but keeps the data about other potential forwarders in SFL. Secondary forwarder list issued for repairing any broken route inside the network. Infact, link failure recovery is probably the greatest features of NAMP [1, 2, 3, 4].

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