A Literature Survey of Routing Protocols in MANETs

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Abstract: ***Mobile Ad Hoc Network (MANET) is collection of multi-hop wireless mobile nodes that communicate with each other without centralized control or established infrastructure. The wireless links in this network are highly error prone and can go down frequently due to mobility of nodes, interference and less infrastructure. Therefore, routing in MANET is a critical task due to highly dynamic environment. In recent years, several routing protocols have been proposed for mobile ad hoc networks and prominent among them are DSR, AODV and TORA. This research paper provides an overview of these protocols by presenting their characteristics, functionality, benefits and limitations and then makes their comparative analysis so to analyze their performance. The objective is to make observations about how the performance of these protocols can be improved.***

Keywords: MANET, Proactive and Reactive routing protocols, Multicasting, DSDV.

1. Introduction

Mobile networks can be classified into infrastructure networks and mobile ad hoc networks [1] according to their dependence on fixed infrastructures. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. The access points compose the backbone for an infrastructure network. In contrast, mobile ad hoc networks are autonomously self-organized networks without infrastructure support. In a mobile ad hoc network, nodes move arbitrarily, therefore the network may experiences rapid and unpredictable topology changes. Additionally, because nodes in a mobile ad hoc network normally have limited transmission ranges, some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router.

A. Characteristics of routing protocols

To compare and analyze mobile ad hoc network routing protocols, appropriate classification methods are important. Classification methods help researchers and designers to understand distinct characteristics of a routing protocol and find its relationship with others.

a) Proactive, reactive and hybrid routing

One of the most popular methods to distinguish mobile ad hoc network routing protocols is based on how routing information is acquired and maintained by mobile nodes. Using this method, mobile ad hoc network routing protocols can be divided into proactive routing, reactive routing and hybrid routing.

A proactive routing protocol is also called "table driven" routing protocol. Using a proactive routing protocol, nodes in a mobile ad hoc network continuously evaluate routes to all reachable nodes and attempt to maintain consistent, up-to-date routing information. Therefore, a source node can get a routing path immediately if it needs one.

In proactive routing protocols, all nodes need to maintain a consistent view of the network topology. When a network topology change occurs, respective updates must be propagated throughout the network to notify the change. Most proactive routing protocols proposed for mobile ad hoc networks have inherited properties from algorithms used in wired networks. To adapt to the dynamic features of mobile ad hoc networks, necessary modifications have been made on traditional wired network routing protocols. Using proactive routing algorithms, mobile nodes proactively update network state and maintain a route regardless of whether data traffic exists or not, the overhead to maintain up-to-date network topology information is high

Reactive routing protocols for mobile ad hoc networks are also called "on-demand" routing protocols. In a reactive routing protocol, routing paths are searched only when needed. A route discovery operation invokes a route-determination procedure. The discovery procedure terminates either when a route has been found or no route available after examination for all route permutations.

In a mobile ad hoc network, active routes may be disconnected due to node mobility. Therefore, route maintenance is an important operation of reactive routing protocols. Compared to the proactive routing protocols for mobile ad hoc networks, less control overhead is a distinct advantage of the reactive routing protocols. Thus, reactive routing protocols have better scalability than proactive routing protocols in mobile ad hoc networks. However, when using reactive routing protocols, source nodes may suffer from long delays for route searching before they can forward data packets. The Dynamic Source Routing (DSR) [2] and Ad hoc On- demand Distance Vector routing (AODV) [3] are examples for reactive routing protocols for mobile ad hoc networks.

b) Structuring and delegating the routing task

Another classification method is based on the roles which nodes may have in a routing scheme. In a uniform routing protocol, all mobile nodes have same role, importance and functionality. Examples of uniform routing protocols include Wireless Routing Protocol (WRP), Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector routing (AODV) and Destination Sequence Distance Vector (DSDV) routing protocol. Uniform routing protocols normally assume a flat network structure. In a non-uniform routing protocol for mobile ad hoc networks, some nodes carry out distinct management and/or routing functions. Normally, distributed algorithms are exploited to select those special nodes. In some cases, non-uniform routing approaches are related to hierarchical network structures to facilitate node organization and management. Non-uniform routing protocols further can be divided according to the organization of mobile nodes and how management and routing functions are performed. Following these criteria, non-uniform routing protocols for mobile ad hoc networks are divided into zone based hierarchical routing; cluster-based hierarchical routing and core-node based routing.

A cluster based routing protocol uses specific clustering algorithm for cluster head election. Mobile nodes are grouped into clusters and cluster heads take the responsibility for membership management and routing functions. Cluster head Gateway Switch Routing (CGSR) [4] will be introduced in Section 5 as an example of cluster based mobile ad hoc network routing protocols. Some cluster based mobile ad hoc network routing protocols potentially support a multi-level cluster structure, such as the Hierarchical State Routing (HSR) [5].

c) Exploiting network metrics for routing

Metrics used for routing path construction can be used as criteria for mobile ad hoc network routing protocol classification. Most routing protocols for mobile ad hoc networks use "hop number" as a metric. If there are multiple routing paths available, the path with the minimum hop number will be selected. If all wireless links in the network have the same failure probability, short routing paths are more stable than the long ones and can obviously decrease traffic overhead and reduce packet collisions. However, the assumption of the same failure properties may not be true in mobile ad hoc networks. Therefore, the stability of a link has to be considered in the route construction phase. For example, routing approaches such as Associativity Based Routing (ABR) [6] and Signal Stability based Routing (SSR) [7] are proposed that use link stability or signal strength as metric for routing.

d) Evaluating topology, destination and location for routing

In a topology based routing protocol for mobile ad hoc networks, nodes collect network topology information for making routing decisions. Other than topology based routing protocols, there is some destination-based routing protocols proposed in mobile ad hoc networks. In a destination–based routing protocol a node only needs to know the next hop along the routing path when forwarding a packet to the destination. For example, DSR is a topology based routing protocol. AODV and DSDV are destination based routing protocols. The availability of GPS or similar locating systems allows mobile nodes to access geographical information easily. In location-based routing protocols, the position relationship between a packet forwarding node and the destination, together with the node mobility can be used in both route discovery and packet forwarding. Existing location-based routing approaches for mobile ad hoc networks can be divided into two schemes. In the first scheme, mobile nodes send packets merely depending on the location information and do not need any extra knowledge. The other scheme uses both location information and topology information. Location Aided Routing (LAR) [8] and Distance Routing Effect Algorithm for Mobility (DREAM) [9] are typical location-based routing protocols proposed for mobile ad hoc networks.

e) Multicast routing protocols

Most classification methods used for unicast routing protocols for mobile ad hoc networks are also applicable for existing multicast routing protocols. For example, multicast routing algorithms for mobile ad hoc networks can be classified into reactive routing and proactive routing. The Ad-hoc Multicast Routing (AMRoute) [10] and Ad hoc Multicast Routing protocol utilizing Increasing id numbers (AMRIS) [11] belong to category of proactive multicast routing and the On-Demand Multicast Routing Protocol (ODMRP) [12] and Multicast Ad hoc On-demand Distance Vector (MAODV) [13] are reactive multicast routing protocols.

2. Proposed Proactive Routing Protocol

2.1 The Wireless Routing Protocol (WRP)

WRP [14] belongs to the general class of path-finding algorithms [15, 16, 17], defined as the set of distributed shortest path algorithms that calculate the paths using information regarding the length and second-to-last hop of the shortest path to each destination. WRP reduces the number of cases in which a temporary routing loop can occur. For the purpose of routing, 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 neighbors of a node. The nodes in the response list of update message (which is formed using MRL) should send acknowledgments. If there is no change from the last update, the nodes in the response list should send an idle Hello message to ensure connectivity. A node can decide whether to update its routing table after receiving an update message from a neighbor and always it looks for a better path using the new information. If a node gets a better path, it relays back that information to the original nodes so that they can update their tables. After receiving the acknowledgment, the original node updates its MRL. Thus, each time the consistency of the routing information is checked by each node in this protocol, which helps to eliminate routing loops and always tries to find out the best solution for routing in the network.

2.2 The Destination Sequence Distance Vector (DSDV) routing protocol

DSDV [18] is developed on the basis of Bellman–Ford routing [15] algorithm with some modifications. In this routing protocol, each mobile node in the network keeps a routing table. Each of the routing table contains the list of all available destinations and the number of hops to each. Each table entry is tagged with a sequence number, which is originated by the destination node. Periodic transmissions of updates of the routing tables help maintaining the topology information of the network. If there is any new significant change for the routing information, the updates are transmitted immediately. So, the routing information updates might either be periodic or event driven. DSDV protocol requires each mobile node in the network to advertise its own routing table to its current neighbors. The advertisement is done either by broadcasting or by multicasting. By the advertisements, the neighboring nodes can know about any change that has occurred in the network due to the movements of nodes. The routing updates could be sent in two ways: one is called a ‘‘full dump’’ and another is ‘‘incremental.’’ In case of full dump, the entire routing table is sent to the neighbors, where as in case of incremental update, only the entries that require changes are sent.

2.3 Cluster Gateway Switch Routing Protocol (CGSR)

CGSR [17] considers a clustered mobile wireless network instead of a ‘‘flat’’ network. For structuring the network into separate but interrelated groups, cluster heads are elected using a cluster head selection algorithm. By forming several clusters, this protocol achieves a distributed processing mechanism in

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the network. However, one drawback of this protocol is that, frequent change or selection of cluster heads might be resource hungry and it might affect the routing performance. CGSR uses DSDV protocol as the underlying routing scheme and, hence, it has the same overhead as DSDV. However, it modifies DSDV by using a hierarchical cluster-head-to-gateway routing approach to route traffic from source to destination. Gateway nodes are nodes that are within the communication ranges of two or more cluster heads. A packet sent by a node is first sent to its cluster head, and then the packet is sent from the cluster head to a gateway to another cluster head, and so on until the cluster head of the destination node is reached. The packet is then transmitted to the destination from its own cluster head.

2.4 Global State Routing (GSR)

In GSR protocol [19], nodes exchange vectors of link states among their neighbors during routing information exchange. Based on the link state vectors, nodes maintain a global knowledge of the network topology and optimize their routing decisions locally. Functionally, this protocol is similar to DSDV, but it improves DSDV in the sense that it avoids flooding of routing messages.

2.5 Fisheye State Routing (FSR)

FSR [20] is built on top of GSR. The novelty of FSR is that it uses a special structure of the network called the ‘‘fisheye.’’ This protocol reduces the amount of traffic for transmitting the update messages. The basic idea is that each update message does not contain information about all nodes. Instead, it contains update information about the nearer nodes more frequently than that of the farther nodes. Hence, each node can have accurate and exact information about its own neighboring nodes.

2.6 Hierarchical State Routing (HSR)

HSR [21] combines dynamic, distributed multilevel hierarchical clustering technique with an efficient location management scheme. This protocol partitions the network into several clusters where each elected cluster head at the lower level in the hierarchy becomes member of the next higher level. The basic idea of HSR is that each cluster head summarizes its own cluster information and passes it to the neighboring cluster heads using gateways. After running the algorithm at any level, any node can flood the obtained information to its lower level nodes. The hierarchical structure used in this protocol is efficient enough to deliver data successfully to any part of the network.

2.7 Zone-Based Hierarchical Link State Routing Protocol (ZHLS)

In ZHLS protocol [22], the network is divided into non overlapping zones as in cellular networks. Each node knows the node connectivity within its own zone and the zone connectivity information of the entire network. The link state routing is performed by employing two levels: node level and global zone level. ZHLS does not have any cluster head in the network like other hierarchical routing protocols. The zone level topological information is distributed to all nodes. Since only zone ID and node ID of a destination are needed for routing, the route from a source to a destination is adaptable to changing topology. The zone ID of the destination is found by sending one location request to every zone.

2.8 Landmark Ad Hoc Routing (LANMAR)

LANMAR [22] combines the features of Fisheye State Routing (FSR) and Landmark Routing [23]. It uses the concept of landmark from Landmark Routing, which was originally developed for fixed wide area networks. A landmark is defined as a router whose neighbor routers within a certain number of hops contain routing entries for that router. Using this concept for the nodes in the MANET, LANMAR divides the network into several pre-defined logical subnets, each with a preselected landmark. All nodes in a subnet are assumed to move as a group, and they remain connected to each other via Fisheye State Routing (FSR).The routes to the landmarks, and hence the corresponding subnets, are proactively maintained by all nodes in the network through the exchange of distance vectors. LANMAR could be regarded as an extension of FSR, which exploits group mobility by summarizing the routes to the group members with a single route to a landmark.

2.9 Optimized Link State Routing (OLSR)

OLSR [24] protocol inherits the stability of link state algorithm. This protocol performs hop-by-hop routing; that is, each node in the network uses its most recent information to route a packet. Hence, even when a node is moving, its packets can be successfully delivered to it, if its speed is such that its movements could at least be followed in its neighborhood. The optimization in the routing is done mainly in two ways. Firstly, OLSR reduces the size of the control packets for a particular node by declaring only a subset of links with the node's neighbors who are its multipoint relay selectors, instead of all links in the network. Secondly, it minimizes flooding of the control traffic by using only the selected nodes, called multipoint relays to disseminate information in the network. As only multipoint relays of a node can retransmit its broadcast messages, this protocol significantly reduces the number of retransmissions in a flooding or broadcast procedure.

3. Proposed Reactive Routing Protocols

3.1 Associativity-Based Routing (ABR)

ABR [25] protocol defines a new type of routing metric "degree of association stability" for mobile ad hoc networks. In this routing protocol, a route is selected based on the degree of association stability of mobile nodes. Each node periodically generates beacon to announce its existence. Upon receiving the beacon message, a neighbor node updates its own associativity table. For each beacon received, the associativity tick of the receiving node with the beaconing node is increased. A high value of associativity tick for any particular beaconing node means that the node is relatively static. Associativity tick is reset when any neighboring node moves out of the neighborhood of any other node.

3.2 Signal Stability–Based Adaptive Routing Protocol (SSA)

SSA [26] protocol focuses on obtaining the most stable routes through an ad hoc network. The protocol performs on demand route discovery based on signal strength and location stability. Based on the signal strength, SSA detects weak and strong channels in the network. SSA can be divided into two cooperative protocols: the Dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP). DRP uses two tables: Signal Stability Table (SST) and Routing Table (RT). SST stores the signal strengths of the neighboring nodes obtained by periodic beacons from the link layer of each neighboring node. These signal strengths are recorded as weak or strong. DRP receives all the transmissions and, after processing, it passes those to the SRP. SRP passes the packet to the node's upper layer stack if it is the destination. Otherwise, it looks for the destination in routing table and forwards the packet. If there is no entry in the routing table for that destination, it initiates the route-finding process. Route-request packets are forwarded to the neighbors using the strong channels. The destination, after getting the request, chooses the first arriving request packet and sends back the reply. The DRP reverses the selected route and sends a route-reply message back to the initiator of route request. The DRPs of the nodes along the path update their routing tables accordingly. In case of a link failure, the intermediate nodes send an error message to the source indicating which channel has failed. The source in turn sends an erase message to inform all nodes about the broken link and initiates a new route-search process to find a new path to the destination.

3.3 Temporarily Ordered Routing Algorithm (TORA)

TORA [27] is a reactive routing protocol with some proactive enhancements where a link between nodes is established creating a Directed Acyclic Graph (DAG) of the route from the source node to the destination. This protocol uses a ''link reversal'' model in route discovery. A route discovery query is broadcasted and propagated throughout the network until it reaches the destination or a node that has information about how to reach the destination. TORA defines a parameter, termed height. Height is a measure of the distance of the responding node's distance up to the required destination node. In the route discovery phase, this parameter is returned to the querying node. As the query response propagates back, each intermediate node updates its TORA table with the route and height to the destination node. The source node then uses the height to select the best route toward the destination. This protocol has an interesting property that it frequently chooses the most convenient route, rather than the shortest route. For all these attempts, TORA tries to minimize the routing management traffic overhead.

3.4 Cluster-Based Routing Protocol (CBRP)

CBRP [28] is an on-demand routing protocol, where the nodes are divided into clusters. When a node comes up to start a timer and to broadcast a HELLO message. When a cluster-head receives this HELLO message, it replies immediately with a triggered HELLO message. After that, when the node receives this answer, it changes its state into the member state. But when the node gets no message from any cluster-head, it makes itself as a cluster-head, but only when it has bidirectional link to one or more neighbor nodes. Otherwise, when it has no link to any other node, it stays in the undecided state and repeats the procedure with sending a HELLO message again. Each node has a neighbor table. For each neighbor, the node keeps the status of the link and state of the neighbor in the neighbor table. A cluster head keeps information about all of its members in the same cluster. It also has a cluster adjacency table, which provides information about the neighboring clusters.

3.5 Dynamic Source Routing (DSR)

DSR [29] allows nodes in the MANET to dynamically discover a source route across multiple network hops to any destination. In this protocol, the mobile nodes are required to maintain route caches or the known routes. The route cache is updated when any new route is known for a particular entry in the route cache. Routing in DSR is done using two phases: route discovery and route maintenance. When a source node wants to send a packet to a destination, it first consults its route cache to determine whether it already knows about any route to the destination or not. If already there is an entry for that destination, the source uses that to send the packet. If not, it initiates a route request broadcast. This request includes the destination address, source address, and a unique identification number. Each intermediate node checks whether it knows about the destination or not. If the intermediate node does not know about the destination, it again forwards the packet and eventually this reaches the destination. A node processes the route request packet only if it has not previously processed the packet and its address is not present in the route record of the packet. A route reply is generated by the destination or by any of the intermediate nodes when it knows about how to reach the destination.

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

AODV [30] is basically an improvement of DSDV. But, AODV is a reactive routing protocol instead of proactive. It minimizes the number of broadcasts by creating routes based on demand, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighboring nodes in turn broadcast the packet to their neighbors and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. The reply is sent using the reverse path. For route maintenance, when a source node moves, it can reinitiate a route discovery process. If any intermediate node moves within a particular route, the neighbor of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbor. This process continues until the failure notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase.

4. Proposed Hybrid Routing Protocols

4.1 Dual-Hybrid Adaptive Routing (DHAR)

DHAR [31] uses the Distributed Dynamic Cluster Algorithm (DDCA) presented in [20]. The idea of DDCA is to dynamically partition the network into some non-overlapping clusters of nodes consisting of one parent and zero or more children. Routing is done in DHAR utilizing a dynamic two level hierarchical strategy, consisting of optimal and least overhead table-driven algorithms operating at each level. DHAR implements a proactive least-overhead level-2 routing protocol in combination with a dynamic binding protocol to achieve its hybrid characteristics. The level-2 protocol in DHAR requires that one node generates an update on behalf of its cluster. When a level-2 update is generated, it must be flooded to all the nodes in each neighboring cluster. Level-2 updates are not transmitted beyond the neighboring clusters. The node with the lowest node ID in each cluster is designated to generate level-2 updates. The binding process is similar to a reactive route discovery process; however, a priori knowledge of clustered topology makes it significantly more efficient and simpler to accomplish the routing. To send packets to the desired destination, a source node uses the dynamic binding protocol to discover the current cluster ID associated with the destination. Once determined, this information is maintained in the dynamic cluster binding cache at the source node. The dynamic binding protocol utilizes the knowledge of the level-2 topology to efficiently broadcast a binding request to all the clusters. This is achieved using reverse path forwarding with respect to the source cluster.

4.2 Adaptive Distance Vector Routing (ADV)

ADV [32] routing protocol is a distance-vector routing algorithm that exhibits some on-demand features by varying the frequency and the size of routing updates in response to the network load and mobility patterns. ADV uses an adaptive mechanism to mitigate the effect of periodic transmissions of the routing updates, which basically relies on the network load and mobility conditions. To reduce the size of routing updates, ADV advertises and maintains routes for the active receivers only. A node is considered active if it is the receiver of any currently active connection. There is a receiver flag in the routing entry, which keeps the information about the status of a receiver whether it is active or inactive. To send data, a source node broadcasts network-wide an init-connection control packet. All the other nodes turn on the corresponding receiver flag in their own routing tables and start advertising the routes to the receiver in future updates. When the destination node gets the init-connection packet, it responds to it by broadcasting a receiver-alert packet and becomes active. To close a connection, the source node broadcasts network-wide an end connection control packet, indicating that the connection is to be closed. If the destination node has no additional active connection, it broadcasts a non-receiver-alert message. If the init-connection and receiver-alert messages are lost, the source advertises the receiver's entry with its receiver flag set in all future updates. ADV also defines some other parameters like trigger meter, trigger threshold, and buffer threshold. These are used for limiting the network traffic based on the network's mobility pattern and network speed.

4.3 Zone Routing Protocol (ZRP)

ZRP [33] is suitable for wide variety of MANETs, especially for the networks with large span and diverse mobility patterns. In this protocol, each node proactively maintains routes within a local region, which is termed as routing zone. Route creation is done using a query-reply mechanism. For creating different zones in the network, a node first has to know who its neighbors are. A neighbor is defined as a node with whom direct communication can be established, and that is, within one hop transmission range of a node. Neighbor discovery information is used as a basis for Intra-zone Routing Protocol (IARP), which is described in detail in [34]. Rather than blind broadcasting, ZRP uses a query control mechanism to reduce route query traffic by directing query messages outward from the query source and away from covered routing zones. A covered node is a node which belongs to the routing zone of a node that has received a route query. During the forwarding of the query packet, a node identifies whether it is coming from its neighbor or not. If yes, then it marks all of its known neighboring nodes in its same zone as covered. The query is thus relayed till it reaches the destination. The destination in turn sends back a reply message via the reverse path and creates the route.

4.4 Sharp Hybrid Adaptive Routing Protocol (SHARP)

SHARP [35] adapts between reactive and proactive routing by dynamically varying the amount of routing information shared proactively. This protocol defines the proactive zones around some nodes. The number of nodes in a particular proactive zone is determined by the node-specific zone radius. All nodes within the zone radius of a particular node become the member of that particular proactive zone for that node. If for a given destination a node is not present within a particular proactive zone, reactive routing mechanism (query-reply) is used to establish the route to that node. Proactive routing mechanism is used within the proactive zone. Nodes within the proactive zone maintain routes proactively only with respect to the central node. In this protocol, proactive zones are created automatically if some destinations are frequently addressed or sought within the network. The proactive zones act as collectors of packets, which forward the packets efficiently to the destination, once the packets reach any node at the zone vicinity.

4.4 Neighbor-Aware Multicast Routing Protocol (NAMP*)*

NAMP [36] is a tree-based hybrid routing protocol, which utilizes neighborhood information. The routes in the network are built and maintained using the traditional request and reply messages or on-demand basis. This hybrid protocol uses neighbor information of two-hops away for transmitting the packets to the receiver. If the receiver is not within this range, it searches the receiver using dominant pruning flooding method [37] and forms a multicast tree using the replies along the reverse path. Although the mesh structure is known to be more robust against topological changes, the tree structure is better in terms of packet transmission. As NAMP targets to achieve less end-to-end delay of packets, it uses the tree structure. There are mainly three operations addressed in NAMP: Multicast tree creation, Multicast tree maintenance and Joining and leaving of nodes from the multicast group. All the nodes in the network keep neighborhood information of up to two-hop away nodes. This neighborhood information is maintained using a proactive mechanism. Periodic hello packet issued for this. To create the multicast tree, the source node sends a flood request packet to the destination with data payload attached. This packet is flooded in the network using dominant pruning method, which actually minimizes the number of transmissions in the network for a particular flood request packet. During the forwarding process of the packet, each node selects a forwarder and creates a secondary forwarder list (SFL). The secondary forwarder list (SFL) contains the information about the nodes that were primarily considered as possible forwarders but finally were not selected for that purpose. Each intermediate node uses the chosen forwarder to forward the packet, but keeps the knowledge about other possible forwarders in SFL. Secondary forwarder list issued for repairing any broken route in the network. Infact, link failure recovery is one of the greatest advantages of NAMP.

5. Conclusion

Routing is an essential component of communication protocols in mobile ad hoc networks. The design of the protocols are driven by specific goals and requirements based on respective assumptions about the network properties or application area. The survey tries to review typical routing protocols and reveal the characteristics and trade-offs.

This paper presents a number of routing protocols for MANET, which are broadly categorized as proactive and reactive. Proactive routing protocols tend to provide lower latency than that of the on-demand protocols, because they try to maintain routes to all the nodes in the network all the time. But the drawback for such protocols is the excessive routing overhead transmitted, which is periodic in nature without much consideration for the network mobility or load. On the other hand, though reactive protocols discover routes only when they are needed, they may still generate a huge amount of traffic when the network changes frequently. Depending on the amount of network traffic and number of flows, the routing protocols could be chosen. When there is congestion in the network due to heavy traffic, in general case, a reactive protocol is preferable. Sometimes the size of the network might be a major considerable point. For example, AODV, DSR, OLSR are some of the protocols suitable for relatively smaller networks, while the routing protocols like TORA, LANMAR, ZRP are suitable for larger networks. Network mobility is another factor that can degrade the performance of certain protocols. When the network is relatively static, proactive routing protocols can be used, as storing the topology information in such case is more efficient. On the other hand, as the mobility of nodes in the network increases, reactive protocols perform better. Overall, the answer to the debating point might be that the mobility and traffic pattern of the network must play the key role for choosing an appropriate routing strategy for a particular network. It is quite natural that one particular solution cannot be applied for all sorts of situations and, even if applied, might not be optimal in all cases. Often it is more appropriate to apply a hybrid protocol rather than a strictly proactive or reactive protocol as hybrid protocols often possess the advantages of both types of protocols.

6. Scope for future research

More and more efficient routing protocols for MANET might come in front in the coming future, which might take security and QoS (Quality of Service) as the major concerns. So far, the routing protocols mainly focused on the methods of routing, but in future a secured but QoS-aware routing protocol could be worked on. Ensuring both of these parameters at the same time might be difficult. A very secure routing protocol surely incurs more overhead for routing, which might degrade the QoS level. So an optimal trade-off between these two parameters could be searched. In the recent years some multicast routing protocols have been proposed. The reason for the growing importance of multicast is that this strategy could be used as a means to reduce bandwidth utilization for mass distribution of data. As there is a pressing need to conserve scarce bandwidth over wireless media, it is natural that multicast routing should receive some attention for ad hoc networks. So it is, in most of the cases, advantageous to use multicast rather than multiple unicast, especially in ad hoc environment where bandwidth comes at a premium. Ad hoc wireless networks find applications in civilian operations (collaborative and distributed computing) emergency search and-rescue, law enforcement, and warfare situations, where setting up and maintaining a communication infrastructure is very difficult. In all these applications, communication and coordination among a given set of nodes are necessary. Considering all these, in future the routing protocols might especially emphasize the support for multicasting in the network.

References

[1] IETF Manet charter, http://www.ietf.org/html.charters/manet-charter.html

[2] D. Johnson, D. A. Maltz, Dynamic source routing in ad hoc wireless networks, in Mobile Computing (T. Imielinski and H. Korth, eds.), Kluwer Acad. Publ., 1996.

[3] C.E. Perkins and E.M. Royer. Ad hoc on demand Distance Vector routing, mobile computing systems and applications, 1999. Proceedings. WMCSA ’99. Second IEEE Workshop on, 1999, p90 - p100.

[4] C. C. Chiang, T. C. Tsai, W. Liu and M. Gerla, Routing in clustered multihop, mobile wireless networks with fading channel, The Next Millennium, The IEEE SICON, 1997.

[5] A. Iwata, C.-C. Chiang, G. Pei, M. Gerla, and T.-W. Chen, Scalable routing strategies for ad hoc wireless networks. IEEE Journal on Selected Areas in Communications, Special Issue on Ad-Hoc Networks, August 1999, p1369-p1379.

[6] C.-K. Toh, Associativity Based Routing For Ad Hoc Mobile Networks. Wireless Personal Communications Journal, Special Issue on Mobile Networking and Computing Systems, p103-p139, March 1997.

[7] R. Dube et al., Signal stability based adaptive routing for ad hoc mobile networks, IEEE Pers. Comm., February 1997, p 36-p45.

[8] Y. B. Ko and N. H. Vaidya. Location Aid Routing (LAR) in mobile ad hoc networks. In Proc. ACM/IEEE MOBICOM, Oct. 1998.

[9] S. Basagni, I. Chlamtac, V. Syrotiuk and B. WoodWard, A Distance Routing Effect Algorithm for Mobility (DREAM). Proc. 4th MOBCOM, 1998.

[10] M. Liu, R. Talpade, A. McAuley, and E. Bommaiah, AMRoute: Ad-hoc multicast routing protocol. Technical Report, CSHCN T. R. 99-1, University of Maryland.

[11] C.W. Wu, Y.C. Tay, AMRIS: a multicast protocol for ad hoc wireless networks. Proceedings IEEE MILCOM’99, Atlantic City, Nov. 1999

[12] S.J. Lee, M. Gerla, C.C. Chiang, On Demand Multicast Routing Protocol. Proceedings of IEEE WCNC’99, New Orleans, pages 1298-1302, Sept 1999

[13] E. M. Royer and C. E. Perkins, Multicast operation of the Ad hoc On Demand Distance Vector Routing protocol. ACM MOBICOM, Aug.1999.

[14] Murthy S, Garcia-Luna-Aceves JJ (1996) An Efficient Routing Protocol for Wireless Networks. Mobile Networks and Applications, Volume 1, Issue 2:183–197

[15] Cheng C, Riley R, Kumar SPR, Garcia-Luna-Aceves JJ (1989) A LoopFree Extended Bellman-Ford Routing Protocol Without Bouncing Effect. ACM SIGCOMM Computer Communications Review, Volume 19, Issue 4:224–236

[16] Humblet PA (1991) Another Adaptive Distributed Shortest-Path Algorithm. IEEE Transactions on Communications, Volume 39, Issue 6:995–1003

[17] Chiang C-C, Wu H-K, Liu W, Gerla M (1997) Routing in Clustered Multihop, Mobile Wireless Networks with Fading Channel. Proceedings of IEEE SICON:197–211

[18] Perkins CE, Bhagwat P (1994) Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers. Proceedings of ACM SIGCOMM 1994:234–244

[19] Chen T-W, Gerla M (1998) Global State Routing: A New Routing Scheme for Ad-hoc Wireless Networks. Proceedings of IEEE ICC 1998:171–175

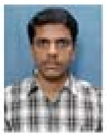
[20] Iwata A, Chiang C-C, Pei G, Gerla M, Chen T-W (1999) Scalable Routing Strategies for Ad Hoc Wireless Networks. IEEE Journal on Selected Areas in Communications, Volume 17, Issue 8:1369–1379

[21] Jao-Ng M, Lu I-T (1999) A Peer-to-Peer Zone-Based Two-Level Link State Routing for Mobile Ad Hoc Networks. IEEE Journal on Selected Areas in Communications, Volume 17, Issue 8:1415–1425

[22] Pei G, Gerla M, Hong X (2000) LANMAR: Landmark Routing for Large Scale Wireless Ad Hoc Network with Group Mobility. First Annual Workshop on Mobile and Ad Hoc Networking and Computing 2000 (MobiHoc 2000):11–18

[23] Tsuchiya PF (1988) The Landmark Hierarchy: A New Hierarchy for Routing in Very Large Networks. Computer Communication Review, Volume 18, Issue 4:35–42
[24] Jacquet P, Mu¨ hlethaler P, Clausen T, Laouiti A, Qayyum A, Viennot L (2001) Optimized Link State Routing Protocol for Ad Hoc Networks. IEEE INMIC 2001:62–68
[25] Toh C-K (1996) A Novel Distributed Routing Protocol to Support AdHoc Mobile Computing. Proceedings of the 1996 IEEE 15th Annual International Phoenix Conference on Computers and Communications:480–486
[26] Dube R, Rais CD, Wang K-Y, Tripathi SK (1997) Signal StabilityBased Adaptive Routing (SSA) for Ad Hoc Mobile Networks. IEEE Personal Communications, Volume 4, Issue 1:36–45
[27] Park VD, Corson MS (1997) A highly adaptive distributed routing algorithm for mobile wireless networks. Proceedings of IEEE INFOCOM 1997, Volume 3:1405–1413
[28] Jiang M, Li J, Tay YC (1999) Cluster Based Routing Protocol (CBRP). IETF Draft, August 1999, available at http://tools.ietf.org/html/draftietf-manet-cbrp-spec-01. Accessed 21 February 2008
[29] Broch J, Johnson DB, Maltz DA (1999) The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks. IETF Draft, October, 1999, available at http://tools.ietf.org/id/draft-ietf-manet-dsr-03.txt. Accessed 21 February 2008
[30] Perkins CE, Royer EM, Chakeres ID (2003) Ad hoc On-Demand Distance Vector (AODV) Routing. IETF Draft, October, 2003, available at http://tools.ietf.org/html/draft-perkins-manet-aodvbis-00. Accessed 21 February 2008
[31] McDonald AB, Znati T (2000) A Dual-Hybrid Adaptive Routing Strategy for Wireless Ad-Hoc Networks. Proceedings of IEEE WCNC 2000, Volume 3:1125–1130 26. McDonald AB, Znati T (1999) A Mobility Based Framework for Adaptive Clustering in Wireless Ad-Hoc Networks. IEEE Journal on Selected Areas in Communications, Special Issue on Ad-Hoc Networks, Volume 17, Issue 8:1466–1487
[32] Boppana RV, Konduru SP (2001) An Adaptive Distance Vector Routing Algorithm for Mobile, Ad Hoc Networks. Proceedings of IEEE INFOCOM 2001:1753–1762
[33] Haas ZJ, Pearlman MR, Samar P (2002) The Zone Routing Protocol (ZRP) for Ad Hoc Networks. IETF draft, July 2002, available at http://tools.ietf.org/id/draft-ietf-manetzone-zrp-04.txt. Accessed 21 February 2008 94 A.-S.K. Pathan and C.S. Hong
[34] Haas ZJ, Pearlman MR, Samar P (2002) Intrazone Routing Protocol (IARP). IETF Internet Draft, July 2002, available at http://tools.ietf.org/wg/manet/draft-ietf-manetzone-ierp/draft-ietf-manetzone-ierp-02-from-01.diff.txt. Accessed 21 February 2008
[35] Ramasubramanian V, Haas ZJ, Sirer, EG (2003) SHARP: A Hybrid Adaptive Routing Protocol for Mobile Ad Hoc Networks. Proceedings of ACM MobiHoc 2003:303–314
[36] Pathan A-SK, Alam MM, Monowar MM, Rabbi MF (2004) An Efficient Routing Protocol for Mobile Ad Hoc Networks with Neighbor Awareness and Multicasting. Proceedings of IEEE E-Tech, July, 2004:97–100
[37] Lim H, Kim C (2000) Multicast Tree Construction and Flooding in Wireless Ad Hoc Networks. Proceedings of the 3rd ACM International Workshop on Modeling, Analysis and Simulation of Wireless and Mobile Systems:61–68

Author Profile



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