A SURVEY OF MOBILE AD-HOC NETWORK PROTOCOLS FROM MOBILITY POINT OF VIEW

Rishi P.J[1], Manjula R.B[2], Sunilkumar S. Manvi[3]
Dept. of Electronics and Communication
REVA Institute of Technology and Management, VTU, Bengaluru, India

Abstract*: Mobile ad hoc network (MANET) is a collection of wireless mobile nodes forming a temporary network dynamically without the aid of any existing infrastructure. This dynamic nature of MANETs makes them suitable for forming networks in war field. Due to high degree of mobility in the nodes, efficient and reliable communication has become a major challenge in this type of network. The survey reveals that ad-hoc protocols work efficiently when configured with suitable mobility patterns. In this paper, we discuss major ad-hoc protocols from the mobility point of view.

Keywords*: Ad-hoc, MANETS, Mobility models, Routing protocols, OLSR, BATMAN.

I. INTRODUCTION

A mobile ad hoc network (MANET) is a continuously self-configuring, infrastructure-less network of mobile devices connected wirelessly. Ad hoc is a Latin word which means "for this purpose". [1] A device or a node in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Every node has duty to forward traffic or packet to other nodes if the packet is of not its own use, and therefore it acts as a router. The primary challenge in building a MANET is to empower each device to continuously maintain the information required to properly route traffic. Nodes in a MANET initially do not have knowledge of the network topology. They discover it step by step by continuously. A node will find its local topology by broadcasting its presence, and listening to broadcast announcements from its neighbors. Gradually each node gets to know about all other nodes and finds one or more ways to reach them. A Mobile Ad Hoc Network is built on the fly where a number of wireless mobile nodes work in cooperation without the engagement of any centralized access point. Two nodes in such a network can communicate in a bidirectional manner if and only if they mutually within their transmission ranges. If a node wants to communicate with another node outside its transmission range, multi-hop routing technique is used. Movements of nodeswill cause topology changes in MANET.This will lead to link breakages, and in turn, it will trigger flooding of update packets in the network. Therefore the protocol must be carefully chosen so that it must be most suitable with the anticipated mobility pattern of the nodes.Considering this unique aspect of MANET, a number of routing protocols have been proposed.

II. RELATED WORK

To build MANET, many protocols have been developed to enhance-bandwidth utilization, minimum energy consumption, higher throughputs, less overhead etc. These protocols use various metrics to determine an optimal path between the sender and the recipient. They have their own advantages and disadvantages. The emphasis in this paper is on the study, survey and comparison of most popular routing protocols -Ad-hoc On Demand Distance Vector, Dynamic Source Routing, Temporally Ordered Routing Algorithm, Destination-Sequenced Distance-Vector, Optimized Link State Routing, Cluster-Head Gateway Switch Routing, Zone Routing Protocol, Fish eye State Routing Protocol, Better Approach to Mobile Ad-hoc Networking, Location – Aided Routing, Greedy Perimeter Stateless Routing, Caching and Multipath Routing Protocol and Ad Hoc On-Demand Multipath Distance Vector Routing as these are best suited for ad-hoc networks. Our work is to methodically investigate the characteristics of proactive and on-demand routing approaches by studying some of the protocols. In section III we enumerate few widely used mobility models. In section IV we compare major ad-hoc routing protocols suitable for MANET from the mobility point of view. In the V section we conclude this paper by putting forward a suitable protocol with its associated mobility model.

III. WIDELY USED MOBILITY PATTERNS IN AD – HOC NETWORK

Random Waypoint Mobility model [1]: In RWP, a node randomly chooses a destination, called waypoint, and moves towards it in a straight line with constant velocity, which is selected randomly from 0 to Vmax. After reaching the waypoint, the node pauses for some time and then repeats the same procedure.Movement of people in a cafeteria or mall, and movement of nodes in a conference are some of its practical applications.

Gauss Markov Mobility model [2]: In this model, the velocity of the mobile node is assumed to be correlated over time and modeled as gauss-markov stochastic process.This model calculates the speed and direction of movement for each mobile node and then it moves with the calculated speed and direction for a period. After this period, the similar movement begins again. The time that is used in the movement in each interval before the change of speed and direction is constant.

RPGM: Reference Point Group Mobility model [1]:

Hereeach group has a center which behaves as a group leader. Initially, each member of the group is uniformly distributed in the neighborhood of the group leader. Subsequently, at each instant, every node has a speed and direction that is derived by randomly deviating it from the group leader's position. When nodes move (from time t to t + 1), their locations, they are updated according to the group logical center being d(t + 1).Eg: soldiers moving together in a platoon. Movement of the group leader defines movement of the whole group.

City selection mobility model [3]: It uses a simulation area that represents street layout of a city. A node is not allowed to choose any point on the graph. It should select a point that is determined by an algorithm, which calculates the shortest travel time between source and destination points. After reaching to the destination point, node waits there for a defined pause time and randomly chooses another destination on the street layout and repeats the process.

IV. CLASSIFICATION OF ROUTING PROTOCOLS

Protocols in MANETs are broadly classified into four categories; they are Reactive, Proactive, Hybrid, Location Aware and Multipath as shown in figure below.

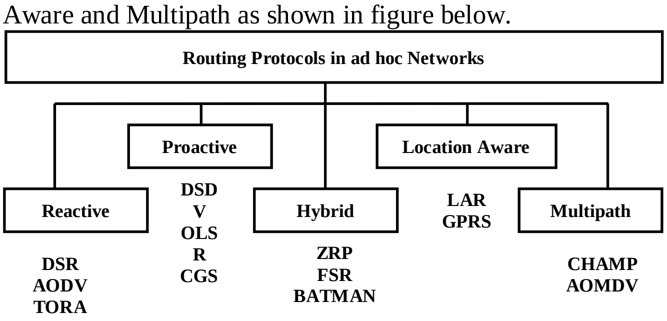

Fig1: Categories of ad-hoc routing protocols

V. REACTIVE ROUTING PROTOCOLS

Reactive routing protocols are also known as on-demand routing protocols. A routing path is discovered only when the need arises. There is no periodic transmission of hello packets. However some reactive protocols do exchange hello packets only when they find a topology change in the network. Since there is no periodic beaconing, these protocols reduce unwanted packet overhead and energy consumption of nodes.

A. DSR- Dynamic Source Routing

DSR [6]is an "on-demand" routing protocol. It has route discovery and route maintenance phase. Route discovery contains both route request messages and route reply messages. In route discovery phase, when a node wishes to send a message, it first broadcasts a route request packet to its neighbors. Every node within a broadcast range appends their node id to the route request packet and rebroadcasts. Eventually, one of the broadcast messages will reach either to the destination or to a node that has a recent route to the destination. Since each node maintains a route cache, it first checks its cache for a route that matches the requested destination. Maintaining a route cache in every node reduces the overhead generated by a route discovery phase. If a route is found in the route cache, then the node will return a route reply message to the source node rather than forwarding the route request message further. The first packet that reaches the destination node will have a complete route. DSR assumes that the path obtained is the shortest since it takes into consideration the first packet to arrive at the destination node. A route reply packet is sent to the source that contains the complete route from source to destination. Thus, the source node knows its route to the destination node and can initiate the routing of the data packets. The source caches this route in its route cache. In route maintenance phase, two types of packets are used, namely route error and acknowledgements. DSR ensures the validity of the existing routes based on the acknowledgments received from the neighboring nodes that data packets have been transmitted to the next hop. Acknowledgment packets also include passive acknowledgments as the node overhears the next hop neighbor is forwarding the packet along the route to the destination. A route error packet is generated when a node encounters a transmission problem, which means that a node has failed to receive an acknowledgment. This route error packet is sent to the source in order to initiate a new route discovery phase. Upon receiving the route error message, nodes remove the route entry that uses the broken link within their route caches. Route discovery phase is shown in the Fig 2.

B. AODV- Ad-hoc On Demand Distance Vector

AODV [8] is designed to reduce the number of broadcast messages sent throughout the network by discovering routes on-demand instead of keeping complete up-to-date route information. When a source node wants to send a data packet to a destination node it checks its route table to see if it has any valid route to the destination node. If a route exists, it simply forwards the packets to the next hop along the route path to the destination. On the other hand, if it finds no valid route then it begins a route discovery process. It broadcasts a route request (RREQ) packet. This packet floods throughout the network until it reaches either the destination or an intermediate node with a route to the destination. This route request packet contains the source address, destination address, current sequence number and the sequence number last known. Intermediate nodes can reply to the route request packet only if they have a destination sequence number greater than or equal to the one in the route request packet. When the intermediate nodes forward route request packets to their neighbors, they record the address of the neighbor from which the first copy of the packet had arrived. This recorded information is later used to construct the reverse path for the route reply (RREP) packet.

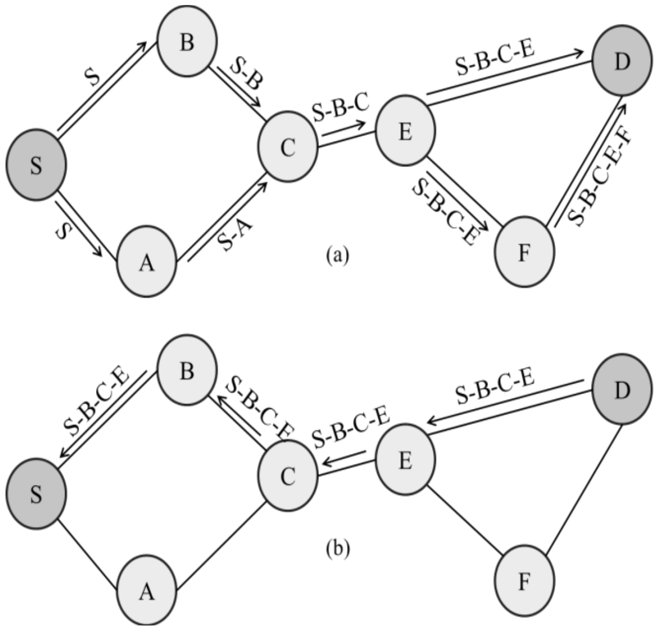

Fig 2: (a) Route Discovery (b) Using route record to send the route reply

If the same RREQ packets arrive later on, they are all discarded. When the route reply packet arrives from the destination or the intermediate node, the nodes forward it along the established reverse path and store the forward route entry in their route table by the use of symmetric links. Route maintenance is required if either the source or the intermediate node moves away. If a source node becomes unreachable, it simply reinitiates the route discovery process. If an intermediate node moves, it sends a link failure notification message to each of its upstream neighbors to ensure the deletion of that particular part of the route. Once the message reaches to source node, it then reinitiates the route discovery process. Local movements do not have global effects, as was the case in DSDV. The stale routes are discarded; as a result, no additional route maintenance is required. AODV has a route aging mechanism; however, it does not find out how long a link might be alive for routing purposes. AODV deletes invalid routes by making use of a special route error message called Route Error (RERR). Latency is minimized due to avoidance of using multiple routes. AODV also supports multicast routing. For multicast routing it uses a separate route table. In multicast routing, each multicast group has its own sequence number that is maintained by multicast group leader.

C. TORA-Temporally Ordered Routing Algorithm

TORA [14] is a reactive routing protocol with some proactive enhancements. Here link between nodesare established by creating a Directed Acyclic Graph (DAG) of the route from the source to the destination. This protocol uses a ‘‘link reversal’’ algorithm in order to make a route discovery. A route discovery query packet is broadcasted and propagated throughout the network until it reaches the destination or a node that already has path to destination. TORA defines a parameter, termed height metric. 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. However,due to its complexity DSR and AODV have proven better than TORA.

VI. PROACTIVE ROUTING PROTOCOLS

Proactive routing protocols are table driven. They periodically update their tables by exchanging hello packets. Thus, whenever there is a need for a route to a destination, such route information is available immediately without any latency.

DSDV- Destination-Sequenced Distance-Vector

The Destination-Sequenced Distance-Vector (DSDV) [10] is a table-driven routing protocol and it uses Bellman–Ford routing algorithm. Every node maintains a routing table which has an entry of all other nodes in the network, sequence number and the number of hops to reach these nodes. Sequence numbers are used to avoid loops and stale routes from the network. The route labeled with the most recent (highest number) sequence number is used for this purpose. The shortest route is chosen if any of the two routes have the same sequence number. Periodic updates are sent throughout the network in order to maintain routing table consistency. There are two types of updates.

(a) Full dump and

(b) Incremental dump

A full dump sends the entire routing table to the neighbors whereas incremental updates transmit only the deviations since the last full dump update. A Full dump is more frequent in a fast moving network and incremental dump is frequent in a stable network.

OLSR- Optimized Link State Routing

The OLSR[15] utilizes pure link state routing algorithm. It reduces the total control overhead by minimizing the number of packet retransmissions in a network. It employs multipoint relaying technique to flood the control messages in a network in an efficient manner. Each node selects a set of one-hop neighbors which are called its multipoint relays (MPRs). The neighbors which are not MPRs process the packets but do not forward them since the carefully chosen MPRs are adequate to reach the two-hop neighbors. These MPRs must be a minimum set so as to minimize the broadcast packets. Two hop neighbors must process bidirectional link. This characteristic can be determined by periodic hello packets which contain information about all neighbors and their link status. Therefore in this technique a route is a sequence of hops from source to destination through MPRs within the network. OLSR MPR selection is shown Fig: 3.

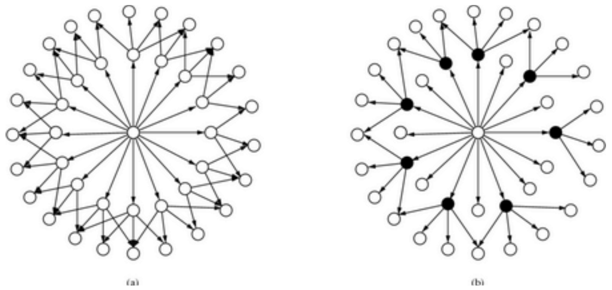

Fig 3: MPR selection in OLSR routing protocol

CGSR- Cluster-Head Gateway Switch Routing

CGSR[17]is a hierarchical routing protocol. CGSR organize nodes into clusters. Each cluster has a special node called cluster-head. This cluster-head is elected dynamically using a distributed least cluster change (LLC) algorithm. According to this algorithm, a node can become a cluster-head only if it comes under the range of another cluster-head where a tie is broken either using the lowest id or highest connectivity algorithm. Clustering helps in efficient bandwidth utilization by a mechanism called bandwidth reuse. All member nodes of a cluster are reached by the cluster-head to provide improved coordination among nodes that fall under it. A token based scheduling is used within a cluster for sharing the bandwidth among the member of the cluster. All nodes inside a cluster communicate data and control information to their cluster-head. Communication between two clusters takes place through a node that is a member of both the clusters. This node which is a member of more than one cluster is called a cluster gateway. This protocols working is analogues to RPGM mobility model hence it is seen to work at its best under RPGM mobility scenarios. See Fig 4.

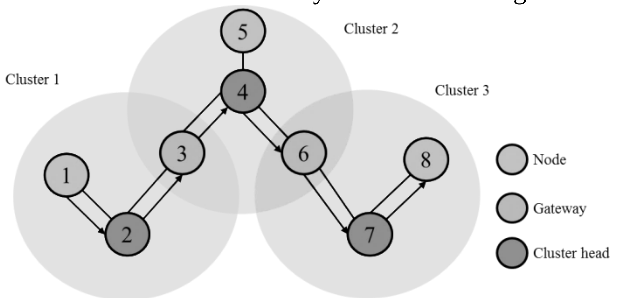

Fig 4: Cluster gateway switching Routing protocol

VII. HYBRID ROUTING PROTOCOL

Hybrid routing protocol is a mixture of both proactive and reactive routing protocols. These protocols are designed to deliver the best from both the worlds. Hybrid protocols include some of the characteristics of proactive protocols and some of the characteristics of reactive protocols.

ZRP- Zone Routing Protocol

ZRP[19] is a well-known hybrid routing protocol built for large scale networks. This protocol uses a proactive mechanism in case of intra-zone communication and reactive mechanism for inter-zone communication. ZRP utilizes the fact that node communication in ad hoc networks is mostly localized, thus the changes in the node topology within the vicinity of a node are of primary importance. ZRP makes use of this characteristic to define a framework for node communication with other existing protocols. Local neighborhoods, called zones, are defined for nodes. The size of a zone is decided on ρ factor, which is defined as the number of hops to the perimeter of the zone. There can be many overlapping zones, which helps in route optimization. Neighbor discovery is achieved by either the Intra-zone Routing Protocol (IARP) or simple “Hello” packets. IARP is a proactive approach and always maintains up-to-date routing tables. The Inter-zone Routing Protocol (IERP) uses a reactive approach for communicating with nodes in different zones. Route queries are sent to peripheral nodes using the Broadcast Resolution Protocol (BRP). Since nodes do not resend the query to the nodes from where they received the query originally, the control overhead is significantly reduced and redundant queries are also minimized. ZRP can be optimized to take full advantage of any other current protocols. The ZRP architecture can be seen inFig 5.

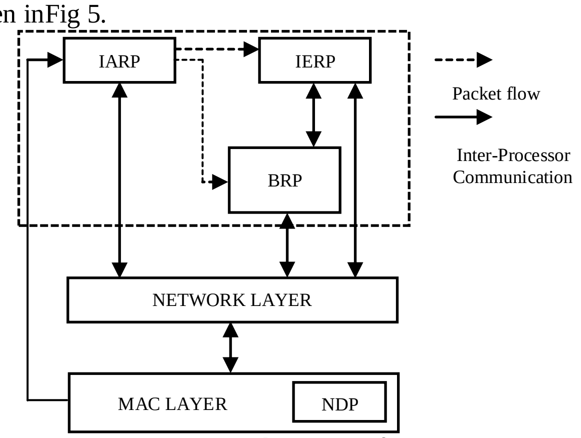

Fig 5: Architecture of ZRP

FSR-Fish eye State Routing Protocol

FSR[20] is a hierarchical table driven routing protocol which aims at reducing control packet overhead by introducing the multilevel scope technique. This technique is very effective to reduce the size of information required to represent graphical data. It uses the concept that the eye of a fish captures with greater details nearer to the focal point while detail decreases as the distance from the focal point increases.FSR is similar to link state routing, because it maintains a routing table at each node. The only difference is in the maintenance of these tables. FSR introduces the scope concept, which depends on the number of hops a packet traveled from its source. A higher frequency of update packets are generated for nodes inside asmaller scope whereas for farther-away nodes, updates are fewer in general. This protocol scales well to large size of networks while keeping the control overhead low without compromising on the accuracy of route calculations. Routes to farther destinations may seem stale; however, they become increasingly accurate as a packet approaches its destination.

BATMAN- Better Approach to Mobile Ad-hoc Networking

BATMAN [24]is improvement made on OLSR protocol. A community wireless network based on OLSR known as Freifunk in Berlin noticed that OLSR had many performance limitations when the network grew very large. OLSR routes regularly go up and down due to route tables being unnecessary flushed as a result of routing loops. It was a realized that a routing algorithm for a large static mesh needs to be developed from first principles and as a result the BATMAN project was started. In BATMAN all nodes periodically broadcasts hello packets, also known as originator messages[OGM], to its neighbors. Each originator messages consists of an originator address, sending node address and a unique sequence number. Each neighbor changes the sending address to its own address and rebroadcast the message. On receiving its own message the originator does a bidirectional link check to verify that the detected link can be used in both directions. The sequence number is used to check the freshness of the message. BATMAN does not maintain the full route to the destination, each node along the route only maintains the information about the next link through which you can find the best route.

VIII. LOCATION AWARE ROUTING

Location-aware routing schemes in mobile ad hoc networks assume that the individual nodes are aware of the locations of all the nodes within the network. The best and easiest technique is the use of the Global Positioning System (GPS) to determine exact coordinates of these nodes in any geographical location. This location information is then utilized by the routing protocol to determine the routes.

LAR –Location –Aided Routing

The LAR protocol[21][22]is an approach that utilizes location information to minimize the search space for route discovery toward the destination node. The aim of this protocol is to reduce the routing overhead for the route discovery, and it uses the Global Positioning System (GPS) to obtain the location information of a node.The intuition behind using location information to route packets is very simple and effective. Once the source node knows the location of the destination node and also has some information of its mobility characteristics such as the direction and speed of movement of the destination node, the source sends route requests to nodes only in the “expected zone” of the destination node. Since these route requests are flooded throughout the nodes in the expected zone only, the control packet overhead is considerably reduced.

GPRS-Greedy Perimeter Stateless Routing

GPSR[25]also uses the location of the node to selectively forward the packets based on the distance. Packet forwarding is carried out on a greedy basis by selecting the node closest to the destination. This process continues until the destination is reached. However, in some scenarios, the best path may be through a node which is farther in geometric distance from the destination. In this case, move around the obstacle and resume the greedy forwarding as soon as possible. Note that the location information is shared by beacons from the MAC layer. A node uses a simplistic beaconing algorithm to broadcast beacon packets containing the node ID and its x and y coordinates at periodic intervals, helping its neighbors to keep their routing tables updated. With greater mobility, the beaconing interval must be reduced to maintain up-to-date routing tables; however, this results in greater overhead. To reduce this overhead, the sender node’s location information is piggybacked with the data packets.

IX. MULTIPATH ROUTING

Multipath routing protocols create multiple routes from source to destination. Advantage of discovering multiple pathsare that the bandwidth between the links is used more effectively with greater delivery reliability. It also helps during times of the network congestion. Multiple paths are generated on demand or by using a proactive approach and are of great significance because routes generally get disconnected quickly due to node mobility.

CHAMP-Caching and Multipath Routing Protocol

CHAMP [25] uses data caching and shortest multipath routing. It has mechanisms to reduce packet drops in the presence of frequent route breakages. Every node maintains a small buffer for caching the forwarded packets. This technique is helpful in the cases when a node close to the destination encounters a forwarding error and cannot transmit the packet. In such situations, instead of the source retransmitting again, an upstream node that has a cached copy of the packet may retransmit it, thereby reducing end-to-end packet delay. In order to achieve this, multiple paths to the destination must be available. In CHAMP each node maintains two caches: (a) a route cache containing forwarding information and (b) a route request cache that contains the recently received and processed route requests. Those entries that have not been used for a specific route lifetime are deleted from the route cache. Nodes also maintain a send buffer for waiting packets and a data cache for storing the recently forwarded data packets. A route discovery is initiated when there is no available route. The destination replies back with a corresponding route reply packet. There may be multiple routes of equal length established, each with a forwarding count value that starts with a zero from the source and is increased by one with every retransmission.

AOMDV- Ad Hoc On-Demand Multipath Distance Vector Routing

The AOMDV [27] protocol uses the basic AODV route construction process, with extensions to create multiple loop-free and link-disjoint paths. AOMDV computes the multiple paths during route discovery process, and it consists of two main components: (a) a route updates process to find multiple paths at each node and (b) a distributed protocol to calculate the link-disjoint paths. Route request and route reply packet arriving at a node is potentially using a different route from the source to the destination. All of these routes cannot be accepted, since they can lead to creation of loops. The “advertised hop count” metric is used in such a scenario. The advertised hop count for a node is the maximum acceptable hop count for any path recorded at that node. A path with a greater hop count value is simply discarded, and only those paths with a hop count less than the advertised value is accepted. Values greater than this threshold means the route most probably has a loop. Table 1 lists all protocol with their optimum mobility model.

Table 1:Protocols and their optimum mobility model

	RWM	GMM	RPGM	CSM
DSR	*			
AODV	*			
TORA		*		
DSDV	*			
OLSR		*		
CGSR			*	
ZRP			*	
FSR			*	
BATMAN		*		
LAR		*		
GRPS				*
CHAMP				*
AOMDV				*

X. CONCLUSION

In large mobile ad hoc network reliable routing of message packets are governed by the protocols that are embedded in them. Efficiency of a protocol is linked to mobility patterns. A protocol is seen to work at its best when run in its suitable mobility pattern. Presently a number of protocols have been proposed from this point of view. In this paper various types of widely used mobility models and ad hoc routing protocols are discussed. Each protocol has specific advantages and disadvantages. It is not easy to identify a single protocol suitable for all mobility scenarios.Simulations results have shown that DSR protocol is found to be the most efficient protocol when run with RPGM mobility model.But, OLSR routing protocol is widely deployed in most of the mobile ad-hoc networks because of its MPR selectivity characteristic. At the same time it processes certain limitations such as node overhead. Researches are going on BATMAN routing protocol to overcome the drawbacks of OLSR.

REFERENCES

[1] Malarkodi, B.; Gopal, P.; Venkataramani, B., "Performance Evaluation of Adhoc Networks with Different Multicast Routing Protocols and Mobility Models," Advances in Recent Technologies in Communication and Computing, 2009. ARTCom '09. International Conference on , vol., no., pp.81,84, 27-28 Oct. 2009.

[2] Ariyakhajorn, J.; Wannawilai, P.; Sathitwiriyawong, C., "A Comparative Study of Random Waypoint and Gauss-Markov Mobility Models in the Performance Evaluation of MANET," Communications and Information Technologies, 2006. ISCIT '06. International Symposium on, vol., no., pp.894,899, Oct. 18 2006-Sept. 20 2006.

[3] Ad-Hoc, Mobile, and Wireless Networks: 5th International Conference, ADHOC-NOW 2006, Ottawa, Canada, August 17-19, 2006 Proceedings by Thomas Kunz, S.S. Ravi

[4] Algorithms and protocols for wireless and mobile ad-hoc networks edited by AzzedineBoukerche

[5] Guide to Wireless Ad Hoc Networks edited by SudipMisra, Isaac Woungang and Subhas Chandra Misra

[6] D. Johnson and D. Maltz. Dynamic source routing in ad hoc wireless networks. In T. Imielinski and H. Korth, editors, Mobile Computing, Kluwer Academic Publishers, Norwell, MA 1996, pp. 153–181.

[7] B.Karthikeyan, N.Kanimozhi and Dr. S. Hariganesh, "Analysis of Reactive AODV Routing Protocol for MANET", 2014 World Congress on Computing and Communication Technologies, 978-1-4799-2877-4.

[8] C. Perkins and E. Royer. Ad hoc on-demand distance vector routing. In Proceedings of the Second IEEE Workshop on Mobile Computing Systems and Applications, 1999, pp. 99–100.

[9] Uma Rathore Bhatt, AbhishekDangarh, AkankshaKashyap and AishwaryaVyas, "Performance analysis of AODV & DSR Routing protocols for MANET", 2014 Fourth International Conference on Communication Systems and Network Technologies,vol.1,p.p 254-258.

[10] QutaibaRazouqi, Ahmed Boushehri, Mohamed Gaballah and LinaAlsaleh, "Extensive Simulation Performance Analysis for DSDV, DSR and AODV MANET Routing Protocols", 2013 27th International Conference on Advanced Information Networking and Applications Workshops, vol.1, p.p 335-342.

[11] Nagham H. Saeed, Maysam F. Abbod and Hamed S. Al-Raweshidy, "MANET Routing Protocols Taxonomy", 2012 International Conference on Future Communication Networks, vol.1, p.p 123-128.

[12] CharuWahi and Sanjay Kumar Sonbhadra, "Mobile Ad Hoc Network Routing Protocols: A Comparative Study",International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.3, No.2, April 2012.

[13] A. da Fontoura, R. Schmidt and M. Trentin, "Simulation of Ad-hoc Routing Protocols in an Interurban University Mesh Network ", IEEE Latin America Transactions, VOL. 7, NO. 1, March 2009.

[14] V. Park and S. Corson. Temporally-ordered routing algorithm (TORA) version 1 functional specification. Internet Draft, Internet Engineering Task Force, November 2000. http://www.ietf.org/internet-drafts/draft-ietf-manet-tora-spec-03.txt.

[15] T. Clausen, P. Jacquet, A. Laouiti, P. Muhlethaler, A. Qayyum, and L. Viennot. Optimized link state routing protocol for ad hoc networks. In: Proceedings of the IEEE INMIC, 2001, pp. 62–68.

[16] Luc Hogie. "Mobile Ad Hoc Networks: Modeling, Simulation and Broadcast-based Applications". PhD thesis,University of Luxembourg, April 2007.

[17] C. Chiang, H. Wu, W. Liu, and M. Gerla. Routing in clustered multihop, mobile wireless networks. In Proceedings of IEEE SICON, 1997, pp. 197–211.
[18] L. Kleinrock and K. Stevens. Fisheye: A lenslike computer display transformation. Technical Report, Department of Computer Science, UCLA, 1971.
[19] P. Samar, M. Pearlman, S. Haas, Independent zone routing: an adaptive hybrid routing framework for ad hoc wireless networks, IEEE/ACM Transactions on Networking, 12(4): 595–608, 2004.
[20] G. Pei, M. Gerla, and T.-W. Chen. Fisheye state routing in mobile ad hoc networks. In Proceedings of ICDCS Workshop on Wireless Networks and Mobile Computing, 2000, pp. D71–D78.
[21] Y. Ko and N. Vaidya. Location-Aided Routing (LAR) in mobile ad hoc networks. In Proceedings of the ACM MOBICOM, 1998, pp. 66–75.
[22] Y. Ko, N. Vaidya, Location-Aided Routing (LAR) in mobile ad hoc networks. Wireless Networks, 6(4):307–321, 2000.
[23] S. Basagni, I. Chlamtac, V. Syrotiuk, and B. Woodward. A distance routing effect algorithm for mobility (DREAM). In Proceedings of the ACM MOBICOM, 1998, pp. 76–84.
[24] Chissungo, E.; Blake, E.; Hanh Le, "Investigation into Batman-adv Protocol Performance in an Indoor Mesh Potato Testbed," Intelligent Networking and Collaborative Systems (INCoS), 2011 Third International Conference on , vol., no., pp.8,13, Nov. 30 2011-Dec. 2 2011
[25] B. Karp and H. Kung. GPSR: Greedy perimeter stateless routing for wireless networks. In: Proceedings of the ACM MOBICOM, 2000, pp. 243–254.
[26] A.Valera, W. K. G. Seah, and S. V. Rao. Cooperative packet caching and shortest multipath routing in mobile ad hoc networks. In Proceedings of the IEEE INFOCOM, Vol. 1, 2003, pp. 260–269.
[27] M. K. Marina, and S. Das. On-demand multi path distance vector routing in ad hoc networks. In Proceedings of the IEEE ICNP, 2001, pp. 14–23.

