Available online at www.elixirpublishers.com (Elixir International Journal)

Computer Science and Engineering

Elixir Comp. Sci. & Engg. 60 (2013) 16219-16224

ISSN: 2229-712X

A Survey on On-Demand Routing Techniques in MANET

Deeptanoy Ghosh* and Poonam Thakur

Department of CSE, Lovely Professional University, Phagwara, India.

ARTICLE INFO

Article history:

Received: 15 May 2013;

Received in revised form:

17 June 2013;

Accepted: 5 July 2013;

Keywords

ABR,
AODV,
ABR, CBRP,
DSR, LAR,
LMR, MANET.

ABSTRACT

Mobile Ad Hoc Network (MANET) is collection of multi-hop wireless mobile nodes that communicate with each other without centralized administration or fixed infrastructure or permanent topology. Routing protocols developed for wired networks are inadequate as they not only assume mostly permanent topology but also having high overheads. This problem leads to several routing algorithms/proposals specifically for ad hoc networks. However, some of these proposals are optimized variants of protocols designed for wired networks. This paper focused on various On Demand Routing protocols known as reactive protocols such as DSR, AODV, TORA, ABR, DYMO, LMR, LAR, SSA CBRP, RDMAR, MSR, AOMDV, ARA and their comparison with advantages and disadvantages.

1. Introduction

Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes dynamically forming a temporary network without the use of existing network infrastructure or centralized administration [1] [2] [3]. In Infrastructure less or Mobile Ad Hoc wireless network, the mobile nodes can move freely while communicating. In the network there are no fixed base stations and all the nodes in the network act as routers. Each node in the network participates in an Ad Hoc routing protocol that allows it to discover multi hop paths through the network to any other node. The mobile nodes in the Ad Hoc network dynamically establish routing among themselves to form their own network 'on the fly'. The nodes or routers are free to move randomly and organize themselves arbitrarily. This type of network may operate in a standalone fashion and different protocols are needed. This paper is organized as follows. Section 2 describes the need and specialty of Ad Hoc Reactive Routing protocols in brief with its vital components. Section 3 provides challenges in routing algorithms. Section 4 presents with various on-demand reactive routing protocols with their advantages and disadvantages that are used in ad hoc networks. Section 5 provides an analysis and a parameter wise comparison among all the surveyed papers. Section 6 presents conclusion of this paper and future work and lastly the references.

2. The need and speciality of routing protocols

A MANET routing protocol should function effectively over small, collaborative, ad hoc groups to larger mobile, multihop networks. The networking opportunities for MANETs are intriguing and the engineering tradeoffs are many and challenging. So, a set of performance issues requires new protocols for network control.

These protocols try to eliminate the conventional routing tables and consequently reduce the need for updating these tables to track changes in the network topology compared to proactive routing protocols which maintain all up-to-date information at every node [4]. Routes are created only when desired by the source node in on-demand routing protocols. In reactive approach, a source node requires to a destination, it needs to establish a route by route discovery procedure, maintain it by some form of route maintenance procedure until either the route is no longer desired or it becomes inaccessible. Finally demolish it by route deletion procedure. Routes are always available in pro-active protocols (regardless of need), with the consumption of power and signaling traffic. While, being more efficient at power consumption and signaling, re-active protocols suffer longer delay while route discovery. Proactive and reactive routing protocols have been improving to be more secure, scalable and to support higher QoS [5][6][7].

3. Routing challenges in MANET

Mobile Ad hoc Networks (MANETs) provide a vast area of research for students of universities and computer network researchers. Frequently changing topologies, battery lifetime, disconnected operations and security are some of the challenges that MANET is facing in present days. Students and researchers can only speculate about wide spread future use, with solutions to these problems. In MANET, mobile nodes are given the responsibility of routing traffic within the network. So problem arises which topology it should follow and how to reduce the communication overhead and query latency.

That is why wireless networking environment is one of scarcity rather than superfluity. As bandwidth is relatively limited, and energy may be as well. The limited transmission range of wireless network coupled with the highly dynamic routing infrastructure needs extra care. Mobility also creates a lot of anxiety.

Issues such as dynamic routing, synchronization, efficient channel access and quality-of-service (QoS) support, lack of central coordination, distributed nature should be considered for communication [8] [9]. Routing protocols also set some limits for the scalability of ad hoc networks. Route acquisition, service location and encryption key exchange is examples of tasks that will increase overhead in the network, which will grow rapidly with the increase of network size.

Tele:
E-mail addresses: deeptanoyghosh@gmail.com

4. Overview of various on-demand routing protocols

In On-Demand routing protocols, the routes are created as and when it is needed. Once a route has been established in the network, it is maintained until either the destination becomes inaccessible or until the route is no longer used.

Existing on-demand re-active routing protocols are:

A. DSR (Dynamic Source Routing),
B. AODV (ad hoc On-Demand Distance Vector Routing),
C. TORA (Temporally-Ordered Routing Algorithm),
D. ABR (Associativity Based Routing),
E. LAR (Location Aided Routing),
F. LMR (Light-Weight Mobile Routing),
G. SSA (Signal Stability Based Adaptive Routing Algorithm)
H. H. CBRP (Cluster Based Routing)
I. RDMAR (Relative Distance Micro-Discovery Ad-Hoc Routing)
J. MSR (Multi-Path Source Routing)
K. AOMDV (Ad-Hoc On-Demand Multi-Path Distance Vector Routing)
L. ARA (Ant-Colony Based Routing Algorithm).

A. Dynamic Source Routing

The Dynamic Source Routing (DSR) [7] [8] is one of the classic example of an on-demand routing protocol that is based on the idea of source routing. DSR protocol is designed (1996) for use in multihop ad hoc networks for mobile nodes. DSR [10] [11] [20] protocol allows the network to be completely self-organizing and self-configuring and does not need any existing network infrastructure. It uses no periodic routing messages, thereby reduces network bandwidth overhead, conserves power and avoids large routing updates. Route Discovery and Route Maintenance are two main features of DSR, which work together to allow nodes to discover routes and maintain source routes to arbitrary destinations in the network. DSR needs support from the MAC layer to identify link failure.

Advantages

1. A route is established only when it is required. It uses a reactive approach that allows the sender to select and control routes there by reducing load and hence the need to find routes to all other nodes in the network as required by the table-driven approach is eliminated.
2. one of the main benefit of DSR protocol is that there is no need to keep routing table so as to route a given data packet as the entire route is contained in the packet header.
3. The other advantage includes loop-free routing in networks containing unidirectional links.
4. The intermediate nodes utilize the route cache information efficiently to reduce the control overhead.

Disadvantages

1. The limitation of DSR protocol is that this is not scalable to large networks.
2. It requires significantly more processing resources than most other protocols.
3. Every node must spend lot of time to process any control data it receives in order to obtain the routing information even if it is not the intended recipient.
4. The source route has to be included with each packet causing significant overheads.
5. Aggressive use of caching and lack of any mechanism to detect freshness of routes which causes delay and throughput reduction.
6. The connection setup delay is higher than in table-driven protocols.
7. The source need to add the IDs of all nodes along the path to the destination which increase the overhead in every data packet sent.
8. When a link is broken Route Error packets need to go all the way to the source to inform it about the problem hence more route reconstructions is needed.
9. Intermediate node can use outdated routes stored in their cache.

B. Ad-Hoc On-Demand Distance Vector Routing

AODV is a modification of the DSDV algorithm [10] [11]. Originally AODV (1999) is a combination of both DSR [12] [20] [22] and DSDV approach. It inherits the basic on-demand mechanism of route discovery and route maintenance from DSR and the use of hop-by hop routing sequence. AODV shares DSR's on-demand characteristics in that it also discovers routes on an "as needed" basis via a similar route discovery process. The recent specification of AODV includes an optimization technique to control the RREQ flood in the route discovery process. It uses an expanding ring search initially to discover routes to an unknown destination. Increasingly larger neighborhoods are searched to find the destination in the expanding ring search. The search is controlled by the Time-To-Live (TTL) field in the IP header of the RREQ packets. If the route to a previously known destination is required, the prior hop-wise distance is used to optimize the search. This enables computing the TTL value used in the RREQ packets dynamically, by taking into consideration the temporal locality of routes.

Advantages

1. The main advantage includes its adaptability to highly dynamic networks and reduced overhead. The main feature of AODV is quick response to link breakage in an active route.
2. Lower setup delay for connections and detection of latest route to the destination.
3. AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR that preserves multiple route cache entries for each destination.
4. AODV minimizes the number of broadcasts by creating routes on-demand as opposed to DSDV that maintains the list of all the routes. Route error propagation in AODV can be visualized.
5. AODV protocol favors the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for nodes in constant movement.
6. AODV does not put any additional overheads on data packets as it does not make use of source routing. AODV also responds very quickly to the topological changes that affects the active routes. An important feature of AODV is the maintenance of timer-based states in each node.

Disadvantages

1. It requires periodic updates. The distinguishing feature is the use of a destination sequence number for each route entry. While source sequence number is very old it leads to inconsistent routes.
2. Unnecessary bandwidth consumption occurs in response to periodic beaconing.
3. AODV is vulnerable to various kinds of attacks as it based on the assumption that all nodes must cooperate and without their cooperation no route can be established. Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead.
4. AODV protocol expects/requires that the nodes in the broadcast medium can detect each others' broadcasts. A valid

route is expired can be possible and the determination of a reasonable expiry time is difficult.

C. Temporally-Ordered Routing Algorithm

Temporally-Ordered Routing Algorithm (TORA, 1999) is a distributed protocol designed to be highly adaptive so it can operate in a dynamic multihop network. TORA [7] [10] is designed to minimize reaction to topological changes. The basic underlying algorithm is in a family referred to as to as link reversal algorithm. A key concept in its design is that control messages are typically localized to a very small set of nodes. TORA uses an arbitrary height parameter to determine the direction of link between any two nodes for a given destination [11] [14] [20]. As a consequence of this for a given destination multiple routes are often present, but none of them are necessarily the shortest route. When a node wants to initiate a route, it starts to broadcasts a Query to its neighbors. TORA also relies on intermediate lower layers for certain functionality. It assumes, for example, neighbor discovery, link status sensing, in-order packet delivery and address resolution are all readily available. This makes the overhead for this protocol difficult to separate from that imposed by the required lower layer.

Advantages

1. One of the benefits of TORA is that the multiple routes between any source destination pair are supported by this protocol.
2. Removal or failure of any of the nodes is quickly resolved without source intervention by switching to an alternate route.

Disadvantages

1. TORA relies on synchronized clocks among nodes in the network. Intermediate lower layers for certain functionality presume that the link status sensing, in order packet delivery, neighbor discovery and address resolution is all readily available.
2. TORA was not energy efficient and does not scale to large networks.

D. Associativity Based Routing

ABR (1996) is totally different routing protocol for Ad-hoc wireless network. In Associativity Based Routing, ABR [15] protocol uses a different metrics than shortest path. In this protocol each node has its degree of association stability and each node in the network is selected based on its degree of association stability. It also uses the same mechanism as DSR which is aggregating the node IDs along the path to the final destination [20][22]. In this protocol each node generates a beacon to signify its existence and when this is received by neighboring nodes then due to this beacon the associativity table id updated. The metric used instead of the shortest hop count is the Location Stability or the Associativity between nodes. The objective is to select a longer lived route which will help in reducing the cost of reconstructing routes. Nodes periodically broadcast beacons to signify their existence with their neighbors. Location Stability is determined by counting the periodic beacons that a node receives from its neighbors. Links between nodes are classified into Stable and Unstable links based on the count of beacons. Source Node broadcast RouteRequest packets. Each neighbor will check if its ID is in the list or if it received this request before. It will drop the packet if positive. If not it will append its ID and the status of the link weather it is stable or not to the packet and rebroadcast the packet again.

Advantages

1. Stable routes have a higher preference compared to shorter routes. ABR protocol is totally free from loops, deadlocks and packet duplication. Fewer paths will break which reduces flooding.
2. ABR defines a new routing metric for mobile ad hoc network.
3. A broken link is repaired locally. Just because of this the source node won't start a new path-finding-process when a broken link appears.

Disadvantages

1. Due to the preference given to stable paths, sometimes the chosen path may be longer than the shortest path.
2. Stability information is only used during the route selection process. Local query broadcasts may result in.
3. Association stability is defined by connection stability of one node with respect to another node over time and space. Moving nodes tend to break the associativity with their neighbors and hence they are not good candidates to carry routes.

E. Location Aided Routing

Location Aided Routing (1998) decreases overhead of route discovery by using the location information for mobile host. LAR [16] [17] [18] uses the basic flooding algorithm that is defined in DSR with the exception that it uses location information of a particular node to limit the flooding in the network. It limits the search to a smaller request zone causing significant reduction of the number of routing messages [20] [22]. The location information can be gathered using the Global Positioning System (GPS). Sometimes the GPS might only give the approximate location of a node in the network. LAR calculates the expected zone of a particular node.

Advantages

1. A node forwards a route request only if it belongs to the "request zone". LAR aims to reduce the routing overhead for the route discovery.
2. The LAR protocol utilizes location information to minimize the search space for route discovery towards the destination node.
3. LAR essentially describes how location information such as GPS can be used to reduce the routing overhead in an ad hoc network and ensure maximum connectivity.
4. If LAR fails to find the route to the destination due to estimation error, the routing protocol resorts to flooding of routing message throughout the MANET.

Disadvantages

1. LAR can efficiently reduce the RREQ flooding cost but main problem with this protocol, obtaining accurate location information may be difficult in some environments. GPS does not work well indoors, and proximity does not guarantee connectivity.

F. Lightweight Mobile Routing Protocol

The LMR (1995) protocol is based on the concept of link reversal algorithm. LMR addresses the issue of partitioned network by providing a link erasure mechanism. LMR requires two passes to re-establish and converge to an alternate route, if one exists. Routes may be redundant. A higher level protocol could use redundant routes in a round-robin fashion to economically use local bandwidth.

Advantages

2. It is designed to reduce the control message propagation in highly dynamic mobile networking environment.
3. The benefit of this protocol is that routes will be found rather quickly and broken links will have only local affect.
4. In the case of dense network, it has good performance if the network connectivity is high.
5. LMR can erase invalid routes and detect partition in a single pass. Due to this shortest hop paths are given only secondary

importance and this protocol fits under the stability criteria. Another advantage of this protocol is that each node only maintains routing information to their neighbors.

Disadvantages

1. The limitation of this protocol is that in a rapidly changing network there may be many false RPY (reply) packets producing message overhead.
2. LMR may produce temporary invalid routes. It introduces extra delays in determining a correct loop.

G. Signal Stability Based Adaptive Routing Algorithm (SSA)

The SSA (1997) routing protocol is a derivative of the ABR routing protocol. SSA [19] [20] [22] selects routes based on the signal strength between nodes. Signal strength of the link with a neighboring node is determined using the periodic beacons received from that node. If the signal strength is beyond a threshold, the link is considered stable; otherwise, the link is designated to be weak. Preference is given to paths on the stronger stable channels, SSA fits under the stability category. Route discovery in SSA is through source-initiated broadcast request messages. A node forwards the request message to the next hop only if it is received over a stronger channel and has not been previously processed. The destination chooses the first arriving route-search packet and sends back a route-reply in the reverse direction of the selected route. Choosing the path of strongest signal stability, it is most likely that first arriving route-search packet traversed over the shortest and/or the least congested path. Within a specific timeout period, if no route-reply message is received, the source initiates another route-search and also indicates its acceptability of weak channels in the search packet header.

Advantages

1. The main advantage of SSA is that this protocol finds more stable routes to a destination the shortest path aren't necessary the best.
2. With the beacons between the nodes, SSA classifies the link as stable or unstable to find the strongest path.

Disadvantages

1. The limitation of SSA is that there is more bandwidth consumption because it sends Route Request many times.
2. The selected path may not be the shortest as the shortest path may have unstable link.

H. Cluster-Based Routing Protocol (CBRP)

CBRP (1999) is a hierarchical on-demand routing algorithm that uses source routing, to avoid forming loops and route packets. It can best perform in MANETs where nodes in each cluster move together. CBRP [20] [21] [22] groups the nodes in a network into several clusters. Like other hierarchical routing algorithms, CBRP aims to scale well with network size. Each cluster has a cluster head that coordinates data transmission within the cluster and with other clusters. A cluster head keeps a list of its members. It also maintains a cluster adjacency table where each entry contains information about each neighboring cluster, that is, the gateway through which the cluster can be reached and the cluster head of the cluster. When a source wants to send data to a destination, it broadcasts route request packets to its neighborhood. When a cluster head receives the request, it checks if the destination is located within its cluster. If the destination is available within its cluster, it forwards the request to the destination. Otherwise it rebroadcasts the request to all its neighboring cluster heads. This process continues until the destination receives the request packet and responds with a reply. The propagation of route request and route reply is similar to that of DSR. If the source does not receive a reply within a timeout period, it backs off exponentially before sending a route request again. CBRP uses route shortening to reduce the length of a route. To do so a node receiving a source route packet tries to find the farthest node in the route that is its neighbor. This situation can arise due to a topology change. If such a neighbor is found, the node sends the packet to that neighbor directly. While forwarding a data packet, if a node detects a link failure, it sends an error message to the source and also tries to forward the packet through a local repair mechanism. In the local repair mechanism, the node checks if the next hop or the hop after the next hop can be reached through any of its neighbors. If the node succeeds, the data packet can be delivered to the destination over the repaired path.

Advantages

1. Reduces communication.
2. Localized route maintenance.

Disadvantages

1. Introduces additional overhead for forming and maintaining clusters. Temporary routing loops.
2. CBRP may provide invalid routes temporarily as a node moves from one cluster to another.

J. Multi-Path Source Routing (MSR)

MSR (2001) is an extension of DSR protocol [12]. MSR tries to improve end-to-end delay, network congestion, and average queue size and path fault tolerance by employing the multi-path finding capability of DSR protocol in the network. MSR protocol allows the source to receive multiple route reply packets in a single route discovery phase. Each route discovered is stored in the route cache with a unique route index so that multiple routes for a particular destination can be distinguished properly.

Advantages

1. Multi-path routing and load balancing. MSR protocol allows the source to receive multiple route reply packets in a single route discovery phase.
2. MSR tries to improve end-to-end delay, network congestion, and average queue size and path fault tolerance.

Disadvantage

1. Requires periodic probe packets to gather information.

K. Ad-Hoc On-Demand Multi-Path Distance Vector (AOMDV)

AOMDV (2003) extends AODV to support multi-path routing in mobile ad-hoc networks. AOMDV [25] [26] adds some extra fields in routing tables and control packets, and requires few new rules to be followed during a route discovery phase in order to compute loop-free and link disjoint multiple routes. Link-disjoint routes do not contain any common link among the multiple routes between a source and destination pair. Every node maintains a variable called the advertised hop count for each destination in order to achieve loop-freedom. This variable is added in each RREQ (route request) or RREP (route reply) and in the routing table with the usual fields that are used for AODV. When a node initiates a RREQ or RREP with a particular destination sequence number, its advertised hop count field is set to the length of the longest available path to the destination expressed in terms of the number of hops.

Advantages

1. Link-disjoint multi-path routing.

Disadvantages

1. Requires periodic HELLO messages. It is unclear if this method can preserve loop-freedom.

Protocols	WCC [RD]	WCC [RM]	WTC [RD]	WTC [RM]	RS	MR	PB
DSR	O(2N)	O(2N)	O(2D)	O(2D)	F	YES	NO
AODV	O(2N)	O(2N)	O(2D)	O(2D)	F	NO	YES
TORA	O(2N)	O(2a)	O(2D)	O(2D)	F	YES	NO
ABR	O(N+r)	O(a+r)	O(D+C)	O(b+c)	F	NO	YES
LAR	O(2e)	O(2e)	O(2d)	O(2d)	F	YES	NO
LMR	O(2N)	O(2a)	O(2D)	O(2D)	F	YES	NO
SSA	O(N+r)	O(A+r)	O(D+c)	O(b+c)	F	NO	YES
CBRP	O(2M)	O(2A)	O(2D)	O(2B)	H	NO	NO
RDMAR	O(2e)	O(2e)	O(2d)	O(2d)	F	NO	NO
MSR	O(2N)	O(2N)	O(2D)	O(2D)	F	YES	YES
AOMDV	O(2N)	O(2N)	O(2D)	O(2D)	F	YES	YES
ARA	O(N+r)	O(a+r)	O(D+C)	O(D+c)	F	YES	NO

L. Ant Colony Based Routing Algorithm (ARA)

ARA (2002) adopts the food searching behavior of ants to find routes. When ants search for food, they start from their nest and walk towards the food. When ants start to walk, they leave behind a transient trail by depositing pheromone, a substance that ants can smell. Like AODV, ARA [27] [28] [29] uses sequence numbers to avoid forming loops. The concentration of pheromone on a certain route indicates its usage and allows other ants to follow most commonly used route. In the course of time the concentration of pheromone is reduced due to diffusion. Unlike AODV, ARA can find multiple routes between a source and destination pair. During route discovery, a FANT (forward ant) packet is propagated through the network similar to RREQ in AODV. When a node receives a FANT for the first time, it calculates a pheromone value depending on the number of hops the FANT has traveled to reach the node. It creates an entry in its routing table with the calculated pheromone value, the address of the neighbor from which the FANT was received, and the address of the source from which the FANT originated. This entry in the routing table creates a pheromone track towards the source. Once a FANT reaches the destination, the destination creates a BANT (backward ant) from the extracted information of the FANT and returns the BANT to the source. The BANT performs a similar task to the FANT that is, establishing a pheromone track towards the destination.

Advantages

1. Sequence numbers, similar to AODV, are used to avoid duplicate FANTs and prevent forming loops.
2. While forwarding a data packet, if a node detects a link failure, it first checks its routing table to find an alternate route to the destination of that data packet.
3. If the neighbor fails to find an entry in their routing tables for the destination, the request backtracks until it reaches the source node. The source then can initiate a new route discovery phase if needed.

Disadvantages

1. Route discovery is based on flooding.
2. Since the route discovery process is based on flooding, ARA may not scale well as the numbers of nodes and flow increase.

5. Parameter wise comparison of these protocols

Abbreviations: WCC: Worst Case Communication Complexity= Number of messages needed to perform a route discover or an update operation in worst case. WTC: Worst Case Time complexity= Number of steps involved to perform a route discovery or an update operation in worst case. RD: Route Discovery; RM: Route Maintenance; RS: Routing Structure; F: Flat; H: Hierarchical; MR: Multiple Routes; PB: Periodic Beacons; N: Number of nodes in the network; D: Diameter of the network; a: Number of affected nodes; b: Diameter of the affected area; c: Diameter of the directed path of RREP, BANT; d: Diameter of the localized region; e: Number of nodes in the localized region; r: Number of nodes in the route reply path; m: Number of clusters in CBRP.

Most of the reactive routing protocols use a flat routing structure. However if an estimated location of a remote node is not known a priori, these protocols behave like a pure flooding based algorithm. LAR and RDMAR can reduce the number of route discovery packets by limiting the search space within a calculated region. In ABR and SSA routing overheads are minimized by selecting stable routes. However, routes selected in this way may not be the shortest in terms of the numbers of hops. ABR, TORA, and ARA provide localized route repair mechanisms to reduce delays. They can limit route control packets that could otherwise be increased if alternate routes were required to be found by the source nodes. CBRP reduces control overhead by applying a hierarchical structure to the network. CBRP further minimizes delay and the number of control packets by providing a localized route repair mechanism. CBRP may incur excessive processing and communication overheads for cluster formation and maintenance in MANETs. Therefore CBRP is most suitable for medium-sized networks with slow to moderate mobility.

6. Conclusion and Future Work

Being one of the most popular fields of study during the last few years, almost every aspect of ad hoc networks has been explored in some level of detail. Yet, no ultimate resolution to any of the problems is found or, at least, agreed on. In this survey paper, an effort has been made to concentrate on the comparative study and performance analysis of various on demand/reactive routing protocols. Also it is clear that all the above mentioned protocols have certain advantages and some sort of limitations depending on the situation of the network. This survey paper present an overview of these reactive routing protocols for the students or researchers to have an idea about these protocols so that they can be able to enhance the features of these protocols. There is still much work to be done to optimize these routing protocols for different scenarios and applications separately for a general solution.

References

[1] Saleh Ali K.Al-Omari and Putra Sumari, "AN OVERVIEW OF MOBILE AD HOC NETWORKS FOR THE EXISTING PROTOCOLS AND APPLICATIONS", International Journal on applications of graph theory in wireless ad hoc networks and sensor networks (Graph-Hoc), Vol 2, No1, March 2010.

[2] G. Jayakumar and G. Ganapathy, "Performance Comparison of Mobile Ad-hoc Network Routing Protocol", International

Journal of Computer Science and Network Security (IJCSNS), vol.7, No.11, pp. 77-84, November 2007.
[3] M. Chandrika and N. Papanna, "A Survey on Reactive Protocols in Mobile Ad Hoc Networks", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 1, January 2013 ISSN: 2277 128X.
[4] Narendra Singh Yadav and R.P.Yadav, "Performance Comparison and Analysis of Table-Driven and On-Demand Routing Protocols for Mobile Ad-hoc Networks", International Journal of Information and Communication Engineering 4:6 2008.
[5] L. M. Feeney, "A taxonomy for routing protocols in mobile ad hoc networks", Tech. Rep., Swedish Institute of Computer Science, Sweden, October 1999.
[6] P. Mishra, "Routing Protocols for Ad Hoc Mobile Wireless Networks",http://www.cis.ohio-state.edu/~jain/cis788-99/adhoc_routing/index.html,2/7/2000, 10:38:34 AM, pp 1-20.
[7] K. Prabu and Dr. A. Subramani, "Performance Comparison of Routing Protocols in MANET", International Journal of Advanced Research in Computer Science and Software Engineering.
[8] Zhijiang Chang, Georgi Gaydadjiev, "Routing Protocols for Mobile Ad-hoc Networks: Current Development and Evaluation", Mekelweg 4, 2628 CD Delft, The Netherlands.
[9] I. Chlamtac, M. Conti, and J.-N. Liu, "Mobile ad hoc networking: imperatives and challenges," Elsevier Ad Hoc Networks Journal, vol. 1, pp. 13–64, 2003.
[10] Anju Gill and Chander Diwaker, "Comparative Analysis of Routing in MANET", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 7, July 2012 ISSN: 2277 128X.
[11] A.K. Gupta, Dr. H. Sadawarti and Dr. A. K. Verma, "Performance analysis of AODV, DSR & TORA Routing Protocols" in proceeding of IACSIT International Journal of Engineering and Technology, Vol.2, No.2, April 2010, ISSN: 1793-8236, pp. 226-231.
[12] D. Johnson, B.D.A. Maltz, and Y.C.Hu, "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR)", draft-ietf-manet-dsr-10.txt, 2004.
[13] C. Perkins, E. Belding-Royer, and S. Das, "Ad Hoc On-Demand Distance Vector (AODV) Routing", RFC 3561, Network Working Group, 2003.
[14] V. Park, S. Corson, "Temporally-Ordered Routing Algorithm (TORA) Version 1 Functional Specification", IETF Internet draft, work in progress, draft-ietf-manet-toraspec-04.txt, 2001.
[15] C-K. Toh, "Associativity-Based Routing for Ad-Hoc Mobile Networks", Wireless Pers. Communication, vol. 4, no. 2, Mar. 1997, pp. 1–36.
[16] Mohammad A. Mikki and Gaza, Palestine, "Energy Efficient Location Aided Routing Protocol for Wireless MANETs", (IJCSIS) International Journal of Computer Science and Information Security, Vol. 4, No. 1 & 2, 2009.
[17] Young-Bae Ko and Nitin H. Vaidya, "Location-Aided Routing (LAR) in mobile ad hoc networks", Wireless Networks 6 (2000) 307–321
[18] M. Uma And Dr. G. Padmavathi, " A COMPARATIVE STUDY AND PERFORMANCE EVALUATION OF REACTIVE QUALITY OF SERVICE ROUTING PROTOCOLS IN MOBILE ADHOC NETWORKS", Journal of Theoretical and Applied Information Technology.
[19] R. Dube et al., "Signal Stability based adaptive routing for Ad Hoc Mobile networks", Journal of IEEE Personnel Communication, Feb. 1997, pp. 36-45.
[20] C. Liu and J. Kaiser, "A Survey of Mobile Ad Hoc network Routing Protocols, "Tech.Report Series,Nr.2003-08 2003.
[21] A. S. Salunkhe and Dr. S. V. Sankpal, "Performance Evaluation Using Cluster Based Routing Protocol for MANET", International Journal of Application or Innovation in Engineering & Management (IJAIEM), Web Site: www.ijaiem.org, Volume 2, Issue 1, January 2013.
[22] Humayun Bakht, "Routing protocols for mobile ad hoc networks", School of Computing and Mathematical Sciences, Liverpool, John Moores University.
[23] George Aggelou and Rahim Tafazolli, "RDMAR: A bandwidth-efficient Routing Protocol for Mobile Ad hoc Networks".
[24] Deepak Kumar and Dr. P.K. Jakhar, "RELETIVE DISTANCE MOBILE AD HOC NETWORKS (RDMAR)", Deepak Kumar et al, Int. J. Comp. Tech. Appl., Vol 2 (4), 733-735 IJCTA | JULY-AUGUST 2011 Available online@www.ijcta.com 733 ISSN:2229-6093
[25] S. R. Biradar, Koushik Majumder, Subir Kumar Sarkar, and Puttamadappa C, "Performance Evaluation and Comparison of AODV and AOMDV", S.R.Biradar et al. / (IJCSE) International Journal on Computer Science and Engineering Vol. 02, No. 02, 2010, 373-377.
[26] Mahesh K. Marina and Samir R. Das, "Ad hoc on-demand multipath distance vector routing", WIRELESS COMMUNICATIONS AND MOBILE COMPUTING Wirel. Commun. Mob. Comput. 2006; 6:969–988 Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/wcm.432.
[27] Vasundhara Uchhula and Brijesh Bhatt, "Comparison of different Ant Colony Based Routing Algorithms".
[28] P. Deepalakshmi and Dr. S. Radhakrishnan, "Ant Colony Based QoS Routing Algorithm For Mobile Ad Hoc Networks", International Journal of Recent Trends in Engineering, Vol. 1, No. 1, May 2009.
[29] Mesut G"unes¸ Udo Sorges and Imed Bouazizi, " ARA – The Ant-Colony Based Routing Algorithm for MANETs".