

Research Article

A Novel Approach of On Demand Distance Routing (NAODV) Algorithm for Improving Performance of Mobile Ad hoc Network

Anil Lamba^{†*} and Sohan Garg[‡]

[†]Venkateshwara University-Gajraula, India

[‡]SCRIET, C.C.S. University Meerut, India

Accepted 01 July 2015, Available online 02 July 2015, Vol.5, No.4 (Aug 2015)

Abstract

A mobile ad-hoc network (MANET) is a self-configuring, infrastructure less network of mobile devices connected by wireless. Ad hoc is Latin and it means for this purpose. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously withstand the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. The proposed NAODV approach is used for solving routing problems in Mobile Ad Hoc networks. Generally routing algorithm of ad-hoc network uses a blind flooding technique for the route discovery process. However, these techniques are not efficient and create extra routing overheads, which some time creates adverse effect on data transmission in ad-hoc network. In order to overcome such problems, proposed routing protocol implements a query localization approach (QLA) that significantly minimizes the routing overheads and organize the network traffic and improve the performance routing protocol. Proposed on-demand routing protocol is more proficient and accessible.

Keywords: MANET, QLA, MPCS, GPS, DSR, AODV, OSPF, RIP, DSDV, DBF, CPU, NAODV.

1. Introduction

A mobile ad-hoc network (MANET) is formed by a group of mobile nodes connected by wireless links (Basagni, S. *et al*, 2003). The nodes can talk to each other by direct peer-to-peer wireless communication when they are close to each other. When the sender and receiver are far away, their packets can be forwarded by the intermediate nodes along a multi-hop path.

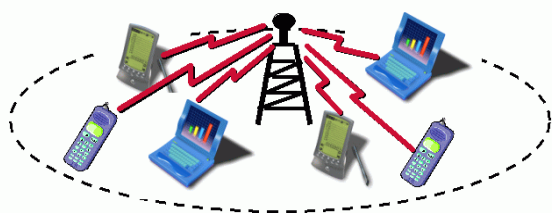


Figure 1.1: Infrastructure-based Wireless network (Chlamtac *et al*, 2003)

An infrastructured network (Figure 1.1) consists of wireless mobile nodes.

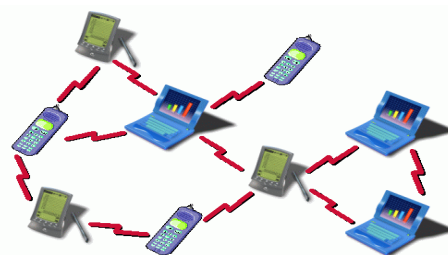


Figure 1.2 Wireless Ad-hoc Network (Khaleel Ur Rahman Khan *et al*)

A mobile node within the network searches for the nearest base station connects to it and communicates with it. The important fact is that all communication is taking place between the wireless node and the base station but not between different wireless nodes. While the mobile node is traveling around and all of a sudden gets out of range of the current base station, a handover to a new base station will let the mobile node communicate seamlessly with the new base station.

In contrary to infrastructured networks, an ad-hoc network (Figure 1.2) lacks any infrastructure. There are no base stations, no fixed routers and no centralized administration. All nodes may move

*Corresponding author Anil Lamba is a Research Scholar

randomly and are connecting dynamically to each other. Therefore all nodes are operating as routers and need to be capable to discover and maintain routes to every other node in the network and to propagate packets accordingly (Freebersyser *et al*, 2001). Mobile ad-hoc networks may be used in areas with little or no communication infrastructure: think of emergency searches, rescue operations, or places where people wish to quickly share information, like meetings etc.

1.1 There are many reasons better to use ad-hoc than infrastructure.

The biggest ad-hoc's strength is its independency from any infrastructure. Therefore, it is possible to establish an ad-hoc network in any difficult situations. The following are the advantages of ad-hoc networks.

- **No infrastructure and lower cost:** (Basagni, S. *et al*, 2003) Services from an infrastructure can be expensive for specific applications. In an area with very low density, like desert, mountain, or isolated area it is not impossible to establish an Infrastructure, however an independent from infrastructure network can be established in such cases.
- **Mobility (MANET only):** In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users (Freebersyser *et al*, 2001). The most popular examples include military networks, emergency or rescue operations, and disaster effort. In these scenarios we can't rely on centralized connectivity.
- **Decentralized and robust:** Another advantage of ad-hoc networks is that they are inherently very robust (Gupte S *et al*, 2003).
- **Easy to build and spontaneous infrastructure:**

1.2 Weakness of ad-hoc network

Lower data rate, security, and medium access control are common problems in the wireless communications:

- **Higher error rate:** Unlike wired transmission, the wireless transmission may deal with problem the characteristic of the electronic wave.
- **Lower data rate:** One of biggest Problem of ad-hoc networks is reduced data rates. The characteristic of wave, which is used for wireless communication, prevents wireless communication to transmit data better than wired communication. A higher frequency can transmit more data, but then it is more vulnerable to interference and performs well in short range.
- **Dynamic topology and scalability:** Because ad-hoc networks do not allow the same kinds of aggregation techniques that are available to standard Internet routing protocols, they are vulnerable to scalability problem (Charles E *et al*, 1998). Since the MANET's nodes are mobile, the routing changes as the nodes move.

- **Security:** Due to dynamic distributed infrastructure-less nature and lack of centralized monitoring points, the ad-hoc networks are vulnerable to various kinds of attacks (Loutfi Valerie *et al*, 2003).
- **Energy limitation (MANET only):** A MANET network allows mobile nodes to communicate in the absence of a fixed infrastructure. Therefore, they operate with on battery power. Because of these limitations, they must have algorithms which are energy-efficient as well as operating with limited processing and memory resources (Sergio Marti *et al*, 2000).

2. Routing in MANET

Routing is the process of information exchange from one host to the other host in a network. Routing is the mechanism of forwarding packet towards its destination using most efficient path. Efficiency of the path is measured in various metrics like, Number of hops, traffic, security, etc. In ad-hoc network each host node acts as specialized router itself (Sergio Marti *et al*, 2000).

Considering the special properties of MANET, when thinking about any routing protocol, generally the following properties are expected, though all of these might not be possible to incorporate in a single solution.

- A routing protocol for MANET should be distributed in manner in order to increase its reliability.
- A routing protocol must be designed considering unidirectional links because wireless medium may cause a wireless link to be opened in unidirectional only due to physical factors.
- The routing protocol should be power-efficient.
- The routing protocol should consider its security.
- A hybrid routing protocol should be much more reactive than proactive to avoid overhead.
- A routing protocol should be aware of Quality of Service (QoS).

2.1 Comparative Study

Routing protocols for MANETs can be broadly classified (D. B. Johnson *et al*, 2001) into three main categories:-

- 1.) Proactive routing protocols:- Every node in the network has one or more routes to any possible destination in its routing table at any given time.
- 2.) Reactive routing protocols:-Every node in the network obtains a route to a destination on a demand fashion. Reactive protocols do not maintain up-to-date routes to any destination in the network and do not generally exchange any periodic control messages.
- 3.) Hybrid routing protocols:-Every node acts reactively in the region close to its proximity and proactively outside of that region, or zone.

2.2 Reactive Routing Protocols

Reactive routing protocols are more popular set of routing algorithms for mobile computation because of their low bandwidth consumption

2.2.1 Dynamic Source Routing (DSR)

- This is an On-demand source routing protocol designed by D. B. Johnson, Maltz and Broch. In DSR the route paths are discovered after source sends a packet to a destination node in the ad-hoc network. The source node initially does not have a path to the destination when the first packet is sent. The DSR has two functions first is route discovery and the second is route maintenance (N. S. M. Usop *et al*, 2011). The distinguishing feature of Dynamic Source Routing (DSR) is the use of source routing. DSR is a reactive protocol i.e. it doesn't use periodic updates. It computes the routes when necessary and then maintains them.

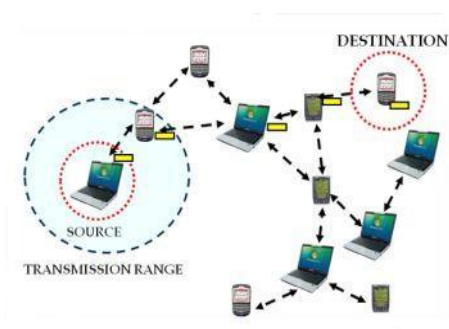


Figure 2.1: Dynamic Routing Protocol (Y.-B. Ko *et al*, 2010)

2.2.2 Ad-hoc On demand Distance Vector (AODV)

- **AODV** uses traditional routing tables, one entry per destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers (S.-J. Lee *et al*, 2001).
- AODV uses a destination sequence number for each route created by destination node for any request to the nodes. (N. S. M. Usop *et al*, 2011).

3. Literature Review

The frequently used routing protocols in the wired networks are Open Shortest Path First (OSPF) and Routing Information Protocol (RIP). RIP is a distance vector protocol while OSPF is based on the link-state routing philosophy. The two protocols, although reasonably efficient for routing data in the wired networks are completely inappropriate for applications in the mobile ad-hoc networks. The dynamic nature of MANET causes random and unpredictable changes in the routes of the network.

Therefore, the computationally expensive operations of the traditional wired protocols would be highly payable in an ad-hoc network in term of battery power resources, CPU time, and memory of the mobile nodes. Destination sequenced distance vector (DSDV). The Destination Sequenced Distance Vector (DSDV) routing algorithm is the improvement of the classic Distributed Bellman-Ford (DBF) algorithm. In MANET any node can act as a router and hence each node maintains a routing table that lists all the nodes in the area of network. List of table contains the entry of destination and the next hop addresses and cost to reach to the destination. The reason DSDV is a modification of the original wired network protocol because it avoids tendency to create routing loops. Each entry in the routing table and protocol message update is marked with a sequence number and maintained by the destination node of a route entry and incremented whenever the node activates its routing information. Because the value is increased in sequential order, a higher value of sequence number indicates that the routing entry is fresher.

4. Comparison of AODV with DSDV

Ad-hoc on-demand distance vector (AODV). This routing protocol is proposed for use by mobile nodes in ad hoc networks where two or more hosts wish to communicate with each other and routes are used to create to provide such connection. AODV offers fast adaptation to dynamic link environment, low processing and memory overhead, less network utilization and determines unicast routes to destinations. The algorithm enables dynamic, self-starting, multi-hop routing among participating mobile nodes desired to set up and sustain an ad hoc network. AODV allows mobile nodes to take action quickly to link breakages and changes in the network topology. When a connection is broken because of some erroneous state, AODV informed the affected set of nodes so that they may nullify the routes using the lost link. The protocol is similar to DSR in the route attainment and route protection mechanisms. However the two protocols differ in that AODV maintain the route information in a distributed manner at each node on the route whereas DSR manage the route information in the header packet of each data packet that is communicated. AODV maintains loop free routes at all times using sequence numbers. This concept is taken from the DSDV routing algorithm.

AODV is categorized as an on demand algorithm. AODV uses the route request/route reply cycle to determine routes to its destinations. There are three messaging types used by in route cycle: (1) Route requests - RREQ (2) Route reply - RREP and (3) Route errors - RERR.

AODV utilizes an improved edition of the traditional route table to manage and maintain routes to destination nodes and cached as long as they are being dynamically used. Therefore routes to destinations are not known before a route being requested. The

protocol is being initialized by a route discovery process by generating and communicating a RREQ packet and each route request packet is identified by the source IP address and a broadcast ID uniquely. The packet is broadcast from source nodes to its neighboring nodes. A node receiving the route request primarily checks to decide if it has newly processed a RREQ with the same source IP and broadcast ID. If a match is found the RREQ is discarded otherwise if the request is new to the node, it maintains a reverse route entry to the source node in its route table or activates an old one. If the node is not the destination node or an intermediate node with a current route to the destination, it broadcasts the route request packet to its neighbors. This process continues until a node is reached to destination. In this manner the RREQ packet is circulated using a network wide flood until a route is found. (refer to Figure 4.1).

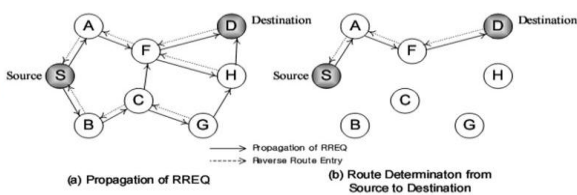


Figure 4.1: Network flood of route request packets in AODV(Khaleel Ur Rahman Khan et al)

The reverse path arrangement at each intermediate node is shown in Figure 4.2. The destination node D does not acknowledge the route request packet from node 7 because it has already received a request with the similar request information from node 5.

It is understandable from Figure 4.2, by the time the RREQ arrives at a node that can grant a route to the destination, a reverse route is established to the source of the route request. The route reply is transmitted along this route to reverse to the source node.

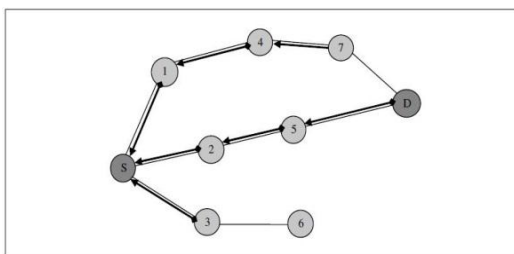


Figure 4.2: Reverse path setup in AODV

Each node through which the RREP packet hops create a forward pointer to the node from which the packet was received. The forward path arrangement can be seen in Figure 4.3 The hop count field in the RREP is incremented by each midway node that processes the message. When the reply reaches the source node, the hop count value presents the distance using hop count between the source and the destination. As soon as the

route reply comes, the route detection process is terminated and the source starts to send the packets which were in queue for the destination.

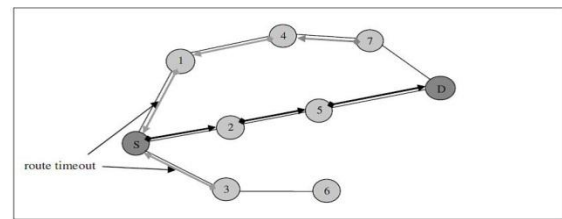


Figure 4.3: Forward path setup in AODV

5. Proposed Protocol Approach

Query Localization Approach (QLA). The proposed QLA presents the concept of adding query localization to the route finding process with application of on-demand algorithm. Our object is to design the flooding method more proficient. The protocol uses a load metric computation with the hop count as an elegant decision criterion for route selection procedure. Purpose of load checking is to make balance of traffic load in the network. To send route request packet to every possible node in the connected component network flooding is one of the acceptable method. However, there is no need to send the route request for every possible node which is not in the path of source and destination because flooding method will take extra overheads in this case. Our proposed technique will be used to reduce protocol routing overhead and making flooding technique more efficient. For this purpose make the flooding of the route request packets more proficient by reducing the area in the network where the packet is be flooded. Query localization approach (QLA) in ad-hoc networks has been introduced to make flooding of the route request packets more proficient.

QLA presents that each host in the MANET Positional Communication System (MPCS) network is organized in a Global Positioning System (GPS) method, which provides the information about the location each host. If a router may be any node in the ad-hoc network has prior knowledge about the location of the destination. Therefore it can be used to support the query localization approach. The proposed method is related to the Location Aided Routing (LAR) algorithm. Location information is used to determine the closeness of an intermediate router to the destination node. The object of QLA is to find the closer nodes in the path to destination node so that reduction of unnecessary traversing between source to destination in ad-hoc network.

5.1 Description of proposed Novel AODV (NAODV) protocol

The protocol Novel AODV (NAODV) proposed technique is an enhancement of the Ad-hoc On-demand Distance Vector (AODV) routing protocol with the application of Query Localization Approach (QLA).

Table 1: Rebroadcast decision in NAODV using QLA

S.No	Terms used and comparison	Analysis and Results
1	$DIST_{sd}$	<ul style="list-style-type: none"> The distance calculated by the source node $DIST_{sd}$ (Figure 5.1) is attached in the route request packet broadcast to its neighbors.
2	$DIST_{id}$	<ul style="list-style-type: none"> The intermediate node then calculates the distance $DIST_{id}$ from the source to the destination ($DISD_{sd}$) using its information for the destination and the location information of the source from the route request packet. The distance field in the route request packet is updated accordingly.
3	$time_{sd}$	<ul style="list-style-type: none"> The timestamp of the location information ($time_{sd}$) used to calculate $DIST_{sd}$ is also one of the fields in the packet.
4	$time_{id}$	<ul style="list-style-type: none"> The timestamp of the location information ($time_{id}$) used to calculate $DIST_{id}$ is used for intermediate nodes between source and destination.
5	Comparison of $time_{id}$ and $time_{sd}$	When a node between the source and destination receives the packet, the first action implementation of QLA. If an entry is found router table, the timestamp of the entry ($time_{id}$) is compared with the location information timestamp in the route request packet ($time_{sd}$). If $time_{sd}$ is older than $time_{id}$, then intermediate node's location information for the destination is more fresher.
6	Comparison of $DISD_{sd}$ and $DIST_{id}$	<ul style="list-style-type: none"> If $time_{id}$ is not fresher, the distance field remains unchanged. The intermediate node calculates its distance to the destination node and compares this value with the source to destination distance. If $DIST_{sd}$ is larger than $DIST_{id}$, the intermediate node rebroadcasts the route request packet. The distance metric to the destination is equated to $DIST_{id}$, thinning the localization region with each hop. If this condition is satisfy the packet is dropped. During QLA, if any node has no entry in its location cache for the destination, it does not execute the QLA algorithm.

Application Query Localization Approach (QLA) may be applied to other on-demand algorithms but in proposed paper it has been used with AODV because of its good performance in MANET Positional Communication System (MPCS) network, organized in a Global Positioning System (GPS) technique.

NAODV is the enhancement AODV where functioning is similar to AODV but enhancement of path searching from source to destination using the concept of QLA. In this technique routing information for each route to a destination is managed in a distributed order in the routing tables of the nodes in the network. Route discovery takes place when source node does not have a route to the destination, if a route is found then data packets are transmitted for the destination. A repaired process of route is being used before further transmission in the case of route is broken during the communication between the source and destination node.

In purposed NAODV approach, when a request takes place then it generates data packets for the destination and create shortest route between source and destination using QLA and these routes are maintained as long as communication tacking place between them. A concept of a timeout period is being used; if this path is not being active with in a timeout period then route is taken as inactive and is diminished.

Query Localization Approach (QLA) used in NAODV may be referred as route localization because this is an optimization of the flooding technique used by on-demand algorithms. In this approach if location-information of each node is available then closer nodes can be found and rebroadcasting takes place to only to nearer nodes instead of all neighboring nodes hence reduce the overheads of routing protocol.

The source node examine its location cache to check its location entry for the desired destination for which route request is generated, if location entry exist then

communication takes place between source and destination quickly; otherwise route discovery takes place using QLA.

The distance of destination may be computed in positional information of the destination using x and y coordinates if location entry is found, using Equation (1).

$$DIST_{sd} = \Delta x + \Delta y + \lambda \tag{1}$$

$DIST_{sd}$ represents the distance from source to the destination node.

Where Δx and Δy is the difference between x and y coordinates of the source and destination nodes respectively. λ is the factor represents the approximation of distance measure is given by

$$\lambda = v \cdot (time_c - time_d) \tag{2}$$

$time_c$ is taken to represent the current time and $time_d$ is taken to represent time stamp of location information and maintain value of time instance, v represent the maximum speed that node can move.

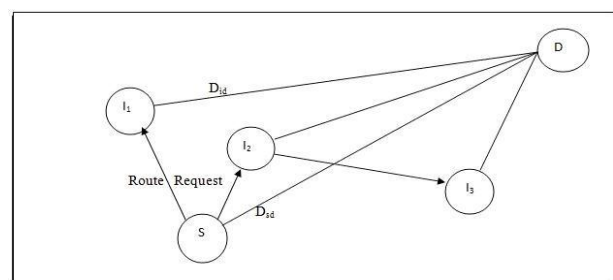


Figure 5.1: Rebroadcast decision in NAODV

Table 2: Steps of Load checking algorithm in NAODV

Step No	Steps Taken by Load checking Algorithm
1	The load checking operation of the protocol is done at each of the intermediate nodes that process a route request.
2	The protocol queue is a first-in-first-out (FIFO) queue in which packets that are awaiting routes are temporarily stored.
	The length of the protocol queue at each node is taken as a measure of the load at a node.
3	If intermediate node receives a route request, then first decision is made at the node is whether it will get involved in the route or not.
4	The node inspects its protocol queue and if it is near to its capacity, then intermediate node rejects the route request by dropping the packet.
5	After the primary load check, then, if the intermediate node determines to act as a router for the source, then foremost creates a reverse route in its route table entry for the source node. This entry will be used to unicast reply packets back to the source node.
6	A load variable in the route request packet counts the number of nodes linking between the source and destination in protocol queues This load variable is initialized to zero by the source node when it generates the packet.
7	The load checking process is executed with each hop that the route request packet takes on route to the destination node. NAODV specifies that the route request should travel to the destination node and that no intermediate node is permitted to reply to the route request
8	There are essentially three conditions that determine whether a route is better than another.
	Case 1: A route is considered better if the load variable of a newly arrived route is lower than that of the previous route.
	Case 2: The load variable is equal between the routes being compared. In such a situation the route with the lower hop count is deemed a better route.
	Case 3: If the newly arrived route has a higher hop count than the previous route, it is only recognized as a route with a better metric, if the load variable is lower. In this case, although a longer route in terms of hop count is chosen, it is a route that is less loaded.

5.2 Load Checking in NAODV

Simulation of NAODV has been performed with the cases in step-8 of Table-2 and without the cases in step-8 of Table-2 and it has been observed from outcomes there is remarkable improvement in the performance. NAODV has shown the expected reduced delay and prevent the creation of clogged critical nodes in the ad hoc network. The congestion is responsible for data packets are queued and made overloaded protocol queues for clogged critical nodes. We purposed to arrange these queues in a first-in-first-out (FIFO) queue structure, which improve the performance. Normally the delay takes place due to queuing at nodes in congested route instead less loaded routes with higher hop count. We have emphasized to reduce the load of queuing due to the creation of clogged critical nodes in the ad hoc network. The load distribution is done by NAODV among the nodes in the network with the elegant selection criteria by using the concept of QLA. Purposed approach has improvement significantly in reduction of latencies for the delivery of packets.

Conclusion

The proposed research work of routing protocols (NAODV) is a meaningful approach because it tries to disclose the major issues for design and implementation principles for AODV protocols and improve the performance of AODV protocol, which was very much effected by mobility and node density in ad hoc network. It is major challenge for developing a solution for ad-hoc networks due to its unique features

like nodes having limited resources in the ad-hoc network and dynamic topologies. The current wireless network protocols offer only limited mobility and this paper has highlighted the reasons for ad-hoc networks being the next step towards truly ubiquitous computing and communications. Especially in military application, the Positional Communication System (PCS) is being used for knowledge of positions of counterparts in present battle field. This PCS has been used for QLA for the proposed approach of on demand distance routing algorithm for improving performance of mobile ad-hoc network. The object of proposed research work is to improve and design a new routing algorithm known as Novel AODV (NAODV) which is suitable for ad-hoc network with the application of PCS network.

References

- Basagni, S., Conti, M., Giordano S., and Stojmenovic, I. (Eds.) (2003) , Ad-Hoc Networking, IEEE Press Wiley, New York.
- Chlamtac, I., Conti, M., and Liu, J. J. N.,(2003) Mobile ad-hoc networking: imperatives and challenges, Ad-Hoc Networks, 1(1), pp. 13-64.
- Khaleel Ur Rahman Khan, Rafi U Zaman, A. Venugopal Reddy, Performance Comparison of on-Demand and Table Driven Ad-Hoc Routing Protocols using NCTUns, Tenth International Conference on Computer Modeling and Simulation.
- Freebersyser, J. A., and Leiner, B. A (2001) DoD perspective on mobile ad-hoc networks, In: Perkins, C. (Ed.) Ad-Hoc Networking, Addison Wesley, Reading, MA, pp. 29-51.
- Gupte, S., and Singhal, M.(2003), Secure routing in mobile wireless ad-hoc networks, Ad-Hoc Networks, 1(1), pp. 151-174.

- Charles E.Perkins and Elizabeth M. Royer (1998) Ad-hoc on demand distance vector (AODV) routing (Internet-Draft),
- Loutfi, Valerie, Bruno (2003) Securing mobile ad hoc networks, MP71 project.
- Sergio Marti, T. J. Giuli, Kevin Lai, Mary Baker (2000) Mitigating Routing Misbehavior in Mobile Ad-Hoc Networks, Proceedings of the 6th annual international conference on Mobile computing and networking, Boston, Massachusetts, Pp: 255 – 265.
- D. B. Johnson, D.A Maltz, and J. Broch (2001) DSR: The Dynamic Source Routing Protocol for Multi-Hop Wireless Ad-hoc Networks, Ad-Hoc Networking, C.E. Perkins, Ed., Addison-Wesley, 139- 172.
- C. Perkins, E. Belding and S. Das (2003) Ad hoc on-demand distance vector (AODV) routing, Request for Comments: 3561.
- D. Lang (2003) A Comprehensive Overview about Selected Ad Hoc Networking Routing Protocols, Master Thesis, Technische Uni. Munich, Germany.
- N. S. M. Usop, A. Abdullah and A. F. A. Abidin (2011) Performance evaluation of AODV, DSDV & DSR routing protocol in grid environment, International Journal of Computer Science and Network Security, vol.9, no.7, pp.261-268.
- N. Sengottaiyan, R. Somasundaram and S. Arumugam (2010) A modified approach for measuring TCP performance in wireless ad-hoc network, Proc. of International Conference on Advances in Recent Technologies in Communication and Computing.
- Y.-B. Ko and N. H. Vaidya(2000) Location-aided routing (LAR) in mobile ad hoc networks, Wireless Networks, vol.6, no.4, pp.307-321.
- S.-J. Lee and M. Gerla(2001) Dynamic load-aware routing in ad hoc networks, Proc. of IEEE International Conference on Communications, pp.3206-3210.