Special Issue of International Journal of Computer Applications (0975 – 8887)
on Wireless Communication and Mobile Networks, No.11. Jan.2012, www.ijcaonline.org

Performance of Routing Protocols in MANETs with Node Density and Mobility using Omni and Directional Antenna

Vinay Kumar
Motilal Nehru National Institute of Technology Allahabad, India-211004

Sanjeev Jain
Motilal Nehru National Institute of Technology Allahabad, India-211004

Sudarshan Tiwari
Motilal Nehru National Institute of Technology Allahabad, India-211004

ABSTRACT
Mobile ad hoc networks are generally assumed to be equipped with omni directional antennas. However, it may be possible to improve the network performance by using directional antennas. Complexities of routing among the nodes are increasing due to the highly dynamic nature of the mobile ad hoc network results in frequent change in network topology. The routing protocols are faced with the challenge of producing multi-hop routing under host mobility and bandwidth constraint. To find out whether directional antennas are beneficial to ad hoc networks, it is mandatory to evaluate the effects of directional antennas on performance of routing protocols. In this paper, analysis and comparisons of various routing protocols such as: Ad hoc On Demand Distance Vectoring Routing Protocol (AODV), Dynamic Source Routing (DSR) and Dynamic MANET On demand Routing (DYMO) have done. We have determined the average end to end delay, average jitter and throughput for omni- directional as well as directional antenna based routing protocols in MANETs. Random waypoint mobility is used in this simulation.

Keywords
Directional antenna, Mobile Ad hoc Networks (MANETs), AODV, DSR, DYMO, Node Mobility and Node Density

1. INTRODUCTION
Directional antennas provide large coverage area and lower power consumption. Because of these advantages, directional antennas have been adopted in IS-95 and 3G cellular systems [13]. Mobile ad hoc networks (MANET) [1], is a self-configuring and self organizing multi hop wireless network that does not rely on a fixed infrastructure and works in a shared wireless medium. Nodes in mobile ad- hoc network sharing same random access wireless channel and each node function not only as a host but also as a router that maintains routes to and forwards data for the other nodes in the networks that may not be within wireless transmission range. Routing in mobile ad hoc networks faces challenges due to a large number of nodes, mobility of the nodes and communication resource constrained like bandwidth and energy [8, 15]. Distance vector routing is a shortest path routing, a vector containing the cast and the path to

all the destinations is kept and exchanged at each node. In a network with population N, link state updating generates routing overhead on the order of O (N^2). If the networks have a large number of nodes, the transmission of routing information will consume most of the bandwidth [5]. Thus, reducing routing control overhead becomes an important to find a solution to the scalability problem of a homogeneous network using a scalable routing protocol. Scalable routing protocol may generally be categorized as: Proactive, Reactive and hybrid routing protocol. Table driven routing protocols attempt to maintain up to date routing information from each node to every other node in the network for ex. OLSR [16], LANMAR. Reactive type of routing creates routes only when desired by the source node for ex. AODV, DSR and DYMO [9]. Hybrid routing is a combination of proactive and reactive for ex. ZRP [18]. Both proactive and reactive routing protocols have their advantages and disadvantages in terms of routing table size, contrast and bandwidth consumption. If we are talking in term of routing table size, a proactive protocol has to maintain entries for all the nodes in the network, hence cannot scale well to large networks. By contrast, routing information to only active communicating nodes is maintained in an on demand routing protocol. For bandwidth consumption, reactive routing protocols are generally considered to have lower control overhead. However, when new routes have to be found frequently, the flooding of RREQ (Route Request) may cause significant overhead. In addition, a path is used as long as it is valid, hence route optimality cannot be achieved in such protocols. This means that the amount of bandwidth wasted due to the sub optimality of routes may become excessive when the call-to-mobility ratio is high. Proactive protocols can potentially be designed with the same level of control overhead as reactive protocols. In a sense, this flexibility of balancing the tradeoff between routing control overhead and path optimality is an advantage of proactive approaches over reactive ones. And if we are talking In terms of delay, proactive protocols have a route to the destination readily available whenever it is needed, while reactive protocols suffer from longer route acquisition latency due to the on-demand route discovery. Ideally, a hybrid routing protocol should have the following properties:

The protocol should choose suitable basic components and should integrate them organically to achieve better performance than any single component, the protocol should be able to dynamically adjust the contribution of each component to achieve different performance goals under different network conditions; such adaptation mechanisms generally require a clear mapping between performance metrics and hybridization parameters. In this paper we have compared and analysis the reactive routing protocols like: AODV, DSR and DYMO on the basis of average jitter, average end to end delay, throughput using omni-directional and directional antenna. The rest of the paper is organized in following structure: Section II presents the previous works. Section III presents a description of directional antenna and routing protocols. Section IV presents simulation setup and analysis of the results and section V contains conclusion of the paper.

2. RELATED WORKS

In this paper authors have evaluated the tradeoffs in using directional antenna in ad hoc routing although problems with utilizing directional antenna have been highlited in last four of five years. To find out whether directional antennas are beneficial to ad hoc network it is necessary to evaluate the effects of directional antenna on the performance of various routing protocols. In this paper, authors have evaluated the performance of DSR using directional antenna. In this authors have proposed routing strategies that adapt the routing protocol to directional communication. Our analysis shows that by using directional antenna, ad hoc networks may achieve better performance.

However, scenarios exist in which using Omni directional antennas may be more appropriate [23]. In the ad hoc wireless networks, nodes are generally powered by batteries. Therefore conserving energy has become a very important objective, and different algorithms have been proposed to achieve power efficiency during the routing process. Directional antennas have been used to decrease transmission power as well as to reduce interference in the networks. Author design an interference model for directional antenna based on a honey grid model to find out the maximum interference. Authors present the maximum end-to-end throughput under the maximum interference.]

Authors further investigate the effect of collision on the energy consumption and propose an energy consumption model that utilizes all aspects of energy wastage [25]. The authors in [3] compare four ad hoc routing protocols using a maximum number of 50 nodes but their traffic load is relatively low, since the data packet size is 64 bytes, the maximum number of sources is 30 and every source node transmits 5 packets / Sec. The authors in [9] compare three routing protocols, AODV, DSR and STAR by using NS-2 simulator. Author in [22] this paper proposed mathematical framework for the evaluation of the performance of proactive and reactive routing protocols in mobile ad hoc networks (MANETs).

The model in this paper covers the mandatory behavior and scalability limits of network size of both classes of routing protocols like proactive and reactive, and provides valuable direction for the performance of reactive or proactive routing protocols under various network condition and mobility model. A thorough work is presented in [11], in which the authors have performed an extensive performance evaluation between DSR and AODV, in which the basic mobility metric is the node pause times.

This work however does not include large-scale networks either. This is also the case with the comparison between AODV, PAODV, CBRP, DSR, and DSDV.

3. ROUTING PROTOCOLS IN MANETS

A directional antenna [23, 24] or beam antenna is an antenna which radiates greater power in one or more directions allowing for increased performance on transmit and receive and reduced interference from unwanted sources. Directional antenna e.g. yagi antennas have enhanced performance as compared to dipole antennas. All practical antennas are at least somewhat directional, although usually only the direction in the plane parallel to the earth is considered, and practical antennas can easily be omni directional antenna.

3.1 DYMO (Dynamic MANET On-demand Routing

DYMO (Dynamic MANET on-demand) [6], [7] and [12] is a reactive type of routing protocol and inspired by AODV and uses sequence number to ensure the usage of fresh and loop free routes. Whenever a source node wishes to send information to the destination node and no path exist in the routing table. It will transmit (RREQ) Route Request Packet. Those nodes received this packet look for an entry for the source node in their routing table, if this entry does not exist or path found invalid, the RREQ is retransmitted. If such an entry exists then the packet is forwarded only if the information is considered valid otherwise discarded DYMOM (Dynamic MANET on-demand for multipath) protocol is an enhanced version of DYMO which supports the use of the multiple node disjoint path towards the destination. DYMOM provide the lesser end to end delay and average jitter than DYMO.

3.2 DSR (Dynamic Source Routing)

Dynamic Source Routing (DSR) [13], [14] and [19] is an on-demand ad hoc network routing protocol composed of two mechanisms: Route Discovery and Route Maintenance. It uses route discovery to dynamically discover it and this route is cached and used as needed for sending further packets. If a route has been broken it will use route maintenance mechanism to detect it.

The important advantage of the source routing design is that the intermediate nodes do not need to update routing information in order to route the packets that they forward, since the packet themselves already contain all the routing decisions. Optimization to route discovery is achieved non propagating route requests, replying from cache and gratuitous route replies. Optimization for route maintenance is achieved by salvaging and gratuitous route errors and optimization to caching strategies achieved by snooping and tapping.

3.3 AODV (Ad hoc on-demand Distance Routing)

Ad-Hoc On-demand Distance Vector’ (AODV) Routing protocol [20], [21] is a reactive protocol that was basically designed for highly dynamic wireless mobile ad hoc networks. It is adopted as a standard routing protocol for ZigBee specification.

To find a route to the destination, the source node that does not have destination route, broadcast Route request packets (RREQs) to neighboring nodes, this then forwards the request to their neighbors and so on. In order to control network-wide broadcast so RREQ packets, the source node uses an expanding ring search technique where the source node starts benefits the throughput since the number of buffered packets will be less due to a shortened inactive period. If the duty cycle is extremely small, the throughput could be reduced significantly because of insufficient bandwidth. If no reply is received within the discovery period, the TTL value incremented by a predefined increment value.

This process continues until a predefined threshold is reached. When an intermediate node forwards the RREQ, it records the address of the neighbors from which first packet of the broadcast is received, thereby establishing a reverse path. When the RREQ reaches a node that is either the destination node or an intermediate node with a fresh enough route to the destination, replies by uni-casting the route reply (RREP) towards the source node. As the RREP is routed back along the reverse path, intermediate nodes along this path set up forward path entries to the destination in its route table and when the RREP reaches the source node, a route from source to the destination establish. A route established between the sources destinations pair is maintained as long as needed by the source.

If the source node moves during an active session, route discovery is reinitiated to find a new route to the destination. However, if the destination or some intermediate node moves, the node upstream of the break removes the routing entry and sends route error (RERR) message to the affected active upstream neighbors. These nodes reactive routing protocol is a good choice especially for event driven or periodic data driven WSN applications. Discovery for that destination by sending out a new RREQ message. AODV is designed for highly dynamic mobile networks but the un-predictable topology change in WSN due to node failure makes them virtual mobile networks.

Hence until the source node is reached. The affected source node may then choose to either stop sending data or reinitiate route a in turn propagate the RERR to their precursor nodes, and so on from the delay and caused due to congestion, topology change in the network. It is measured in second.

4. NETWORK SIMULATION

Network simulator QualNet, is used to analyze the impact of node mobility and node density on on-demand routing protocols in mobile ad hoc networks: AODV, DSR and DYMO. In this paper the simulations use technological specifications of IEEE802.11b wireless networks with a physical layer specification as shown in table I.

4.1 Simulation Metrics

The Impact of node mobility and node density on reactive routing protocols is evaluated using the following performance metrics:

- Throughput: Average rate of successful data packets received at destination is called throughput is the. It is also called actual output. This measured in bps (bit/s)
- End-to-End Delay: Delays due to buffering during queuing at the interface queue, route discovery process, retransmissions at the MAC and propagation and transfer through the channel. It is generally measured in second.
- Average Jitter: It is the change in arrival time of the packets and caused due congestion, topology changes. It is different from the delay and caused due to congestion, topology change in the network. It is measured in second.

4.2 Simulation Methodology

In this paper simulation is performed by increasing the node density and changing the node mobility under varying node speed. The nodes are deployed randomly in the specified area and node follows the random way point mobility model.

These source nodes transmit 1000 byte data packets per second at a constant bit rate (CBR) across the established route for the entire simulation time 120 minutes.

4.2.1 Simulation Results

Aim of this paper is to find out the impact of node speed on the performance of three reactive routing protocols: AODV, DSR and DYMO using directional and omni-directional antenna. In this, simulation occurs: by varying the node speed

Case1: Performance for AODV

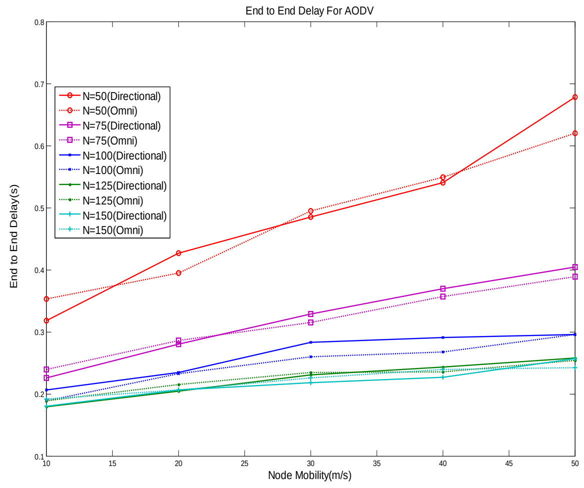

Figure1: End to End Delay Vs Node Mobility for AODV using omni and Directional Antenna

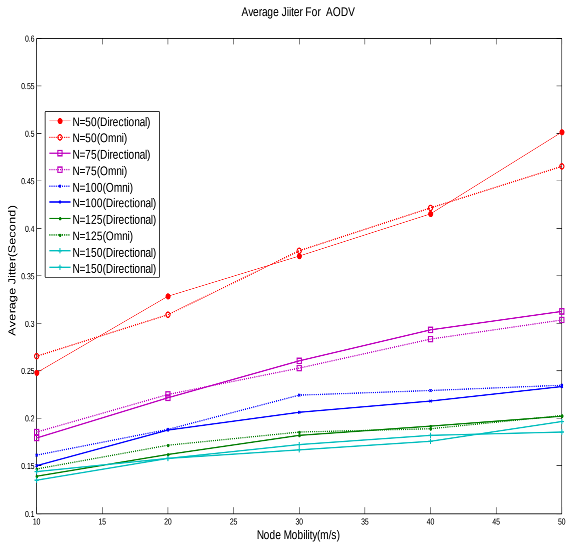

Figure 2: Average Jitter Vs Node Mobility for AODV using omni and Directional Antenna

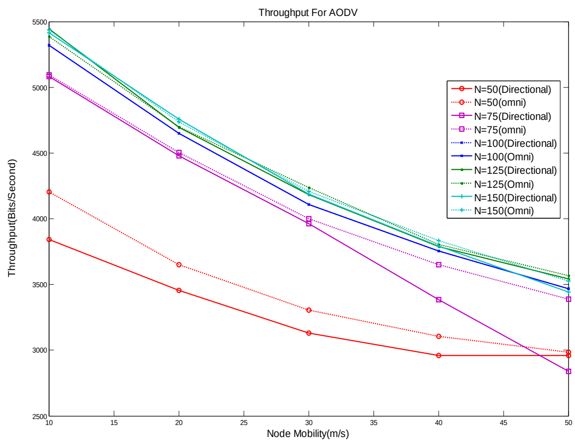

Figure3: Throughput Vs Node Mobility for AODV using omni and Directional Antenna

Case 2: Performance for DSR

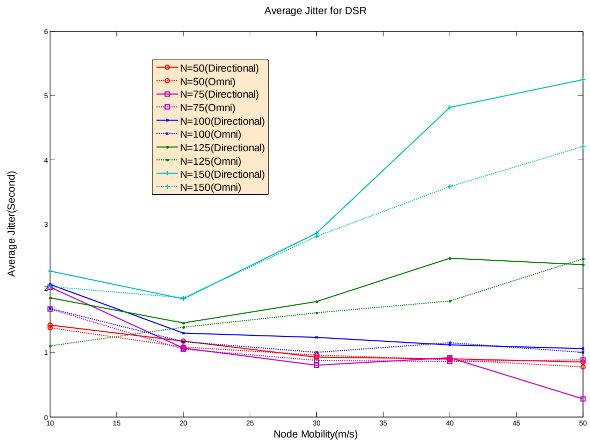

Figure 4: Average Jitter Vs Node Mobility for DSR using omni and Directional Antenna

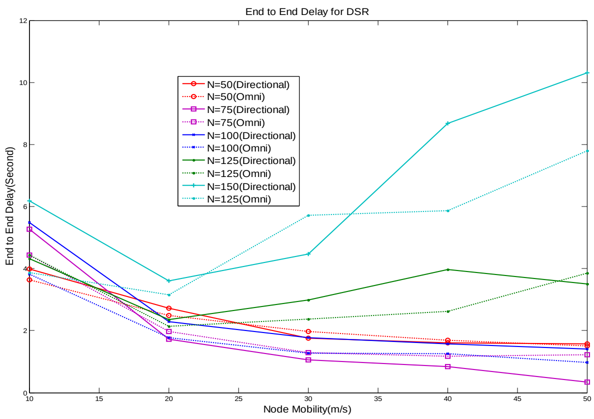

Figure 5: End to End Delay Vs Node Mobility for DSR using omni and Directional Antenna

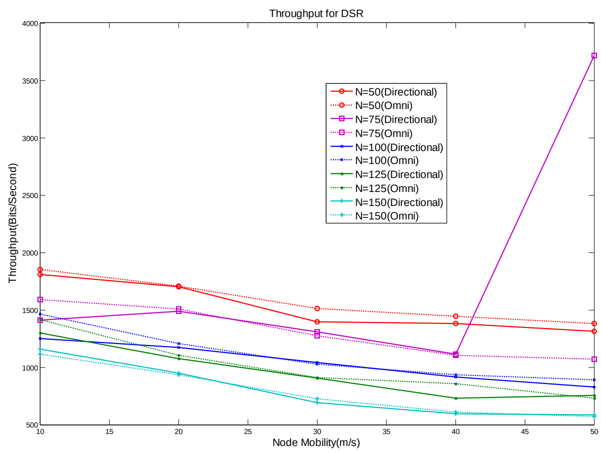

Figure 6: Throughput Vs Node Mobility for DSR using omni and Directional Antenna

Case 3: Performance for DYMO

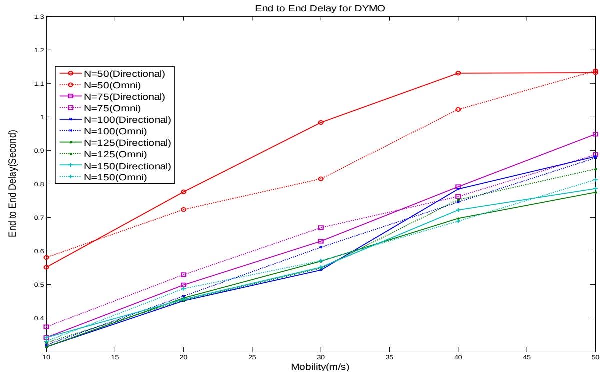

Figure 7: End to end delay Vs Node Mobility for DYMO using omni and Directional Antenna

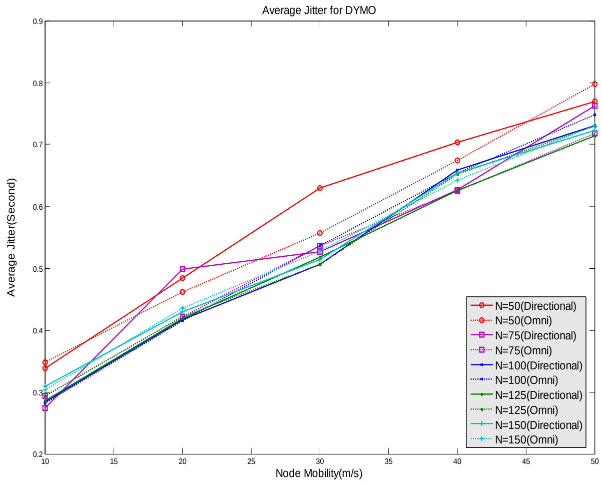

Figure 8: Average jitter Vs Node Mobility for DYMO using omni and Directional Antenna

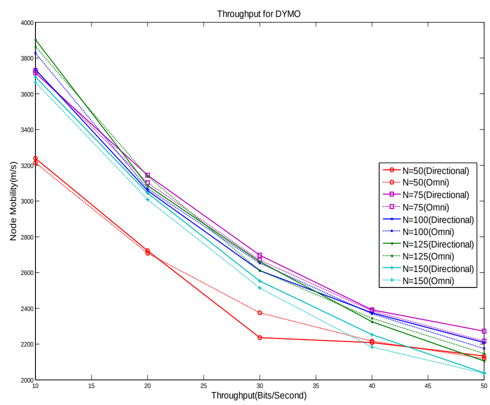

Figure 9: Throughput Vs Node Mobility for DYMO using omni and Directional Antenna

5. CONCLUSIONS & FUTURE WORKS

In this paper, we have analyzed the impact of node mobility on reactive routing protocols (AODV, DSR and DYMO) in mobile ad-hoc networks using omni and directional antenna. These reactive routing protocols performed quite differently and this provides an idea to the fact that results for mobile ad hoc networks have to be analyzed in order to conclude accurate results particularly when the qualities of service (QoS) of routing protocols are considered. We have found that routing protocols (AODV, DSR and DYMO) have both cons and pros in different evaluating parameters with varying node mobility. We can see the comparisons of these routing protocols from above simulation results.

6. REFERENCES

[1] Corson, S. and Macke, J. 1999. Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations. RFC 2501

[2] Royer, E., and Toh, C.1999. A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks. IEEE Personal Comm., 46-55.

[3] Broch, J., Maltz, D.A., Johnson D.B., Hu, Y.-C., and Jetcheva, J.1998. A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols. Proceeding of MobiCom, 85-97

[4] Hu, Y.-C., and Perrig, A. 2004. A Survey of Secure Wireless Ad Hoc Routing, IEEE Security and Privacy, 2, 3, 28-39.

[5] Lee, S.-J., Belding-Royer, E.M., and Perkins, C.E.2003.Scalability Study of the Ad Hoc On-Demand Distance Vector Routing Protocol. Int'l J. Network Management, 13, 2, 97-114.

[6] Perkins, C.E. and Bhagwat, P.1994. Highly Dynamic Destination- Sequenced Distance Vector Routing

[7] (DSDV) for Mobile Computers. Proc. ACM SIGCOMM, 234-244.

[8] Chiang, C.-C., Wu, H.-K., Liu, W. and Gerla M. 1997. Routing in Clustered Multi-hop Mobile Wireless Networks with Fading Channel. Proc. Singapore Int'l Conf. Networks (SICON'97), 197-211.

[9] S. Keshav. An Engineering Approach to Computer Networking: ATM networks, the Internet, and the Telephone Network. Ch. 11, Addison Wesley

[10] Jiang, H. and Garcia-Luna-Aceves, J. J. 2001. Performance Comparison of Three Routing Protocols for Ad Hoc Network. International Conference on Computer Communications and Networks,547-554.

[11] Broch, J., Maltaz, D.A., Johnson, D.B. and Hu, Y.C. 1998. A Performance Comparison of Multihop Wireless Ad Hoc Network Routing Protocol. Proc. IEEE/ACM MOBICOM, 85–97.

[12] Das, S. R., Perkins, C. E., Royer, E. M. and Marina M. K.2001.Performance Comparison of Two On-demand Routing Protocols for Ad hoc Networks. IEEE Personal Communication's Magazine special issue on Ad hoc Networking, 16-28.

[13] Chakeres, C. and Perkins.2006.Dynamic MANET On-demand (DYMO) Routing Protocol. IETF Internet Draft.

[14] Johnson, B. D. and Maltz D.1999.The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks. http://www.ietf.org/internet-drafts/draft ietfmanet- dsr-03, 1999.

[15] Broch, J., Maltz, D.A., Johnson, D.B., Hu. F.-C., Jetcheva, J. 1998. A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocol, Proceedings of ACWIEEE MOBICOM, 85-97.

[16] Hong, X., Geria, M., Pei, G. and Chiang, C.-C. .1999. A Group Mobility Model for Ad Hoc Wireless Networks. Proceedings of ACM/IEEEMS,53-60

[17] Dhurandher, S.K., Obaidat, M.S. and Gupta M.2007.OPHMR: An Optimized Polymorphic Hybrid Multicast Routing Protocol for MANET. IEEE Transactions on Mobile Computing, 6, 5,551 - 562.

[18] Misra, R. and Mandal, C. R. 2004. Performance Comparison of AODV/DSR on Demand Routing Protocols for Ad hoc Networks in Constrained situation. IEEE International Conference on personal wireless communication, 86-89.

[19] Haas, Z.J. and Pearlman M.R. 2001. The Performance of Query Control Schemes for the Zone Routing Protocol. ACM/IEEE Trans. Networking, 9, 4, 427-438

[20] Johnson, D. B., Maltz, D. A. and Broach, J.2001. DSR: The Dynamic Source Routing Protocol for Multi-hop Wireless Ad Hoc Networks. Ad Hoc Networking, C. E. Perkins (Ed.),139–172,

[21] Charles, E., Perkins, and Royer, M. E.1999. Ad-Hoc on Demand Distance Vector Routing. Proc. 2nd IEEE Workshop on Mobile Computing 147 Systems and Applications, 90–100.

[22] Perkins, E. and Royer, E. M. 2001.The Ad Hoc On-Demand Distance-Vector Protocol (AODV). In Ad Hoc Networking, C. E. Perkins (Ed.), 173–219.

[23] Hui, X., Xianren, W., Sadjadpour, H.R. and Garcia-Luna-Aceve, J.J.2010.A unified analysis of routing protocols in MANETs. IEEE transaction on communication 58, 3, 911 – 922.

[24] Choudhury, R. R. and Vaidyas N. H. 2005. Performance of ad hoc routingusing directional antenna.Ad hoc network, 3, 5, 621-628.

[25] Dai,F., Dai, Q. and Wu ,J. 2005. Power efficient routing trees for ad hoc wireless networks using directional antennas. 3, 5, 621-628.

[26] Alawieh,B. Assi,C. and Mouftah, H. 2009. Power aware adhoc networks with directional antennas. Ad-hoc networks.7,3,486-499.