Dynamic Antenna Mode Selection for Link Maintenances in Mobile Ad Hoc Network

P. Shiva Kumar[$], Rinki Sharma[*], G.Varaprasad[#]

[$]Department of Information Technology
Acharya Institute of Management and Sciences
Bangalore-560 058
pshivakmr@rediffmail.com

[*]Department of Electronics and Communication Engineering
M.S. Ramaiah School of Advanced Studies
Bangalore -560 054
rinki@msrsas.org

[#]Department of Computer Science and Engineering
BMS College of Engineering
Bangalore -560 019
drvaraprasad@gmail.com

Abstract: - Mobile ad hoc networks are designed to work in environments, where the terrains have unpredictable obstacles such as hills, water bodies, buildings or regions without any nodes. In the mobile ad hoc network, the mobile nodes use the directional antennas to achieve high spatial reuse. If the nodes with the directional beam move, then the obstacles may come between the communicating nodes. The link quality deteriorates resulting in link break, causing disruption in the communication. This paper proposes a scheme, which allows the mobile nodes to maintain the link in an irregular terrain by dynamically changing antenna mode from directional to omni. The proposed model has been simulated using Qualnet simulator (version 4.5). The simulation results shown that the proposed model is improved the network performance in terms of packet delivery ratio, number of link breaks and number of hops.

Keywords: MANET, Antenna mode, Terrain, Link, Mobility.

I. Introduction

A Mobile Ad Hoc Network(MANET) is an autonomous system of mobile nodes, where each node can act as a source, sink and router. These networks can provide a temporary wireless network capability in scenarios, where fixed infrastructures are lacking and are expensive or infeasible to deploy. Traditionally MANETs use the omni antennas. However, the usage of the directional antennas can reduce the radio interferences, thereby improving the network throughput [1]. In the MANET, two mobile nodes which are outside the wireless transmission range of each other can still be able to communicate. This is done with the help of other mobile nodes in the vicinity, which are willing forward the data packets.

The radio channel places fundamental limitations on the performance of the wireless networks. The transmission path between the transmitter and receiver can be line of sight. On the other hand, it can be severely obstructed by buildings, mountains and foliage. The radio transmission in the MANET normally takes place over the irregular terrain. If a node communicates using the directional antenna mode moves towards an obstruction, the signal strength of the link will down. In this case, the transmitting node finds other nodes in its transmission range to route the data packets. In the directional mode, the coverage area is too narrow, so the number of nodes in the transmission range is very less, whereas in the omni antenna mode, it can find more nodes, because of wider coverage area.

This paper proposes a new scheme in which, when a node senses a link failure, it switches from the directional to omni mode to maintain the failing link. The node goes back to directional mode once the link quality improves. The remainder of this paper is organized as follows: Section II reviews the related work. Antenna mode selection schemes are discussed in section III. Section IV discusses about the simulation environment and methodology. The simulation results are presented in section V. Section VI concludes our research work.

II. RELATED WORK

The MANETs are designed to deal with limited connectivity among the mobile nodes due to mobility, short range radios or terrain obstacles. The idea of deploying additional advantaged nodes to improve communication has been explored in wireless networks [2]. In [3], the advantaged nodes are provided with directional antenna capability to further enhance the delivery performance. In [2-3], a certain number of advantaged nodes are deployed to improve the communication capability of the network. These nodes are computing devices that are equipped with the directional antenna, wireless interfaces and storage. These advantaged nodes participate in the routing scheme used by regular nodes. In[4], standby nodes are used as relaying nodes between two mobile nodes**,** which are invisible to each other. If there is an obstacle obstructing, the direct communication between two mobile nodes, then a set of standby nodes are needed for communication (with a large number of obstacles, there may be many standby nodes in the network). This algorithm also tries to find the minimum number of standby nodes required to provide the connectivity. In [2-3], advantaged nodes are used and [4] use standby nodes. Our scheme uses the neighboring nodes, which are free. This avoids the overhead of maintaining advantaged or standby nodes. In [5], a geo-casting protocol is used for sending short message from the source to geo casting region in the MANET. It keeps the messages away from the unpredictable obstacles and creates a small flooding region. Our scheme works in MAC layer. In an obstacle free environment, the nodes communicate using directional antennas to achieve high spatial reuse. If an obstacle is encountered, then the routing algorithm tries to find an alternate path to the destination through the neighbouring node [6]. At this point, the antenna is switched from the directional to omni antenna mode, which increases the probability of finding the neighbouring nodes.

III. ANTENNA MODE SELECTION SCHEME

The antenna system offers two modes of operations such as omni and directional. The omni antennas have a similar radiation pattern in all directions. These antennas provide a 360 degree horizontal radiation pattern. They are used when the coverage is required in all the directions (horizontally) from the antenna with varying degrees of vertical coverage. It covers more area near the wireless node in order to increase the probability of transmitting or receiving the signal in a multipath environment.

The directional antennas focus the RF energy in a particular direction. As the gain of a directional antenna increases, the coverage distance increases, but the effective coverage angle decreases. For directional antennas, the main lobes are pushed in a certain direction and little energy is there on the back lobe of the antenna. The angular coverage is less, so it cannot cover large area.

In the proposed scheme, a node monitors the link quality. If the link quality is good, then the node communicates with the destination by using directional antenna mode. If the link quality deteriorates, due to the obstacles, then the node switches to omni antenna mode to maintain the link.

IV. SIMULATION ENVIRONMENT AND METHODOLOGY

This section discusses the simulation of MANETs by using the simulator called Qualnet version 4.5[7]. The simulation environment is a 1,500 m X 1,500 m area, where 10 mobile nodes are placed as shown in Figure 1. Node 1 is the transmitter and node 7 is the receiver. The simulation area is loaded with an irregular terrain using the irregular terrain model [8]. CBR/UDP traffic is set between the nodes 1 and 7 and AODV routing protocol is used. Table I gives the detailed simulation parameters. The proposed model is simulated under four scenarios as follows:

A. Stationery nodes with the Omni antenna

The nodes are kept stationery with an irregular terrain loaded on the scenario. The distance between node 1 and node 7 is increased in steps of 50 m. It calculates the parameters such as packet delivery ratio, number of link breaks at the transmitter, and hop counts required by the transmitter to reach the receiver. These parameters are calculated by using the omni antenna mode.

B. Stationery nodes with the directional antenna

In this scenario, the nodes are kept stationery with an irregular terrain. The distance between the node 1 and node 7 are increased in steps of 50m. The packet delivery ratio and number of link breaks parameters are calculated by using directional antenna at the transmitter. The number of hops required by the transmitter to reach the receiver is also measured. These parameters are calculated for directional antenna.

C. Mobile nodes with the omni antenna

The nodes are made to move over an irregular terrain. The simulation is executed for five different mobility levels as shown in Table II**.** By using omni antenna, the simulator calculates the hop count, packet delivery ratio and number of link breaks.

D. Mobile nodes with the directional antenna

In this section, the nodes are mobile with an irregular terrain loaded on the scenario. The simulation is run for five different mobility levels as shown in Table II. Here, we calculate the packet delivery ratio, number of link breaks and hop count by considering the directional antenna mode.

V. PERFORMANCE EVALUATION

This section analyses the network performance of four different scenarios. The packet delivery ratio, number of link breaks and number of hop counts are used as metrics to evaluate the network performance.

A. Stationery nodes with different antenna modes

In this scenario, the distance between the source and destination is increased in steps of 50m. The gap of 50m to 250m is an obstacle free terrain, after that the source and destination encounter an obstacle. In Figure 2, it can be seen that the source node maintains 100% packet delivery ratio up to 250m (obstacle free terrain) under both omni and directional antenna modes. After 250m, the source encounters the obstacle. With directional mode its packet delivery ratio drops and varies in the range of 40% to 60%, whereas if the node switches to the omni antenna mode it can still maintain 100% packet delivery ratio.

In Figure 3, if the source and destination nodes are in an obstacle free terrain (50m gap to 250m gap), then the number of link breaks at the source is 0 for both directional antenna and omni antenna modes. When the nodes encounter the obstacle (300m to 500m gap) the omni antenna mode maintains the link without any break, whereas in the directional mode the link breaks up to 4 times.

If the source and destination nodes are in the obstacle free terrain (50m gap to 250m gap), the number of hop counts from the source to destination is 1. This happens for both directional antenna and omni antenna modes as shown in Figure 4. It means that there is a direct link between the source and destination nodes**.** If the nodes encounter an obstacle (300m to 500m gap), then the number hop counts in omni antenna mode increases up to 3. In the directional mode, the number of hop count increases up to 9.

B. Mobile nodes with different antenna modes

The node with omni antenna mode has higher packet delivery ratio compared to the directional mode under all five mobility levels. At mobility level ML-5, the packet delivery ratio in both the modes drop, but still the omni antenna mode performs better with 80% delivery as compared to 60% in case of directional mode as shown in Figure 5. In Figure 6, the mobile nodes with the omni antenna mode do not have any link breaks in the first four mobility levels, whereas in mobility level ML-5, it has 1 link break. The number of link breaks in the directional antenna mode is higher than that in omni antenna mode in all the mobility levels. In Figure 7 the number of hop counts in omni antenna mode is less than directional antenna mode under all the five mobility levels. It means that under omni antenna mode the source node finds a shorter path to the destination when compared to directional antenna mode. If the node moves towards an obstacle, then switching from the directional to omni antenna mode provides better packet delivery ratio, less number of link breaks and less number of hop counts. This happens because when a node switches to omni mode it has more coverage area near it. The routing protocol has more chance of finding neighbour nodes in the vicinity and route the packets around the obstacles.

VI. CONCLUSIONS

This paper proposes an antenna mode selection scheme for MANETs and investigates its performance by using Qualnet(V4.5). The aim of this work is to improve the performance of MANETs on irregular terrain with unpredictable obstacles. The simulation results show that if a node encounters an obstacle, then it can switch to omni antenna mode to maintain the failing links. This improves the packet delivery ratio and reduces the number of link breaks as well as number of hop counts. The proposed model works on the principle that when a node switches to omni antenna mode it has more coverage in its vicinity. The routing protocol has more probability of finding neighbour nodes in the vicinity and route the data packets around the obstacle.

REFERENCES

[1] Aman Arora, Marwan Krunz, "Interference-limited MAC Protocol for MANETs with Directional Antennas" *In Proceedings of the IEEE International Symposium on World of Wireless Mobile and Multimedia Networks table of contents*, pp. 2-10, 2005.

[2] W.Zhao, Y.Chen, M.Ammar, M.Corner, B.Leveine, E.Zegura(2006), "Capacity Enhancement using throwboxes in DTNs" I*n Proceedings of the IEEE MASS*,2006. www.monarch.cs.rice.edu/monarch-papers/mobicom2000.pdf

[3] M.Chuah, Y.Xi, "Enhanced Delivery In Disruption Tolerant Networks Using Advantaged Nodes With Directional Antenna Capability", *In Proceedings of he IEEE Military Communications Conference*, Vol. 29, No. 31 pp. 1-6, 2007.

[4] Di Wu, Ning Tong, Kequi Li, "Mobile Grid Routing Algorithm In Mobile Ad Hoc Networks With Obstacles", *In Proceedings of the International Conference on Semantics, Knowledge, And Grid*, pp 12, 2006.

[5] Chih-Yung Chang, Chao-Tsun Chang, Shin-Chih Tu, "Obstacle-Free Geocasting for Ad Hoc Wireless Networks", *Wireless Communications And Networking*, Vol. 2, pp 1137-1142, 2003.

[6] Somprakash Bandyopadhyay, Siuli Roy, Tetsuro Ueda, *"Enhancing the Performance of Ad Hoc Wireless Networks with Smart Antennas"*, Boca Raton, New York: Auerbach publications, 2006.

[7] Qual Net 4.5 User's Guide, Scalable Network Technologies.

[8] Qual Net 4.5 Wireless model library, Scalable Network Technologies, 2008.

[9] Rinki sharma, P.Shiva Kumar, "Effect of Propagation and Mobility Model on The Performance of MANETs", *In Proceedings of The National Conference on Information Processing, Communication Networks And Embedded System*, pp. 141-144, 2009.

[10] T. Rappaport, "*Wireless Communications-Principles and Practice*", Prentice Hall, 2002.

[11] Scalable Network Technologies. The QualNet simulator http://www.qualnet.com/.

Author's information

P.ShivaKumar received B.E in Electronics and Communication from M.S. Ramaiah Institute of Technology, Bangalore in 1997 and is pursuing M.Tech in Computer Network Engineering at B.M.S College of Engineering, Bangalore. Currently, he is working as a Senior Lecturer at Acharya Institute of Management and Sciences, Bangalore. His areas of interest are Mobile Communication, Ad Hoc Networks and Disruption Tolerant Networks.

Rinki Sharma received B.E in Telecommunication Engineering from Visvervaraya Technological University, Belgaum in 2003. Received M.Sc (Engg.) from M.S.Ramaiah School of Advanced Studies in collaboration with Coventry University (U.K) in 2005 for which she was awarded with gold medal. She is pursuing her PhD in Wireless Networks from Coventry University. She is presently working as an Asst.Professor at Centre for Communication Engineering, Department of Electronics and Communication, M.S.Ramaiah School of Advanced Studies, Bangalore. Her areas of interest include Wireless Sensor Networks, Mesh Networks, MANETs, VANETs and Routing algorithms.

G.Varaprasad received B.Tech in Computer Science and Engineering from Sri Venkateswara University, Tirupati in 1999 and M.Tech in Computer Science and Engineering from B.M.S. College of Engineering, Bangalore in 2001 and PhD in Computer Networks from Anna University, Chennai in 2004 and worked as a Post-Doctoral Fellow at Indian Institute of Science, Bangalore in 2005. Currently, he is working as an Asst.Professor at B.M.S.College of Engineering, Bangalore. His areas of interests are MANET, mobile communications and SNMP.

TABLE I. SIMULATION PARAMETERS.

Simulation parameter	Simulation value
Simulation time	1,000 sec
Traffic type	CBR
CBR packet size	512 Bytes
No of packets transmitted	100
Routing protocol	AODV
Propagation model	ITM
Terrain data format	Cartesian
Mobility model	Random Waypoint
Topology	1500m X1500m

TABLE II. MOBILITY LEVELS.

SN	Mobility Levels		
	Mobility Type	**Min. Speed in Mbps**	**Max. Speed in Mbps**
1	Walker’s speed (ML-1)	0	5
2	Jogger’s speed (ML-2)	5	10
3	Runner’s speed (ML3)	10	15
4	Slow moving vehicle speed (ML-4)	15	20
5	Medium moving vehicle speed (ML-5)	20	25

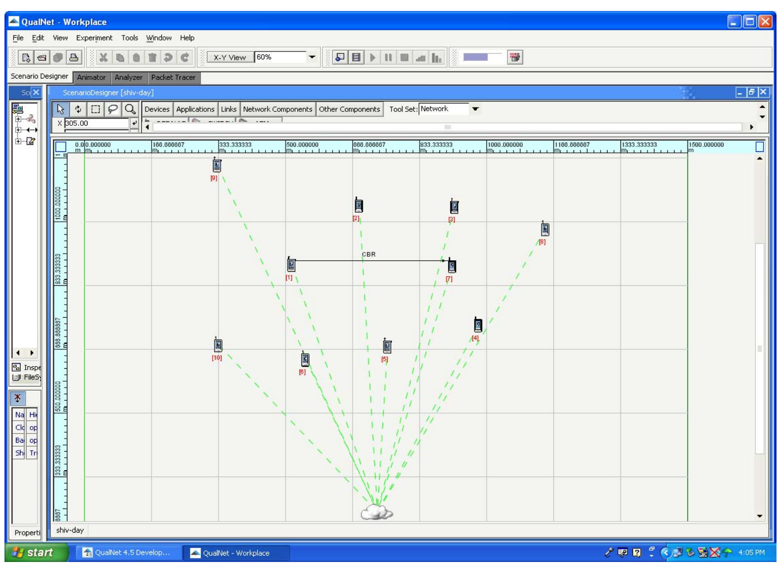

Figure 1. Network topology.

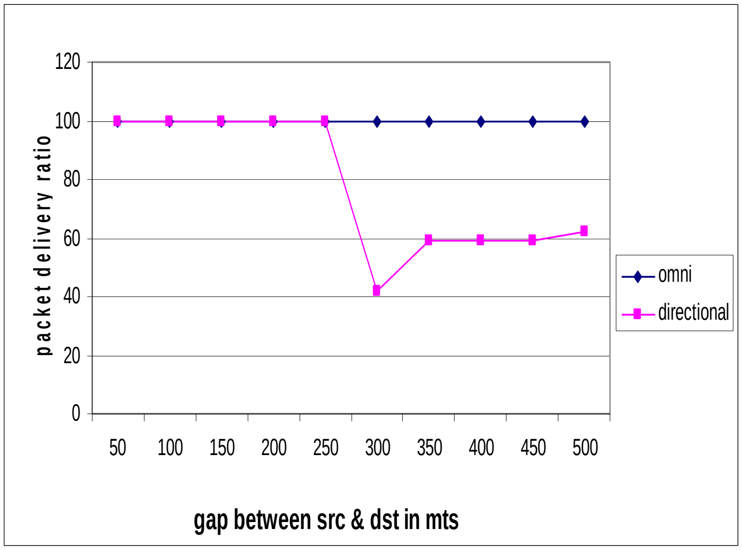

Figure 2. Effect of antenna mode on packet delivery ratio.

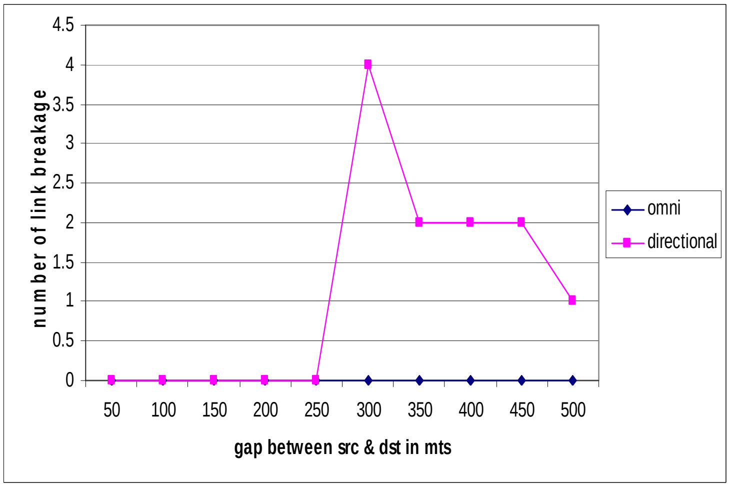

Figure 3. Effect of antenna mode on link break.

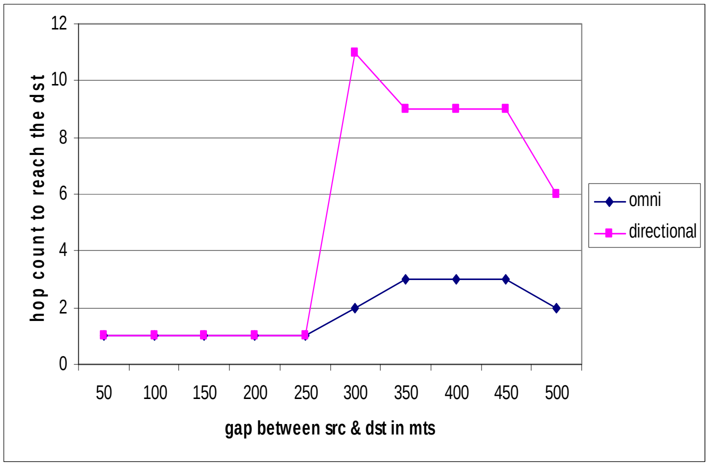

Figure 4. Effect of antenna mode on hop count.

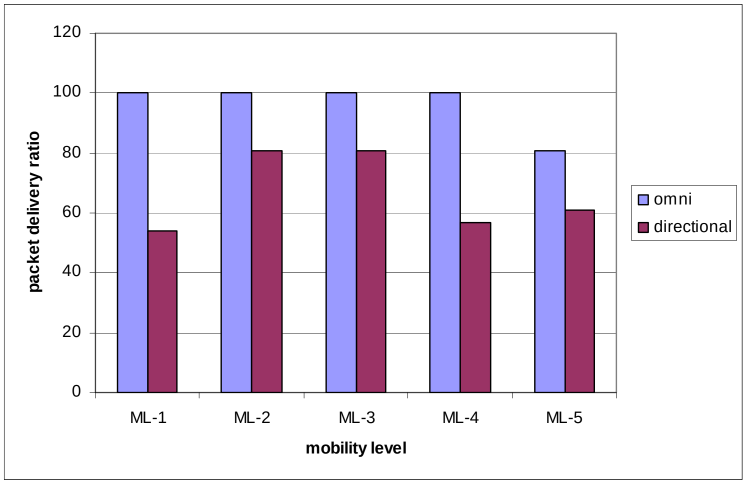

Figure 5. Effect of antenna mode on packet delivery ratio.

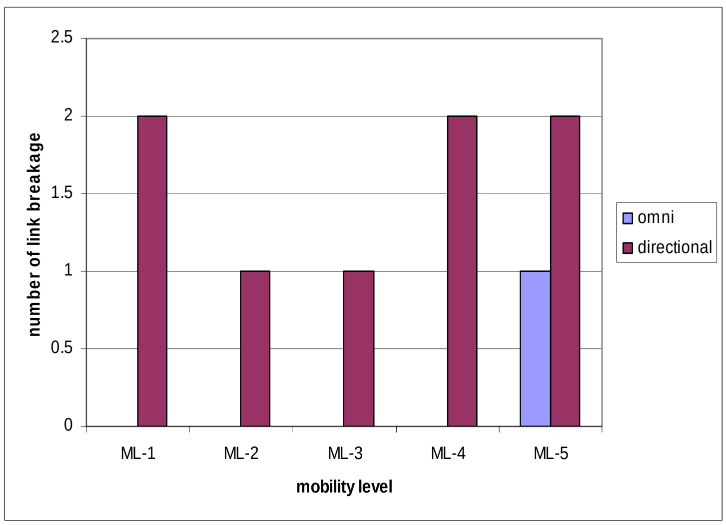

Figure 6. Effect of antenna mode on link break.

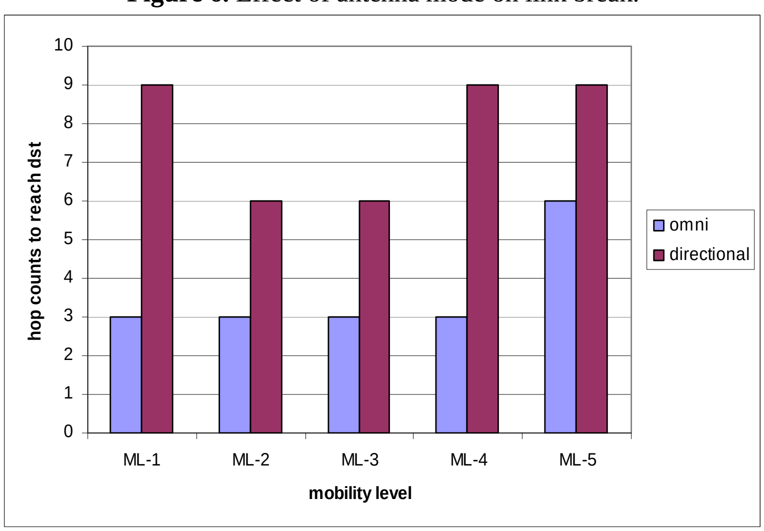

Figure 7. Effect of antenna mode on hop count.