Performance Analysis of AODV Routing Protocol Using Different Directional (Metamaterial) Antenna in MANET

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Abstract--In this paper a comparative study is represented of different directional metamaterial antennas in mobile ad-hoc network using ad-hoc on demand distance vector (AODV) routing protocol. Complexity of routing is increasing between mobile nodes as number of users increasing because of dynamic nature of mobile nodes and rapid change in mobile topologies in mobile ad-hoc networking. However, it is possible to improve the network congestions by using the directional antenna. We use directional antenna because of good directivity. To find out which directional antenna gives better result for mobile ad-hoc networks (MANET), in the paper, we simulate the scenario of three different directional antenna for comparing and analyzing using routing protocol such as AODV, using QualNET simulator 6.01. The metrics used for performance evaluation and comparison of different metamaterial antennas using routing protocol AODV, we are going to compare throughput, average unicast end to end delay, unicast jitter and physical layer metrics is received power of receiving node.

***Keywords*-**Ad-hoc network, AODV,Directional antenna,Metamaterial, QualNet.

I. Introduction

Directional antenna [1] radiates the EM waves or frequency in all the direction and also provides the large area of coverage and directional antenna also provides reduction in power consumption, because of given qualities directional antenna has been used in mobile ad-hoc network. Directional antenna enhances the performance of data transmission and data reception because directional antenna has better directivity than omnidirectional antenna. In this paper metamaterial rectangular patch antenna is used in place of omnidirectional antenna. Metamaterial patch antenna is also a directional antenna having improved properties. Metamaterials are mixture of different elements such as plastics metamaterials are made to get properties which are not found in pure natural materials. Using metamaterial we insert a high permittivity material above the patch antenna and then we add a layer of copper material with specific design. With using metamaterial concept the resonant frequency reduces of patch antenna and return loss also decreases.

MANET stands for “mobile ad-hoc networks”. A MANET is a type of network which can change location itself. A wireless ad-hoc network is a decentralized type network. It means that wireless ad-hoc network has no pre-existing infrastructure. Wireless ad-hoc network does not depend on pre-existing infrastructure, like routers in wired networks, that’s why this is called “ad-hoc”. MANET is also a type of wireless ad-hoc network. Each device in MANET moves independently in any direction, and each node changes its link to other devices.

II. Metamaterial Antenna

Antenna is the primary requirement in a wireless communication system. According to definition, antenna is a device used to transform in RF signal in to the electromagnetic wave in free space. The antenna will emit radiation in free space when a signal is fed in to the antenna. The reduction of size of microstrip patch antenna is becoming a very important design consideration with advancement of communication

integration technology now a days. This paper proposes microstrip rectangular patch antenna in which metamaterial properties applied at top plane. Using metamaterial, the overall size of metamaterial patch antenna is reduced. Three different metamaterial antenna used here, are of 1.382 Ghz, 1.36 Ghz and 1.34 Ghz and also having different antenna gain.

a. 1.382 GHz, 4.2db Metamaterial Antenna

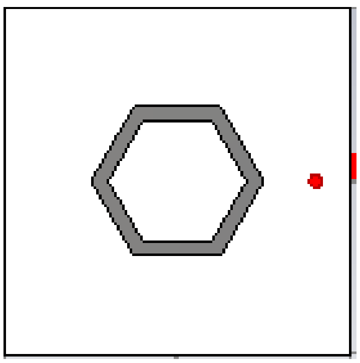

Fig-2.1 Front view of 1.38 GHz, 4.2db antenna

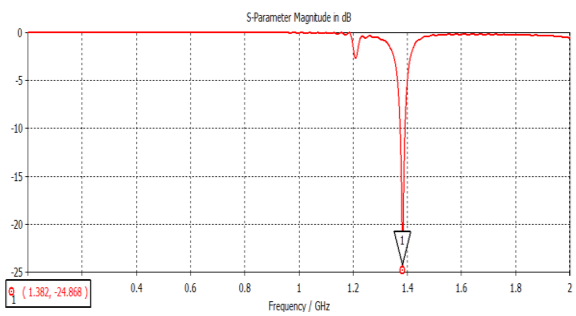

Fig-2.2 Return Loss of Antenna

In this antenna we add a layer of metamaterial in shape of hexagon above basic microstrip patch antenna.

b. 1.36 GHz, 1.324db Metamaterial Antenna

with

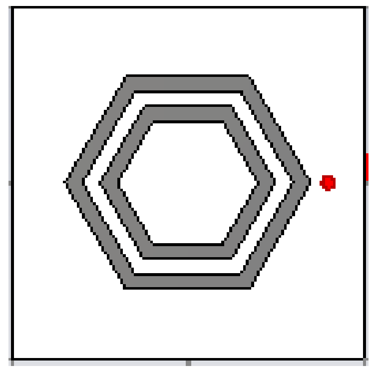

Fig-2.3 Front view of 1.36 GHz Antenna

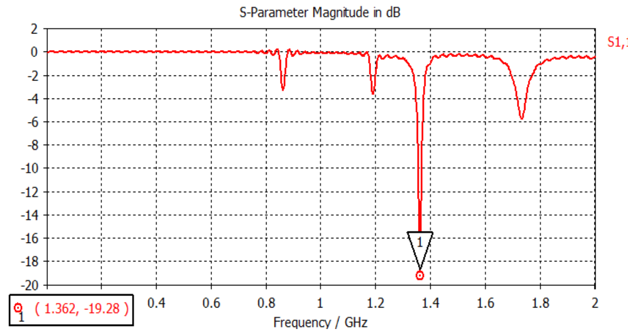

Fig-2.4 Return Loss

This antenna is same as previous antenna but with improved metamaterial structure and reduced resonating frequency.

c. 1.34 GHz, 3.09db Antenna

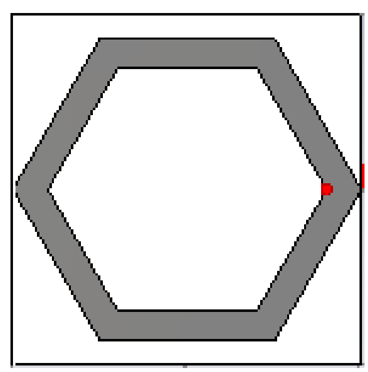

Fig-2.5 1.34 GHz Metamaterial Antenna

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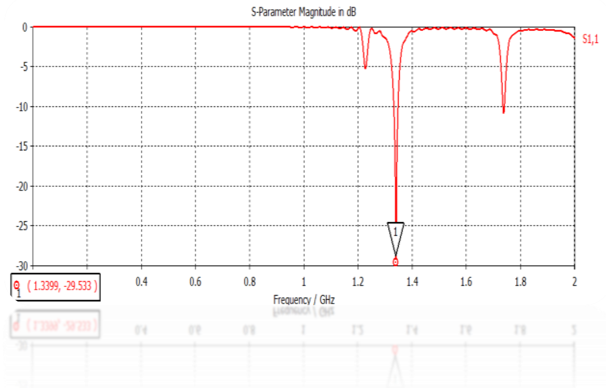

Fig-2.6 Return Loss of Antenna

This antenna is also having hexagonal metamaterial architecture and having reduced resonant frequency and increased antenna gain in comparison of above antenna.

III. Classification of Antenna

Types of antenna can be divided according to their radiation pattern, given as

a) Omnidirectional Antenna
b) Steerable Antenna
c) Switched Beam Antenna

a) Omnidirectional Antenna: Omnidirectional antenna can be used in wireless communication to avoid co-channel interference. This antenna radiates electromagnetic energy in all directions. Routing algorithms of omnidirectional antenna and fixed transmission power have limited bound to the number of intermediate hops between a couple of source and destination. To overcome this problem the omnidirectional antenna focuses antenna beam at narrow angle and radiate the energy in all directions.

b) Steerable Antenna: Steerable antenna is special type of directional antenna which reduces the interference in communication network. The steerable antenna has capability to focus the specific angle of the receiver node. Steerable antenna beam directed toward the receiver node at specific angle.

c) Switched beam Antenna: switched beam antenna is a type of smart directional antenna. It is simpler and low in cost than steerable antennas. Main disadvantage of switched beam antenna is that it has fixed nature due to which it cannot focus at specific angle [1, 2, 3].

IV. AODV Routing Protocol

Ad-hoc network is co-operative network and collection of movable nodes in routing zone without having existing infrastructure. AODV means ad-hoc on demand distance vector routing protocol AODV protocol provides quick adaption for dynamic link condition, link fault and memory usage overhead [4]. AODV routing protocol is specially used for mobile ad-hoc network. In AODV routing protocol mobile nodes obtains their routes [6, 7, 8] quickly for new target and does not require mobile nodes to maintain routs to destinations that are not in active position during communication. AODV protocol supports both IPv4 and IPv6. When a mobile source node is ready to transmit the information packets and does not have updated route to destination then it performs two operations called, route discovery and route maintenance [5].

Route Discovery: As name tells, when we are going to transmit information packets a new route is discovered. To find new route AODV routing protocol broadcast the route request (RREQ) packet. If neighboring nodes having route request packet, has no route information regarding the destination mobile node then it will continue to broadcast RREQ packets in wireless network. If the destination is found then the answer key will be send by route reply packet (RREP). When the RREP is received at the transmitting mobile node, the path is established. The route request (RREQ) packet having source address, broadcast id, source sequence number, destination sequence number, destination address and hope count [5].

Route Maintenance: Route maintenance is done after route discovery in AODV routing protocol. In this step, this protocol finds the errors which comes during transmission like if two nodes that was listed as neighbor on the route moved out of the range of each other, link is broken [5] and then source is informed with a packet called ROUTE ERROR packet and further route discovery mechanism is used to find a route from source node to the destination mobile node.

V. Simulation Environment

Using AODV routing protocol, performance analysis of given three different metamaterial antenna can be done by comparing the performance metrics. The simulation is performed using AODV routing protocol in QualNET simulator 6.1. Each simulation is done under none mobility with 45 mobile nodes. Snapshot of simulation is given as

VI. Simulation Parameters

Simulation of the proposed performance analysis of AODV routing protocol using three different directional antenna is done on Qual NET simulator 6.1.

The proposed scenario is simulated with 45 nodes. Connection type is CBR in this scenario. Performance metrics are compared of three antennas with varying simulation time i.e. from 20 sec to 100 seconds. Simulation parameters are given below in tabular form.

PARAMETERS	VALUE
Number of Nodes	45
Protocol Used	AODV
Channel Type	Wireless Channel
Traffic Type	CBR
Transmission Power	15 dbm
Start Time	1 sec
End Time	100 sec
Item to Send	100
Item Size	512 bytes
Antenna Used	Metamaterial Antenna with gain 4.2 dB, 3.09 dB, 1.324 dB, Omni-directional Antenna
Data Rate	2 Mbps
Terrain Size	1500×1500
Simulation Time	Varying from 20 sec to 100 sec

VII. Performance Metrics

Parameters used for comparison of antennas are called performance metrics. Performance metrics are described below

a. Average Jitter

Jitter value should be minimum for performing the system better. Jitter shows irregularity or unsteadiness of signal or unsteadiness of data transmission in ad-hoc networking. Higher the jitter means higher irregularities and vice versa is also true. Jitter value is minimum then ad-hoc network will perform better. Jitter shows the irregularities of data packets transmission.

b. Average End to End Delay

The parameter end-to-end delay represents that the amount of time required to transfer the information packets from source node to destination node. Minimum end-to-end delay is required for better performance of the ad-hoc network. End-to-end delay plays a vital role to analyze the performance of simulation of different directional antennas.

c. Throughput (bits/sec)

Throughput describes the average rate of information packets delivery over wireless ad-hoc networking from source node to destination node. Throughput is amount of information data packets received successfully at destination node or receiver node in wireless ad-hoc network. Scalability or complexity in ad-hoc network affect the throughput of network. Throughput must be as high as possible for better performance of wireless ad-hoc network.

d. Received Power

Power received at destination node or at receiver node called received power. Received power depends on distance between source node and destination node, transmitted power and transmitter and receiver antenna gain. Formula of received power is given below

$$Received\ Power\ P_r = P_t G_t G_r \left(\frac{\lambda}{4\Pi \mathrm{R}}\right)^2$$

P_t = Power transmitted from source node (15 dbm)
G_t = Transmitter antenna gain
G_r = Receiver antenna gain
R = Distance between transmitter and receiver node antenna

VIII. Simulation Results

The performance analysis of used directional antennas is analyzed by comparing the performance metrics like average end-to-end delay, unicast jitter, throughput and power received at destination node. Antenna will perform better than other directional antenna having higher throughput, less end-to-end delay, minimum jitter and power received should maximum at destination node. Performance metrics are simulated on QualNET simulator 6.1. Performance metrics are given in tabular form below

Table-1 Average Jitter

Directional Antenna Used	Simulation Time (Sec)				
	20	40	60	80	100
1.34 GHz, Antenna	0.007	0.004	0.003	0.003	0.002
1.36 GHz, Antenna	0.007	0.003	0.002	0.002	0.001
1.382 GHz, Antenna	0.007	0.004	0.002	0.002	0.001
Omnidirectional	0.0226	0.013	0.01	0.008	0.008

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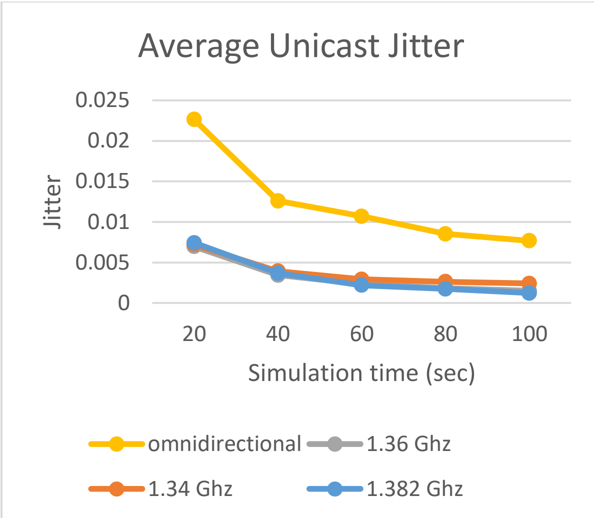
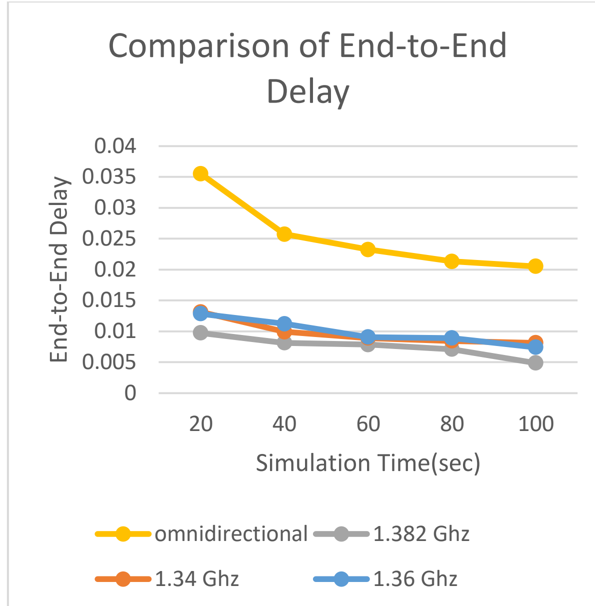


Above graph and table shows that 1.382 GHz antenna having minimum jitter value and jitter decreases as simulation time increases. So antenna with high gain (4.2 dB) having minimum jitter. Omnidirectional antenna has maximum jitter. That's why directional antenna is preferred.

Table-2 Average End-to-End Delay

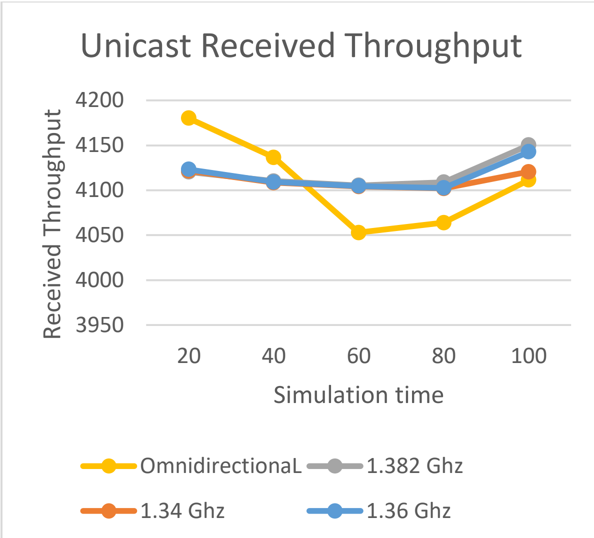
Directional Antenna Used	Simulation Time (Sec)				
	20	40	60	80	100
1.34 GHz, Antenna	0.0129	0.011	0.009	0.009	0.007
1.36 GHz, Antenna	0.0131	0.0099	0.009	0.008	0.008
1.382 GHz, Antenna	0.0098	0.0081	0.008	0.007	0.005
Omnidirectional	0.036	0.026	0.023	0.021	0.0205



As figure shows that omnidirectional antenna having maximum end-to-end delay and when we are using 1.382 GHz, 4.2 dB antenna shows minimum end-to-end delay because this directional antenna has maximum gain.

Table-3 Throughput

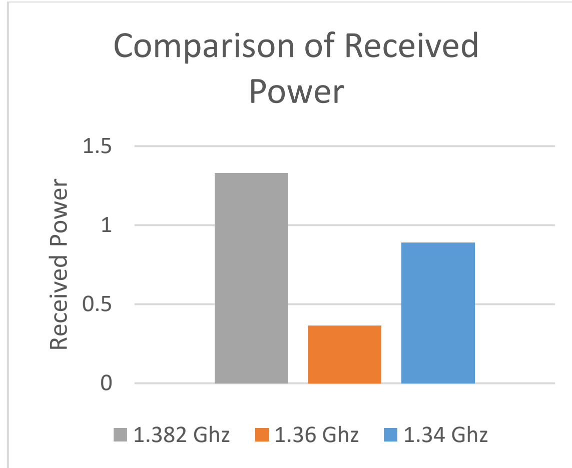
Directional Antenna Used	Simulation Time (Sec)				
	20	40	60	80	100
1.34 GHz, 3.09 dB	4122	4108	4104	4102	4121
1.36 GHz, 1.324 dB	4123	4109	4105	4103	4143
1.382 GHz, 1.324 dB	4121	4110	4105	4109	4150
Omnidirectional	4180	4136	4053	4064	4111



Throughput shows number of information data packets successfully received, it means maximum throughput shows the maximum number of data packets received. Throughput has a very important role in performance analysis of directional antennas. As shown in graph and table that 1.382 GHz, 4.2 dB antenna has maximum throughput or when we are using 1.382 GHz antenna then maximum information packets can be successfully received at destination node. Throughput of 1.34 GHz antenna, and omnidirectional antenna is minimum when we simulate on QualNET simulator 6.1.

Table-4 Received Power

DIRECTIONAL ANTENNA USED	RECEIVED POWER (watt)
1.34 GHz, 3.09 dB Antenna	0.8904
1.36 GHz, 1.324 dB Antenna	0.3667
1.382 GHz, 1.324 dB Antenna	1.33



Received power indicates the power received by the destination node antenna. When we are using 1.382 GHz, 4.2 dB antenna, received power is maximum and when we are using 1.36 GHz, 1.324 dB antenna then received recorded is minimum because of low gain.

IX. Conclusion

To improve the performance of wireless ad-hoc networks directional antenna can be used because throughput of omnidirectional antenna is minimum and decreases as simulation time increases. Higher data rates and small infrastructure can be achieved with narrow directional beam using directional antennas. The performance metrics were compared to analyze that which antenna is performing better. Simulation time effects the performance metrics like on increasing simulation time. End-to-end delay decreases and jitter value also decreases with increasing simulation time. Power received by 1.382 GHz antenna is maximum, power received by 1.36 GHz antenna is minimum. End-to-end delay using 1.382 GHz antenna is minimum and omnidirectional antenna has maximum end-to-end delay and average unicast received throughput is maximum of 4.2 dB antenna and throughput is maximum when simulation time is set to 100 sec. omnidirectional antenna has minimum throughput when we are using simulation time 100 sec. jitter is maximum for omnidirectional antenna using simulation time 100 sec but when we are using 4.2 dB antenna with simulation time 100 sec, jitter becomes minimum which is required for better performing of directional antenna.

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