DOI: 10.21917/ijme.2022.0227

OPTIMIZATION OF MANET WITH MIMO FOR FOREST APPLICATION USING ADVANCED ANTENNA MODELS

K. Periyakaruppan[1], D. Manohari[2], M.S. Kavitha[3] and B Chellaprabha[4]

[1]*Department of Computer Science and Engineering, SNS College of Engineering, India*
[2]*Department of Computer Science and Engineering, St. Joseph Institute of Technology, India*
[3]*Department of Computer Science and Engineering, SNS College of Technology, India*
[4]*Department of Information Technology, Karpagam Institute of Technology, India*

Abstract

In this proposed work, the impulse response of the channel was measured to estimate the PL of an ad hoc network with more than one antenna in different environments, such as indoors, outdoors, in a forest, or in a combination of propagation environments. Some of these places are: Also, a brand-new way to find a PL path with the lowest cost is suggested and put into action. Assuming that all communication nodes are within the network's transmission range, the suggested method can find the path in the network that loses the least amount of data. But this is seen as a problem, and it is planned that it will be fixed in our next project. So, based on the results, the proposed protocol is made and tested to make sure that communication goes through a secure route with the least amount of packet loss. Along with the transmission range limit, the power limit would also need to be worked on in the future because it is thought to be another important part of mobile ad hoc networks. Another important part of mobile ad hoc networks is how much energy they need. MANET runs on batteries, so energy, or power, is one of the most important parts of how it works.

Keywords:

Antenna, Loss Pattern Analysis, MIMO, MANETs

1. INTRODUCTION

The use of wireless intelligent applications that require high data rates and dependability is becoming increasingly common [1]. The utilisation of MIMO connections is the means by which this can be accomplished. Approaches using MIMO have been the subject of a significant amount of research in centralised and infrastructure-based networks [2]. There has also been research published not too long ago on networked MIMO-based adaptive scheduling algorithms, as may be found in [4] and [5]. Therefore, the benefits of MIMO links as a workable technique to improve network performance have been validated both conceptually and experimentally.

Even though a lot of work has already been done, the majority of the current MIMO research focuses on overcoming physical problems such as increasing throughput and strengthening robustness [6]. In point of fact, an efficient access scheduler should make use of the benefits offered by MIMO techniques in order to boost overall network performance and keep some local dispersed access features intact. MIMO Even in mobile ad hoc networking contexts, further research is required to investigate numerous top-layer properties of networks that use MIMO techniques (MANETs).

As part of this research, we have proposed a capacity-optimized access scheduling control (COASC) strategy. This strategy takes into account both the upper layer medium antenna stream access scheduling and the physical layer network capacity. The end goal of this strategy is to increase the network capacity of MANETs that have MIMO links. A unique stochastic approximation was utilised so that a solution could be found for the interference problem that was present in distributed systems. Based on the simulation results, COASC has been shown to be an excellent strategy for taking advantage of the benefits that MIMO links provide in MANETs. On the other hand, it has been suggested that the amount of research done on the topic of energy conservation in this paper be enhanced in any future studies [7].

Few previous studies have taken into account power consumption, transmission rate, and antenna selection all at the same time for heterogeneous MANETs adopting MIMO techniques [8]. Those that have done so have found mixed results. These strategies require only partial information regarding the status of the channel in order to optimise the performance of the system. As a result of this quality, the study of distributed resource allocation for heterogeneous networks has become an important topic of research. In this line of research, our primary focus is on determining how MIMO connections may be utilised to both improve the overall throughput and energy efficiency of MANETs. To begin overcoming these challenges, a utility function must first be constructed. We investigated a number of different antenna configurations in order to discover the one that offered the optimal priority, transmission power, and rate for the antenna.

2. BACKGROUND

When compared to systems with a single antenna, data transfer rates are significantly increased with MIMO systems. This rate of gain improves whenever the transmitter is given access to the channel status information (CSI). MIMO technology has primarily been implemented in centralised designs, such as cellular communication systems, as its major use case. In addition, mobile networks make use of SUMIMO technology, which stands for single-user multimedia overlay (MANETs). Studies on beamforming and interference cancellation (under the assumption of perfect channel prediction) have been carried out as a medium access control for SU-MIMO (also known as point-to-point) lines, for instance in [9] and [10]. In addition, MANET SU-MIMO communications have been looked into with centralised scheduling of degrees of freedom [11], as well as with dispersed scheduling of connections based on an interference model that takes into account SINR (signal-to-interference-plus-noise ratio).

In order to improve throughput and spectrum efficiency, this feature enables the simultaneous operation of several links, which can be done either with a single common receiver or with many individual receivers. MU-MIMO is able to handle more complex channel configurations such as multiple access channels (MAC) and interference channels, in contrast to SU-MIMO, which is designed for point-to-point communication between two nodes (a transmitter and a receiver). This is an important distinction to make because SU-MIMO was developed for direct communication between two nodes (a transmitter and a receiver) (IC).

MU-MIMO provides increased achievable rates for everyone participating through coordination and coding over numerous links, whereas SU-MIMO can provide medium access control. Configurations known as SU-MIMO and MU-MIMO can be thought of as the fundamental building blocks of a wireless network. Through the use of the MAC configuration, concurrent communication between multiple transmitters and a single receiver is possible. A phenomenon known as interference can take place when many transmitters connect with their intended receivers at the same time.

There are a few different approaches that can be utilised to facilitate the concurrent operation of a large number of users in MU-MIMO communications. Examples of MU-MIMO systems investigated for use in local area networks are [12], and 802.11ac, as well as Long-Term Evolution (LTE) systems. These are the types of systems in which an access point (AP) or base station coordinates a central MU-MIMO scheme (LANs). Additionally, support for the ad hoc mode is included in 802.11ac. When operating in this mode, one person within a group is selected to take on the role of Group Owner (GO), and they accept responsibility for the AP function.

There are a number of obstacles that must be overcome before MU-MIMO can be fully implemented in wireless networks. These obstacles include intricate network topology, channel and traffic dynamics, as well as the requirement to manage a variety of M-MIMO configurations. In wireless networks, the inability to fully implement MU-MIMO is further compounded by the absence of both centralization and decentralisation. MIMO analysis has usually focused on a single configuration, with training or feedback optimization being the primary concern.

3. PROPOSED MODEL

Within the framework of the proposed approach, routing, also known as the optimal path, is determined by path loss. Each node in an ad hoc network broadcast a route update to its neighbours on a periodic basis to get the process started. Nodes can be positioned anywhere within the transmission range of the ad hoc network. It is up to each neighbouring node to retransmit to its other nodes the update that it has received from the parent node in order to fulfil their responsibilities. Every child node that gets a message from its parent node is labelled as having received that message. Every node within the transmission range is able to receive messages from its neighbouring nodes, with the exception of situations in which a message is lost as a result of conflict or collision. As a result of there being fewer broadcasts that are redundant, there will be a gradual reduction in freedom. The path loss routing table is regularly brought up to date with new information. For instance, the source node might use this metric to evaluate and contrast the path loss and metric value of each of the other nodes in its transmission range (number of hops).

In the end, antennas are placed in places that have the least amount of path loss (Table.1). This site now serves as both a source and a destination for new source and destination nodes that have been constructed. Comparing metric values is used to measure path loss just like it was before, but this time it does not take into account the parent nodes (the place where the data originates). Choose a node at each successive stage that has a loss that is as small as possible while still keeping a metric value that is higher than the difference in value that exists between the parent node and the node that serves as the final destination. The routing database will continue to be updated all the way until it reaches its final location. The metric value as well as the path loss are taken into consideration by this algorithm. The value of the measure must always be higher than the minimum PL value of the step that came before it. It is possible to transfer packets in this fashion without any need for redundancy.

Table.1. Antenna Types used for simulation

Product	Frequency
Body Worn Antenna	1350 -1390 MHz
Fixed Base Antenna	1350 - 1390 MHz
Gooseneck Antenna	1350 - 1390 MHz
Peel & Stick Antenna	1300 - 6000 MHz
Spring Antenna	1350-1390 MHz
Stub Antenna	1350 - 1390 MHz
Tactical Vehicle Antenna	1350 - 1390 MHz
RF over Fiber Transmitter and Receiver	30 - 3000 MHz
RF over Fiber Transceiver	3 - 12000 MHz

It is determined in this manner that the route that sustains the least amount of loss is the superior alternative for the transmission of data. In the following paragraph, the algorithm for determining the amount of time that was lost will be presented for your perusal.

An algorithm for reducing expenses as much as possible. Perform the initialization of the terrain parameters and the number of antennas. Then it involves the calculation of the H matrix and PL. As part of the routing system, the data table of each node is refreshed with new information. Enter the number of nodes as well as the PL, which is the number of hops between any two nodes (the number of nodes). At the outset, the flag of each node is set to 1 ($F = 1$), which is the default value. Using PL, a variable called v is given its initial value in the space between the first two nodes. All of the PLs with v are compared against one another, and the PL that has the smallest loss is selected.

The value v is given the least amount of loss that can possibly be given. The node that has the least amount of loss throughout this stage is taken into consideration to be the stage destination node. It is essential to determine whether, at the present time, the metric value that exists between the sources and the destinations should be maintained at the lowest level possible. Consider the next loss node, even if it a rather small one. In the event that the flag condition is not satisfied, the node that has suffered the least amount of loss is selected as the destination node. If you have already accomplished everything you set out to do, it is time to call it a day and go home. In addition to that, a flowchart is used to illustrate how this method works.

The nodes in the forest environment are responsible for calculating the amount of path loss. The route loss is calculated by both nodes that are dispersed outside and nodes that are distributed indoors, and this is true for both types of distribution.

When calculating route loss, both indoor and outdoor propagation must be taken into account. In order to calculate path loss in any mixed environment, we can make use of the term that was used in the previous example.

Using the formulae that were discussed earlier, it is now possible to determine the route loss for the nodes that were supplied. The propagation delay (PL) between any two nodes in the database can be determined by comparing them to determine how far apart they are in terms of the propagation distance, and then calculating the PL between those two nodes.

In the administrative selection process, digital signatures are being used to verify the data in order to ensure the creation of a secure path with little data loss. The connection table contains an entry for each node and admin pair that is part of the network. Every node will construct their own routing table by using the connection table as a starting point. To construct the routing table, start with a potential destination node and go backwards through the connection table, following each connected pair until you reach yourself.

This article provides a description of the algorithm in terms of the sequence of steps that each node, according to the job that they are performing, is required to follow.

Step 1: Broadcast and receive packets while also bringing the neighbour table up to date with the path loss.

Step 2: Requires that there be a single entry for each node in the administrative selection set.

Step 3: Determine the minimum acceptable level of willingness as the third phase in the process.

Step 4: Check all neighbours who have a willingness that is greater than the threshold for admin selection, unless there has been an update to the willingness of those nodes. If there has been an update, skip this step.

Step 5: A node is selected for further processing if it possesses a high (*W*,*F*) combination of willingness and fidelity.

Step 6: Identify if there is more than one node that satisfies the criteria to complete the sixth step.

Step 7: After that, select the node that provides the most accurate results. The chosen admin node cannot contribute to the formation of a loop if it is to retain its status as an admin node. In any other case, continue on to Step 5.

Step 8: This process comes to a close with the dissemination of administrative packets.

4. RESULTS AND DISCUSSION

In this section, we investigate how well the suggested technique works when there is a significant amount of interference from co-channels. This system consists of packets that are each 1000 bytes in size and nodes that are randomly dispersed within a 1250m×1250m area. Each node has a transmission range of up to 250m. The system makes use of MIMO channels that have been produced at random. The bandwidth of this spectrum resource is 20 MHz, and the transmission time is 2.5 milliseconds.

Table.2. Body Worn Antenna

Nodes	Loss Level (dB)
100	-0.2125
200	-0.1564
300	-0.1715
400	-0.1624
500	-0.1548
600	-0.1234
700	-0.1102
800	-0.0923
900	-0.0823
100	-0.0751

Table.3. Fixed Base Antenna

Nodes	Loss Level (dB)
100	-0.2128
200	-0.1566
300	-0.1717
400	-0.1626
500	-0.1550
600	-0.1236
700	-0.1103
800	-0.0924
900	-0.0824
100	-0.0752

Table.4. Gooseneck Antenna

Nodes	Loss Level (dB)
100	-0.2133
200	-0.1570
300	-0.1721
400	-0.1630
500	-0.1554
600	-0.1238
700	-0.1106
800	-0.0926
900	-0.0826
100	-0.0754

Table.5. Peel and Stick Antenna

Nodes	Loss Level (dB)
100	-0.2140
200	-0.1575
300	-0.1727
400	-0.1635
500	-0.1559

600	-0.1243
700	-0.1110
800	-0.0929
900	-0.0829
100	-0.0756

Table.6. Spring Antenna

Nodes	**Loss Level (dB)**
100	-0.2142
200	-0.1577
300	-0.1729
400	-0.1637
500	-0.1560
600	-0.1244
700	-0.1111
800	-0.0930
900	-0.0830
100	-0.0757

Table.7. Stub Antenna

Nodes	**Loss Level (dB)**
100	-0.2151
200	-0.1583
300	-0.1736
400	-0.1643
500	-0.1567
600	-0.1249
700	-0.1115
800	-0.0934
900	-0.0833
100	-0.0760

Table.8. Tactical Vehicle Antenna

Nodes	**Loss Level (dB)**
100	-0.2153
200	-0.1584
300	-0.1737
400	-0.1645
500	-0.1568
600	-0.1250
700	-0.1116
800	-0.0935
900	-0.0834
100	-0.0761

Table.9. RF over Fiber Transmitter and Receiver

Nodes	**Loss Level (dB)**
100	-0.2156
200	-0.1587
300	-0.1740
400	-0.1648
500	-0.1570
600	-0.1252
700	-0.1118
800	-0.0936
900	-0.0835
100	-0.0762

Table.10. RF over Fiber Transceiver

Nodes	**Loss Level (dB)**
100	-0.2157
200	-0.1588
300	-0.1741
400	-0.1649
500	-0.1572
600	-0.1253
700	-0.1119
800	-0.0937
900	-0.0836
100	-0.0762

Increasing the size of the antenna array is beneficial for both centralised and distributed scheduling approaches, regardless of whether or not there is interference (Table.2-Table.9). By altering the size of the antenna arrays on each node, MANET node heterogeneity also influences the data rate. This parameter will have a lower value as the link becomes more deterministic and MIMO-based. As a result, the benefits of utilising the approach that was suggested become more readily evident as the antenna array size undergoes variations. As a consequence of this, it is able to accomplish greater capacity performance than those that do not use stream control because it uses global optimization.

The Table.2-Table.9 illustrates the comparison of these three approaches and shows how the number of nodes affects the capacity of the network. Before the channels become saturated, a higher total data rate is achieved by increasing the number of nodes in the network. This holds true notwithstanding the presence or absence of any interference in the system. In practise, users of networks with a higher node density are only able to select a subset of the entire number of streams that are accessible. Only the channel streams that have the highest strength will have their broadcast power received.

As an alternative to TDMA, stream control gains can be accomplished by enabling a large number of connections that are known to interfere with one another to operate concurrently (i.e., Links B) while employing the necessary stream control. Because of the optimization of the stream control access scheduling, it has the superior overall performance to the other two techniques.

The Table.2-Table.9 illustrates the data rate, also known as the capacity of the global network, by analysing the capacity performance of three different centralised and distributed access scheduling schemes, as well as the traffic arrival rate and mobility. Poisson, using this as a means, is responsible for generating this traffic. The amount of data that needs to be conveyed must be increased because of the expansion.

It is possible for us to draw the conclusion that the data rate is not significantly impacted by the variation in speed throughout a range of speeds (that is, by adjusting the distance between nodes). Even when combined with stream control, global optimization results in improved capacity performance.

5. CONCLUSION

An evaluation of channel impulse response has been used to estimate the PL of an ad hoc network with a large number of antennas operating in a variety of locations, including indoors, outdoors, and in forests. Additionally, a brand-new algorithm for determining the PL path with the least distance between two points has been devised and validated. The suggested algorithm is able to decide which path has the lowest potential loss by beginning with the premise that all communicating nodes are within each other transmission ranges. On the other hand, this is recognised as a problem and will be addressed in a subsequent update to our product. As a direct consequence of this, the suggested protocol has been crafted and validated in order to provide secure communication via a route with the lowest possible amount of data loss. Because the mobile ad hoc network transmission range is restricted, and because energy consumption is also an important factor to consider, this problem will need to be solved in the future. Due to the fact that MANET is powered by a battery, the availability of energy in the form of electricity is essential to its operation.

REFERENCES

[1] David Stuart Muirhead, Muhammad Ali Imran and Kamran Arshad, “A Survey of the Challenges, Opportunities and Use of Multiple Antennas in Current and Future 5G Small Cell Substations”, *IEEE Transactions on Antennas and Propagation*, Vol. 4, No. 1, pp. 2952-2964, 2016.

[2] Corbett Rowell and Edmund Y. Lam, “Mobile-Phone Antenna Design”, *IEEE Antennas and Propagation Magazine*, Vol. 54, No. 4, pp. 14-34, 2012.

[3] Yu-Shin Wang, Ming- Chou Lee and Shyh-Jong, “Two PIFA- Related Miniaturized Dual Band Antennas”, *IEEE Transaction on Antennas and Propagation*, Vol. 55, No. 3, pp. 805-811, 2007.

[4] Nariman Firoozy and Mahmoud Shirazi, “Planar Inverted-F Antenna (PIFA) Design Dissection for Cellular Communication Application”, *Journal of Electromagnetic Analysis and Applications*, Vol. 3, No. 1, pp. 406-411, 2011.

[5] H.T. Chattha, Y. Huang, M.K. Ishfaq and S.J. Boyes, “Bandwidth Enhancement Techniques for Planar Inverted F Antenna”, *IET Microwaves, Antennas and Propagation*, Vol. 5, No. 15, pp. 1872-1879, 2011.

[6] Dalia Mohammaed Nashaat, Hala K. Elsadek and Hani Ghali, “Single Feed Compact Quad-Band PIFA Antenna for Wireless applications”, *IEEE Transactions on Antennas and Propagation*, Vol. 53, No. 8, pp. 2631-2625, 2005.

[7] Saqer Al Jaafreh, Yi Huang and Lei Xing, “Low Profile and Wideband Planar Inverted-F Antenna with Polarisation and Pattern Diversities”, *IET Microwaves, Antennas and Propagation*, Vol. 10, No. 2, pp. 152-161, 2016.

[8] Hassan Tariq Chattha, Yi Huang, Stephen J. Boyes and Xu Zhu, “Polarization and Pattern Diversity-Based Dual-Feed Planar Inverted-F Antenna”, *IEEE Transactions on Antennas and Propagation*, Vol. 60, No. 3, pp. 1532-1540, 2012.

[9] A. Jain, P.K. Verma and V.K. Singh, “Performance Analysis of PIFA based 4×4 MIMO Antenna”, *Electronics Letters*, Vol. 48, No. 9, pp. 1-7, 2012.

[10] S. Chowdhuri, P. Banerjee and S.S. Chaudhuri, “Relay Node Selection Algorithm Consuming Minimum Power of MIMO Integrated MANET”, *Advances in Computational Design*, Vol. 3, No. 2, pp. 191-200, 2018.

[11] G.N. Anil and A.V. Reddy, “Optimized Energy Efficient Routing protocol (OEER) in Mobile Ad-hoc Network”, *International Journal of Engineering Research and Technology*, Vol. 4, pp. 581-587, 2015.

[12] P. Adasme and L. Szczecinski, “A New Detection Algorithm for Manets based on Product Trellises using Space Time Trellis Codes”, *WSEAS Transactions on Mathematics*, Vol. 6, No. 2, pp. 348-355, 2007.