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# IMPROVING THE CROSS-LAYER FUNCTIONALITY TO OVERCOME THE COLLISION IN MOBILE ADHOC NETWORK

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**ABSTRACT**

Collision avoidance in widest self organizing and easily formed network for making instant communication of Mobile Adhoc Network was a tedious task due to the mobility of the communication nodes. Many research work address to overcome the issues with the support of the physical layer as well as MAC layers protocols. But none of the methods has given solution to overcome the problem. Incorporating the Directional antenna in to the MAC layer functionality can support for hidden and exposed nodes problem to avoid collision .This research article discuss cross layer functionality with beam sector directional antenna technique in to Physical and hidden and exposed nodes table in MAC layer. This proposed work combines the physical and MAC layers to resolves the collision among the nodes; improve the signal power and routing efficiency in MANET. This antenna find out the receiver direction based on the hidden and exposed nodes location of the next hope received and focus the packet floating, this technique to support the Hidden and Exposed node problem in MANET also improve the routing efficiency and power optimization also this cross layer functionality does not require and Handshaking signals.. This work is simulated using Network simulation and result gained 35 % to 60% of improvement in overall MANET Network performance and metric value 30 % to 60 %, overall antenna gain in Beam sector Antenna 21.5 dBi.

**Keywords:** *MANET, Antenna, Physical Layer, MAC layer, Hidden and Exposed node, Cross Layer*

## 1. INTRODUCTION

Traditionally Omni directional antenna was used within MAC protocol through distribution Coordination Function in IEEE 802.11 named as CSMA/CA along handshaking technique. Recently these antennas are overcome by smart antenna [1] due to provide more number of nodes connectivity and gain power , some kind of antenna supports interference [2], long transmission range [3] and transmission capacity [4]. Many research related to Medium Access Control protocol based antenna provides the solution to Omni directional antenna limitations. Mahmud et al. [5] proposed GPS based MAC designed directional antenna for defend hidden and exposed terminal problem. Wang et al. [6] invented CMDMAC protocol to resolve the MANET Hidden and Exposed node

problem with the corporative directional antenna, Kulcu et al. [1] proposed the smart antenna using IETF 6TiSCH protocol for MAC layer scheduling mechanism to overcome hidden and exposed node issue. Vigneshwaran et al [7] invented the sector based direction antenna by dividing geographical location in to sector and proposed the sector based Antenna. Periyakaruppan [8] uses MIMO link to propose the COASC strategy to overcome the MAC layer problem with support of scheduling in Physical layer network capacity.

Set of research work has evolved in node location based directional with the support of neighbor node discovery [ND] [9] to minimize the convergence time. Sorribes et al. [10] invented collision detection technique with the support of Neighbor nodes location. Wei et al. [11] detect the ND with Gossip technique in VANET by setting sensors on the road vehicle. ISAC technique proposed in [12] [13] for using spectrum and hardware devices which support for reduce the overhead in convergence time. Radar sensing to get prior information about the ND discussed in D. Ji et al. [14] and Wei et al. [15]. Gossip mechanisms to know ND was proposed by D. Cason et al. in [16] for reduce the convergence time. Group of research work has done with the invention of Machine Learning (ML) based ND algorithms. Liu et al. [17] used filter prediction algorithm with reinforcement machine learning, Q-learning model proposed by Y. Wang et al [18] and B. E. Khamlichi et al [19] [20] and policy based scheduling model proposed by B. El Khamlichi et al. [20] and Y. Zhao et al. in [21].

Among the several proposal of smart antenna discussed in this chapter, with the MAC layer routing protocol, ND prediction for convergence time and ML algorithms are not assist to provide solution for MAC layer and Physical layer which are not solved permanent, still the existence of Hidden and Exposed node problem and power management, in MAC and Physical layers predominant issue in MANET. This article addresses the cross layers functionality which compromises the physical layer and Mac layers functionality as shown in the Figure 1. MAC layer determines the hidden and exposed nodes of all the nodes to all other nodes in the communication network , by using this table the antenna direction of forwarding the packet to the next hop is determined . This kind of cross layer functionality based design could not require the handshaking signal of source to other nodes like CTS/RTS etc.

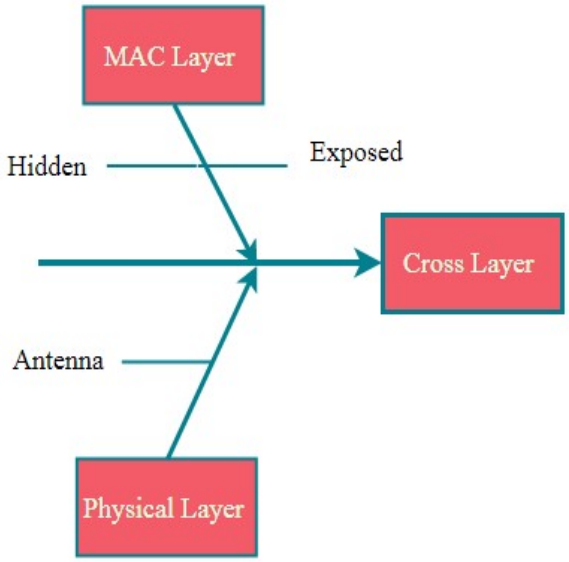


*Figure 1 Cross layer functionality*

Smart antenna with the support of ND and beam defining to float the packet to the next node also uses ME-MAC protocol for finding the hidden and exposed nodes in the network. Through this could achieve the better performance in MANET Physical and MAC layer .The organization of this article start with proposed method in the section 2, followed by research methods and result discussion in section 3 and 4 respectively, finally end with conclusion and feature work in section 5.

## 2. WORK RELATED TO ANTENNA AND MAC LAYER

The authors, Khamlichi et al [19] proposed the ND method for tackling the ND problem in wireless Adhoc Networks using the learning automation discovery process model. This model learns the node and changes the surroundings to obtain a high rate of ND detection. This job is faster only in low density networks, but much slower in high density networks. Khamlichi et al suggested a reinforcement-based ND algorithm for Adhoc networks to overcome the discovery latency problem and the long tail problem with the help of narrow beam. To reduce route discovery latency, this study employs a stochastic multi-player game and a Q-learning-based method. The research results, as compared to other ND, produced the substantially faster but has a higher computational complexity. In this study, Ji et al used radar communication technology to forecast neighbor nodes in a wireless Adhoc network. It uses the radar's full location information to determine the direction of the neighbor. This study restricts the

upper and lower bounds for the mathematical derivation to anticipate the ND while also conserving energy. Wei et al. conducted research on wireless networking for ND detection using radar and machine type communication. When compared to the old technique, simulation results demonstrate that this method uses previous knowledge from the radar to predict the ND, which increases the speed of ND prediction; however, in wireless network nodes, prior information will not be practical to predict the neighbor node.

Wei et al [15] proposed gossip-based neighbor node discovery in VANET by deploying numerous sensors on the roadside and receiving information via GSIM-ND multi packet reception. Simulation results were compared to other existing CRA and SBA algorithms. The convergence time is reduced by 40 to 90% when the number of modulation modes k is set to 1.When the number of modulation modes is changed, the outcome fails to improve convergence time. This approach works well when the derivation of a neighbor node can be completed within the time constraints.

Zhiqing Wei et al discover a strategy for lowering convergence time with prior knowledge of neighbor node information for 6thgeneration mobile nodes. They proposed incorporating the gossip mechanism into the ISAC-enabled ND algorithm. When compared to Q-learning-based mechanisms, simulation of the proposed work lowered convergence time significantly, even when used to reinforcement learning. The ND Algorithm, as well as ISAC techniques, is not required for MANET operation.

Liang et al [22] found neighbor node detection in FANET to solve multiple channel accessing problems. They present two algorithms, BR-DA and BR-DA-FANET, as well as two protocols, ND-LP and ACI-LP, for beam tracking and channel enabling. All of this comes together to produce the FA-MMAC-DA protocol for ND discovery and interruption avoidance. When compared to the previous ND protocol, the simulation of our protocol results in less delay. However, this method fails to detect the rapid finding of ND and transmission delay. Trung Kien Vu and Sungoh Kwon offer a location aware on demand routing system for mobile nodes notwithstanding the presence of node location error. They employed the Kalam filter to determine the actual node location, and the simulation results improved on prior work, but the poor location information about the nodes, which causes incorrect routing, also reduced MANET performance.

Jose Vicente et al [10] conducted research on wireless Adhoc networks for predicting neighbor nodes using unique algorithms CDPRR and CDH. CDPRR employs geometric and uniform distributions, as well as two signals from the traditional synchronization schemes Hello and PRR. The simulation could not solve the CDH protocol with altering clot width and number of nodes, resulting in a better PDR, less over head, and less energy consumed. B. Zeng et al proposed a hybrid design of an Omni Directional Antenna and a Multi Beam Directional Antenna to address design problems in MANET and FANET. This study investigates the stable data communication from target tracking to location prediction. The end result is a 35.8% improvement in data link strength. Palanisamy et al. [23] carried out the Adhoc and infrastructures of two network architecture-based communication in MANET in this article. The server-side node Infrastructure-based communication was introduced, and sector-based routing was employed for antenna transmission. The simulation results created the ideal collision rate, improved efficiency, and distributed dependable nodes.

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To address the issue of exposed nodes in MANETs, the authors of Sivaram et al [24] suggested the RDBTMA protocol, which operates on RTS/CTS and busy tone signals. Furthermore, fast transmission is supported by NACK signals, and simulation results reveal that when compared to the present protocol, this study effort reached just the PDR (17.8%), packet delay was 38%, and throughput was 21.9%.The packet loss rate was 14.9%.The authors Liu Kai et al suggested the ETF MAC protocol with a new multichannel MAC to address the exposed terminal problem. Along with RTS/CTS discourse for channel allocation, conflict-free traffic channel work is performed; this work avoids packet collision. The simulation results are compared with the CAM-MAC protocol using only a few performance variables such as packet drop rate, delay, and channel utilization to determine which the best is.

The writers of Viral et al [25] conducted a collection of studies on hidden node issues and their solutions. This article projected the virtual Jamming issues and RTS/CTS for creating JAM in wireless networks and also addresses WiCCP protocol to resolve the hidden node issues and other techniques usages such as Omni directional antenna, increase transmission time, software enhancement are supports for improving Hidden and exposed node problem but software updates are

not precise. The authors Mekala and colleagues presented the MAC protocol, which is implemented with Sensor and directional antenna support, in this research to improve the performance of wireless sensor networks. The MAC protocol, with the help of a directional antenna, helps to overcome the hidden and exposed node problem, and the research simulation results generate a multihop that is reduced across long distances and is energy optimized.

Authors Chen Jenhui et al [26] introduced a higher throughput achieved MAP protocol for CSMA to support 802.11 and Adhoc networks for concurrent transmission in this study. The time complexity was computed as O (|X| log |X| + |X|M2), where |X| and M signify the number of successful requests, and lastly the simulation results were analyzed higher throughput

The authors Liu Kai and Xing Xiaoqin [27] suggested a unique MAC level protocol with RTS/CTS signal support, reliable ACK, and flexible traffic channel and multi channel selection. This technique eliminates the exposed terminal problem, and the simulation results show that it performs better than the present CAM-MAC protocol. The authors Singh et al conducted a real time MAC protocol comparative analysis and presented the S-MAC real time protocol, which produced consistent data transfer but increased overhead owing to control packets.

The author of Rajeev Kumar [28] this research, proposed a trustworthy MAC protocol for solving the hidden and exposed node dilemma by providing an addressing technique and a channel access mechanism. Authors Hemant et al propose a new resource allocation protocol for increasing QoS in MANET TCP/IP in this study. While designing the protocol, the feature of eliminating hidden and exposed nodes was added to improve QoS. The protocol was simulated using V/UHF radios and the performance of TCP/IP was assessed, revealing that only two characteristics improved: data rate and jitter.

The authors Kalfas et al. [29] presented WiMARK, a hybrid technique for eliminating hidden and exposed nodes. All nodes kept a local matrix for gathering other surrounding nodes' current location and making the transmitter transmit or receive with the use of RTs and Status messages. This work has been improved by including a sleep and awake protocol to reduce node energy consumption. The writers of this survey study, Hussien and Mostafa [30], provide a comprehensive survey connected to building a MAC protocol using modern techniques such as machine learning, deep learning, and artificial intelligence. Finally, three features show that machine learning techniques are ideally suited to MAC protocol design.

In this paper, Mahendrakumar et al [31] a nullifying MAC framework for Adaptive Antenna Array was developed to handle MAC layer concerns such as concealed terminal problem, beam problem, and deafness nodes, among others. Simulation was tested with OPNET and MATLAB, yielding limits of 27.22% throughput and 40.46% SNR increase. The Researchers of Gudodagi [] this study devised CAD-CW, a strategy for avoiding collisions utilizing contention windows. To avoid collisions, this strategy maintains a contention window in which the highest priority node packets are transmitted first. This technique achieves faster throughput, reduced delay, and lower overhead while consuming the least amount of energy.

The inventors and colleagues Linn et al [32] suggested a technique to reduce heterogeneous collisions using the distributed contention-free cooperative medium access control (CFC-MAC) protocol and the corporative communication system and corporative forwarding mechanism. The simulation determines the corresponding position to study the collision; the findings of the simulation comparison reveal that there is less delay and the collision is minimized. Authors Zhou et al suggested an Intelligent Multi-hop Low Duty Cycle (IMLDC) Media Access Control (MAC) protocol based on long short-term memory (LSTM) to address the short life cycle issue in UAVS. For optimal mode environment, an LSTM neural network was applied. Real-time simulation only the network life cycle is improved by the LSTM-based IMLDC MAC protocol over existing MAC protocols.

According to the literature review, Among the several proposal of smart antenna and MAC hidden exposed node problem discussed in this literature , the MAC layer routing protocol, ND prediction for convergence time and ML algorithms are not assist to provide solution for MAC layer and Physical layer which are not solved permanent, still the existence of Hidden and Exposed node problem and power management, in MAC and Physical layers predominant issue in MANET, several protocols were proposed to address the MAC layer hidden and exposed terminal issues, some novel techniques were introduced, distributed channel allocation strategy was also addressed, RTS/CTS signal synchronization, introduction of various algorithms, Uni directional antennas, adaptive

antenna array strategy, and contention window for allocating channels. All of the above methods could not resist the hidden and exposed node issues, and the research work did not address all of the performance in the MAC layer, so more research is needed to find a solution to the hidden and exposed node problem and address all of the performance. This research article focuses on the cross layer functionality of combining the antenna model with Hidden and exposed nodes table to transmit the packet to the defined direction; this could support the hidden and exposed nodes issues and avoid the usage of synchronization messages.

## 3. PROPOSED RESEARCH METHOD

The objective of this research article to proposed the cross layer functionality to do the antenna projection direction based on the hidden and exposed table .Proposed work is spited in to two section, one for maintaining the hidden and exposed node table and another based on the hidden and exposed nodes a transmission direction .Both works together to support the cross layer functionality to achieve the hidden and exposed nodes challenges and avoid collision.

### 3.1 Hidden and Exposed nodes table creation

To provide the Antenna direction for the packet broadcasting or forwarding the every nodes in the MANET need the hidden and exposed nodes which is support for avoiding the beam direction chosen for transmission. To find the Hidden and Exposed nodes and updating about the nodes could be done with the support of following procedure.

1. For all the nodes in the MANET form the region
Maintain the hidden and exposed node table
2 Generate the beacon signal by collecting the node available position
3. Upon receiving the node position the nodes which are in the nodes region

**Hidden Node Table Creation**

1. Set = Node {1, 2, 3 …N}
N are a total number of nodes in a MANET
2. For each node i from 1 to N
Generate location aware of other node in each i th node transmission range
3. All the nodes share the nodes which are in the region to its Transmission range nodes.
4. Repeat for (i=1 to N)
{(For (j= i to N) Hidden node of i = (List of node $i^{th}$ node transmission range) ∩ (List of node in $j^{th}$ transmission range) )}

**Exposed Node Table Creation**

1. Set = Node {1, 2, 3 …N}
N are a total number of nodes in a MANET
2. For each node i from 1 to N
Generate location aware of other node in each i th node transmission range
3. All the nodes share the nodes which are in the region to its Transmission range nodes.
4. Repeat for (i 1 to N)
{ for (j= i to N)
Exposed node of i = If i and j are in the same transmission range and List of node $i^{th}$ node transmission range is not equal to List of node in $j^{th}$ transmission range then i is exposed node to j
}

### 3.2 Antenna Transmission beam design

Upon receiving the hidden and exposed nodes table details the antenna beam is selected for the transmission or forwarding of the packets. Each antenna was designed eight sectors, and sector will cover the 45° of transmission range. The purpose of the selecting of beam is to avoid the collision among the nodes.

**The beam selection is follows the following steps**

MANET SET N = {N1, N2, N3 ….Nn}
Where n is the maximum number of nodes in MANET

Step 1: Collect the Hidden and Exposed node table
Step 2: Form the table based on the each node hidden and exposed nodes location
Step 3: Calculate the angel of the hidden and exposed nodes of every node
Step 4: Determine the direction which is not in the hidden and exposed nodes angle

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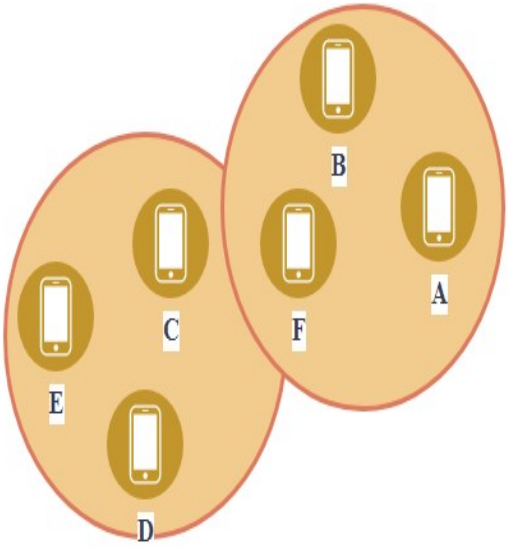


*Figure 2 MANET NODES*

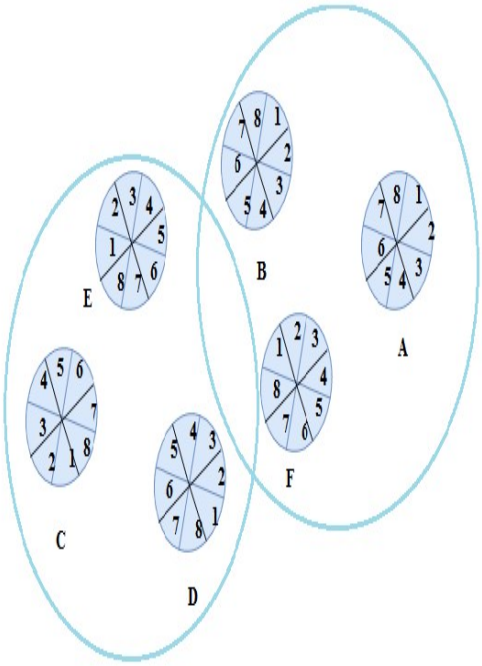


*Figure 3 Antenna Beam sector selection*

For instance the MANET nodes are showing in the Figure 2 and its sector antenna showing in the Figure 3. Suppose the A nodes is Exposed nodes to the D node, D node could not used the transmission of 1, 2, 3 sectors for the transmission because this could interfere the F node transmission.

Let s (t) power signal sent from an antenna Transmission signal weight . For each antenna sector wRi Where 1≤i≤8 the received signal of the i th antenna and Signal output are calculated using the Eq (1) and Eq (2).

$$xi(t) = s(t) \sum_{j=1}^{N} wTj\ hji \text{ ------ } Eq(1)$$

$$\text{Received signal output of } r(t) = \sum_{i=1}^{N} WriXi(t) \text{ ----- } Eq(2)$$

## 4. SIMULATION SETUP OF RESEARCH METHOD

Initially the proposed work is established, the physical layers which does not uses the CSMS/CA techniques over the hidden and exposed node prediction, MAC protocol relays to predict the Hidden and Exposed nodes tables, Data Packets supports for making the connection establishment. Later Antenna determines based on the available . Location which beams to be act for transmitting and receiving of the packet, finally the packet will be send from the sender node to reach the receiving node. Initially Antenna set Zero gain value in other direction so that the other nodes interference will be avoids this support for overcome collision among the nodes.

The proposed cross layer Physical and MAC layer based antenna design was simulated with the support of Omni directional antenna set up with beam sector directional antenna. The several metric are taken for comparing with the Omni directional antenna [22] with the proposed antenna 1) Collection rate, 2) Efficiency, 3) speed, 4.)Signal strength. Simulation parameters [23] are defined as in the Table 1. The total numbers of nodes are ranging from 10 to 50 for making the comparison between the proposed works with existing Omni directional antenna. Starting the simulation with 10 numbers of nodes and slowly increasing the nodes count by 5 in every time duration of 20 ms and computed the evolution metric.

*Table 1 Network Simulator Parameter Setup*

| S.NO | PARAMETER | VALUE SET |
|---|---|---|
| 1 | PHY | DSSS |
| 2 | CWmin | 32 bit |
| 3 | CWmax | 1024 bit |
| 4 | Channel Data Rate | 11Mbps |
| 5 | Basic Data Rate | 1Mbps |

| | | |
|---|---|---|
| 6 | SIFS | 15 µs |
| 7 | DIFS | 45 µs |
| 8 | Slot time | 15 µs |
| 9 | Propagation delay | 1 µs |
| 10 | Packet Payload | 10000bits |
| 11 | MAC Header | 200 bits |
| 12 | PHY Header | 150bits |
| 13 | ACK | 250 bits |
| 14 | RTS | 250 bits |
| 15 | CTS | 250 bits |
| 16 | Hidden signal | 250 bits |
| 17 | Exposed Signal | 250 bits |

Signal power of Omni directional antenna and Beam sector design antenna received power, collision rate, speed and efficiency which depict that the beam power antenna signal strength is double time better than Omni directional antenna probably maximum speed 5.6 Mbps when nodes goes in to increasing order no lagging variation is find in speed and efficiency also increased. From this Comparison the Gain of Omni directional antenna is 13.5 dBi where the Beam sector Antenna 18.5 dBi. Comparison summary of all metric value compared between the Omni directional antenna and beam sector antenna depicted in the Figure 4.

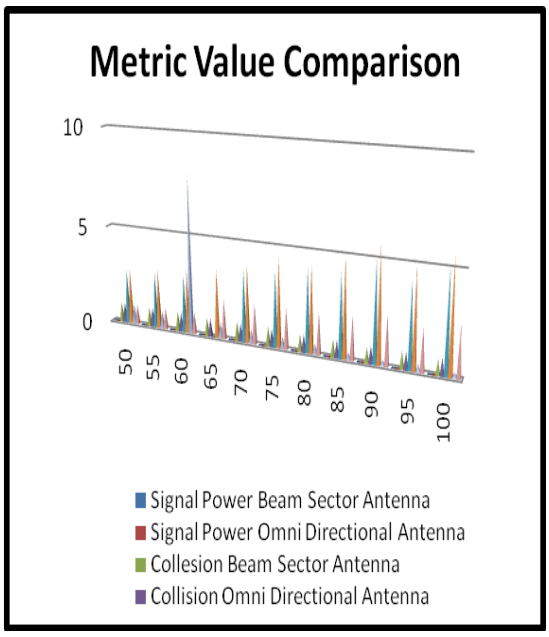


*Figure 4 Metric Value*

## 5. RESULTS AND DISCUSSION

In this part the performance analysis of proposed beam sector based antenna was compared with Omni Directional antenna [24] with the support of Network simulator NS3 version. Existing On demand protocol AODV was chosen for route finding. Collaborative Physical and MAC layers works alone made modification with the support of Beam sector antenna and ME-MAC protocol. The performance factors are taken for comparisons are Energy Consumption, Throughput, and Bit Error Rate.

### 5.1 Energy consumption

The motivation of this research work focus on antenna design to attain maximum energy during the packet delivery with respect to the synchronization packet and data packet. This is computed as in Joules using the Equation Eq (3) with varying the time from 50 ms to 1000 ms.

$$Energy\ Consumption = \frac{Ratio\ of\ Energy\ Spent}{Overall\ Network\ Energy} \quad --- \text{Eq (3)}$$

The result proved that beam sector antenna consumed 10 % of energy compared with Omni directional antenna which is depicted in the Figure 5.

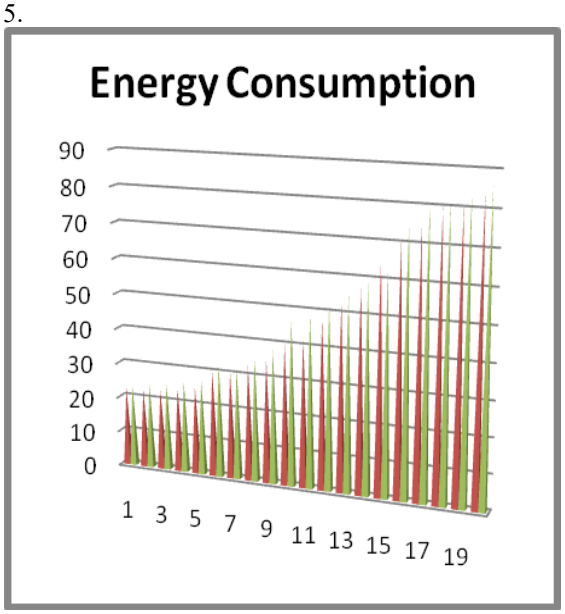


*Figure 5 Energy Consumption*

### 5.2 Throughput Comparison

Throughput is defined at successful packet send from the sender to the receiver which is measure in bps. With efficient utilization of wireless bandwidth and minimum interference makes the throughput is 20 % excellent compared with the Omni directional antenna method which is depicted in the Figure 6.

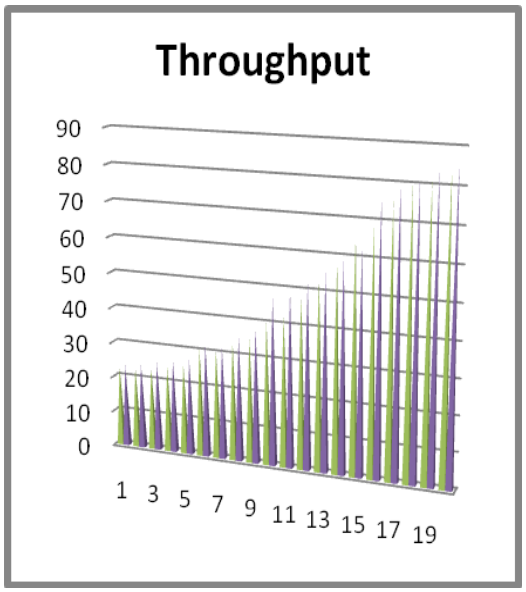


*Figure 6 Throughput*

### 5.3 Bit Error Rate Comparison

Better bit error rate could be achieved if transmission uses distortion free communication and less interference. These two factors are achieved with the support of beam sector antenna broadcasting direction. Ultimately the bits error is not prominent factor in this model design. Error rate is 45% reduced compared with Omni Directional antenna design which is shown in the Figure 7.

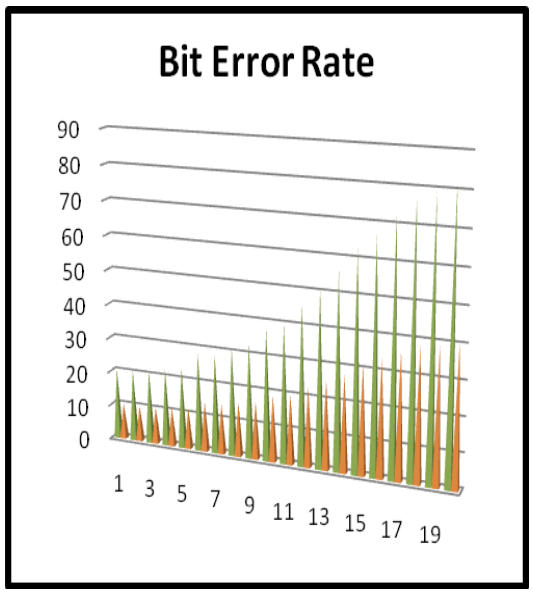


*Figure 7 Bit Error Rate*

## 6. CONCLUSION

This article elaborates the cross layer functionality Beam based directional antenna for making the transmission between the nodes in MANET. The simulation results are shown that better improvement from the performance factors of Physical layer and MAC layer. This work is simulated using Network simulation and result gained 35 % to 60% of improvement in overall MANET Network performance and metric value 30 % to 60 %, overall antenna gain in Beam sector Antenna 21.5 dBi. This cross layer functionality is used only the physical and MAC layer, in future it could be enhance in to the network layer to produce the novel routing protocol following the antenna and Hidden and exposed table to avoid the collision in the MANET.

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