International Journal of Computer Networks and Applications (IJCNA)
DOI: 10.22247/ijcna/2021/209991 Volume 8, Issue 5, September – October (2021)

RESEARCH ARTICLE

A DCM Algorithm for AODV to Implement Energy Efficient Routing in MANET with Capacity Maximization

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Received: 21 August 2021 / Revised: 20 September 2021 / Accepted: 24 September 2021 / Published: 27 October 2021

Abstract – Ad-hoc networks are architecture-less networks because the sender and receiver nodes are mobile, and a node can act both as sender and receiver. Mobile Ad-hoc networks (MANET's) work on the principle of routing protocols that transmit the data packets from the sender to receiver using a routing path and various nodes that act as hops. Utilizing the multi-path routing will improve the throughput and route resilience than single-path and it has not been used widely thoroughly in MANET. Due to the broadcast nature of the node, there is increased power consumption which reduces the network's lifetime. Hence an efficient algorithm is needed for power control thereby reducing the interference and enhancing the performance of the network. Because of the dynamic network topology structure where nodes may join or leave the network leads to link and path failure. Other limitations are it requires some other node to act as a forwarding agent if the radio range is not in this transmission range. To avoid the link failure and to improve Throughput with reliable data delivery by considering route resilience the Novel routing algorithm is proposed here. Ad-hoc On-Demand Vector (AODV) protocol is a standard protocol used in MANETs. AODV has the issue of scalability, load balancing, link failure, security, Packet Delivery Ratio & Throughput decreases and more power consumption when the number of nodes increases and for high data rates. This standard protocol required various enhancements to compare different parameters of the network data transmission, and this work considers data rates, throughput, and power consumption and proposes a new algorithm called DCM Algorithm (Data rate, Communication range, Message size) for enhancing the performance of the AODV protocol. The Enhanced Version is called Intelligent Energy Efficient Enhanced AODV (IEEE-AODV) it identifies the malicious Black-hole node and provides security from black-hole attacks. This research design was simulated on an OMNet++ software tool, the simulation results and graphs of various enhancements are discussed. The results and comparison between the default AODV and IEEE-AODV are explained with different parameters, and it was found that the IEEE-AODV has higher throughput values and lower power consumption with good scalability.

Index Terms – Algorithm, AODV, MANET, Mobile Ad-Hoc Networks, Power Consumption, Throughput.

1. INTRODUCTION

Modern technologies demand improvements and enhancements regularly. Networking technologies are the foundation for a large number of industries that handle digital data. Networking essentially means that the data need to be sent from the sender to the receiver with multiple hops and transmission paths. This is a challenging task because there are numerous levels at which the data packet crosses and reaches the destination. The challenge aggravates when the sender and receiver nodes are mobile and cannot prefer a fixed protocol. The nodes are continuously moving, and it is a challenging task to send all the data packets without any losses to the receiver, especially when there are numerous hops [1]. The nodes have the responsibility of analyzing the inputs from the sender node and transmitting them towards the next step and further towards the receiver node. The increase or decrease in the message size or packets will significantly influence the quality of data transmission because the network routing is difficult for more nodes.

The configuration of MANETs is dynamic, and the topology needs to be discovered by the nodes so that the transmission is effective and does not compromise any performance parameter. When there is a new node entering the network, all the nodes should be aware of this new entrant, and an announcement is usually published and flooded across the network. There are different types of routing protocols used in these networks that contribute towards higher performance. The mechanism of the routing protocols can be classified into proactive and reactive types [2]. Proactive protocols function with a list of values in a routing table that helps the nodes to understand the path and move towards the receiver.

The routing path is usually updated after every iteration, and all the nodes are supposed to follow the variables and entries in the routing table. When a request is raised for transmission for the data packet, the values in the routing table are checked, and the respective requests are raised to the center and receiver nodes. The second type of routing mechanism is the reactive mechanism in which a routing table is not used, but the node is responsible for identifying all the required details and discover the route within the network to reach the receiver node [3]. AODV is a benchmark in reactive protocols, and the standard version was used in many network technologies. However, there are many disadvantages, especially when the variables and characteristics of the data packets, such as data rate and communication range, are varied. This research project considers enhancing the standard AODV routing protocol with a new DCM algorithm that enhances the performance in the form of throughput when there are changes in the communication range and data rate.

1.1. Challenges and Issues in MANET

MANET's are dynamic so the nodes will move randomly and cause the problem in finding the path between the source and the destination. Each node may join or leave the network it disturbs the communication which leads to packet loss and less throughput. Mobility and Bandwidth limitation is considered as the major issue in Routing protocol. All the nodes in the network will access the same medium that leads to collision and congestion and it will degrade the performance of the network. All the nodes in the network are battery-operated devices so the power constraint is the major issue to be addressed by considering the mobility of the node. Reducing the power consumption will increase the lifetime of the network so that the network capacity may get enhanced. No routing protocol addresses the above issues without creating much delay in the network.

1.2. Problem Statement

MANET may be a self-sustaining device that contains mobile hosts that are all connected with the help of Wi-Fi hyperlinks and no static infrastructure as well as base stations. If two hosts aren't in at same communication range, all the messages between them can submit to the intermediate hosts that act as routers. These hosts are absolved to move haphazardly that reasons the constellation is dynamic. Utilizing the multi-path routing mechanism when put next to single-path routing can supply development in throughput and route resilience within the case of the wired network. But multi-path routing is not used in detail in MANET. The Nodes in MANET are broadcast in nature creates hidden terminals and exposed terminals issues that appreciably reduce the network ability. There is a requirement for an effective power management algorithm rule to cut back interference and enhance network performance.

2. RELATED WORK

AODV is a standard in routing protocols, and many research studies have discussed its efficiency. The standard version of the routing protocol is not suitable for many applications due to the dynamic characteristics of the nodes. The effectiveness of the routing protocol is analyzed and enhanced in different ways. The most common characteristics of the data transmission, such as delivery ratio and throughput, are discussed in many research studies, and different approaches have been implemented. In AODV-BR [4], an extended version of AODV [5], multiple routes square measure maintained and utilized only if the first roots fail. Split multi-path routing (SMR), projected in [6], focuses on building and maintaining different ways but the load is transported in two routes each session. In [7], the additive impact of alternate path routing (APR) on load equalization and end-to-end delay in mobile unintended networks has been explored. In a motivating application [8,9], multi-path path transport (MPT) is united along by multiple description cryptography to send video and image info within the multi-hop mobile radio network. From the analysis of literature for multi-path routing mechanism [10],[11],[12],[13], their square measure still several problems in adapting multi-path routing techniques into mobile unintended networks that square measure to be coated. quality and density were utilized as criteria in a very comparison of routing protocols. AODV exceeded DSR and OLSR in terms of outturn and route load [14].

Different parameters of the routing protocols have been analyzed in a research study that considers the overhead values and reviewed the importance of flexibility. There are numerous methods to address this issue, and the research study considers packet delivery ratio as an important factor because it affects the load of the data packets and thereby the performance of the entire routing protocol [15].

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Optimal path selection is a major challenge in MANETs, and the research studies in this area have considered popular protocols like Ant Colony Optimization and AODV. The quality of service in these networks needs to be significantly enhanced, and the mechanism of the Ant colony can help enhance the performance of AODV. The value of the path is calculated using the reliability and the residual energy, which makes the path an optimal solution. These values are dynamically changed to simulate all the possible changes, and then the enhancements are significant [16].

Trust model-based enhancement has been proposed for AODV, and the dynamic nature of the routing protocol was analyzed. The trust model was enhanced using the combination of encounter rates for AODV, which could offer the solution for trust models. This research article considers the importance of trust value and addresses the problem of performance, especially when the mobility of the nodes and routes is high. The efficacy has been proved in this research study. The difference between the current method and this research study is the factors considered for enhancement. The studies in the research literature consider combining or modifying other algorithms with AODV and do not essentially consider changing the parameters or improving their browser protocol without major changes to the core functionality. Additionally, an energy-efficient sliding window network coding scheme for MANETs was presented (SWNC-EE) [17]. The work introduces EAOMDV, a multipath routing system that chooses paths between source-destination pairs based on a route cost function [19]. the black hole attack's End-to-End Delay is noted to be larger. In comparison to flooding and rushing assaults, black hole attacks significantly lower network throughput. As a result, black hole attacks have a higher influence on the performance of the network [19]. The Ant Colony Optimization (ACO) technique was investigated for its efficacy in path selection and node overhead reduction [20]. congestion control AODV (CC-AODV) is used to handle the provided routing state [21]

Research studies have also considered the parameters such as link availability [22]. Security enhancements [23], using the AODV protocol for specific attacks such as black hole attacks [15], other security attacks [24], etc., were also part of the literature review. These studies have the importance in terms of improving the entire protocol by changing the functionality that could result in modifications to the performance. Specific techniques that consider the dynamic nature of MANETs are also part of the literature review [25]. The AODV protocol's primary constraint is that the designated route remains active as long as no data is transmitted; the route becomes invalid only when the data packet is transmitted [26].

Specific applications have been considered, especially in the automotive domain [27]. Alliance to methods like fuzzy logic and security enhancements have also been proposed in the literature, but the uniqueness of this research study is in the changes to the combination of parameters and their influence on the performance.

2.1. The Motivation of the Work

The real-world applications of AODV demand higher performance and stability. AODV offers the flexibility to enhance it and customize the protocol for various requirements. Researchers have tried to enhance the core protocol and change the configuration to improve the performance in terms of throughput and power consumption. One of the important observations from the literature is that the routing protocol has not been enhanced or analyzed for the specific changes in the values of throughput, route resilience, and power consumption. The packet delivery ratio and delays are not analyzed by weighting the parameters in the research studies, which could significantly improve the performance. This research study analyzed these factors of network transmission and simulated the results to find the relationship between the parameters and the performance.

2.2. Research Objective

The goal of power control is to be achieved by adjusting the power level of the transmitting node, transmission range to reduce the interference with its associates. This increases the overall Networks performance by decreasing packet loss, enhancing throughput, increasing spatial reuse, and reducing the energy intake of the overall network. To govern the power successfully, a cell node desires vicinity data of its neighbors and in all likelihood its associates' associates it may be received by using the use of GPS Effective Scheme for use in routing mechanism to avoid packet collision and congestion inside the network. The routing set of rules must be adaptive through thinking about the mobility of nodes at the same time as designing the strength to manipulate the algorithm. Because of the nearer or further movement of neighboring nodes, the set of rules have to increase or lower the strength degree for that reason.

- Designing algorithm needs to implement the idea of energy-efficient routing with capacity maximization.
- To design a multi-path routing mechanism that improves throughput, Packet Delivery Ratio, and route resilience for MANET with reduced power consumption.

3. INTELLIGENT ENERGY EFFICIENT ENHANCED AODV(IEEE-AODV)

3.1. Design and Importance

MANET is a collection of tiny mobile nodes in which all are battery-operated. So the power consumption must be reduced sufficiently to maximize the capacity of the network. Here in this research, the three important parameters considered in the design are communication range, data rate, message size.

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These three parameters are considered important because it affects the communication and the network's performance so all these are checked with different combinations for throughput and power consumption. The IEEE-AODV is designed mainly to improve throughput and reduce the power consumption of the overall network when compared to standard AODV Routing. Figure 1 gives the proposed Data Flow Diagram of IEEE-AODV.

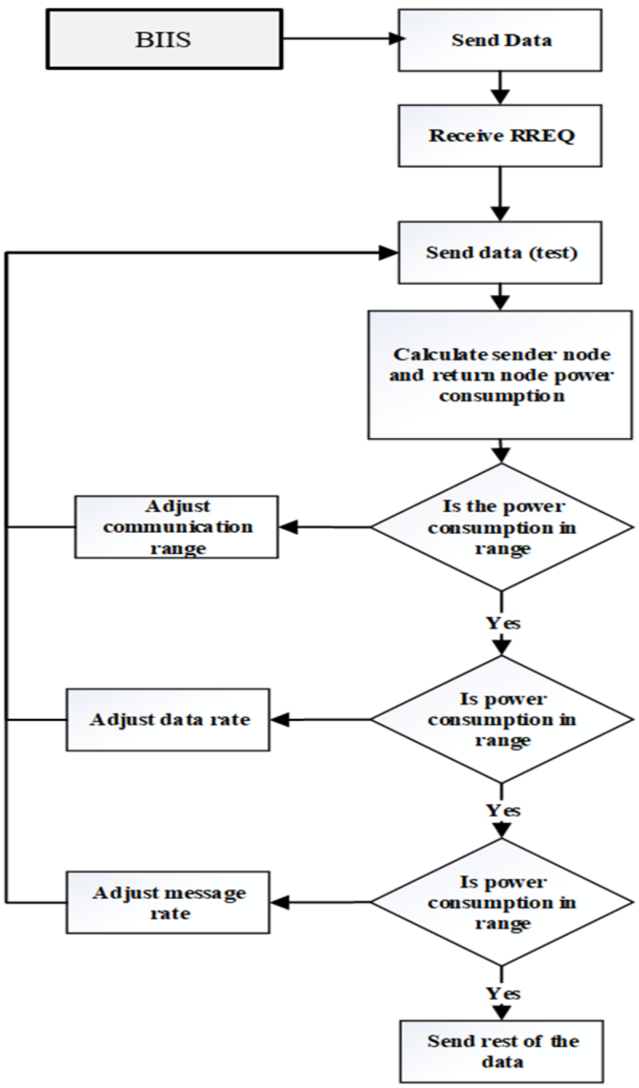

Figure 1 Proposed Data Flow Diagram of IEEE-AODV

Intelligent Energy Efficient Enhanced AODV (IEEE-AODV) mainly identifies the malicious Black-hole nodes before the data transmission. A black-hole Attack is a common attack in MANET that degrades the performance of MANET. A black-hole attack is one in which the malicious node acts as the intermediate node between source and destination. It claims itself as the shortest path to the destination and tries to get all packets to pass through it. So for reliable transmission of packets and to improve throughput black-hole nodes should be detected and it should not be in the part of routing. Here Figure 2 represents the black-hole Identification and Ignorance scheme (BIIS) which is implemented in the routing protocol to provide security and to improve the capacity of the network. BIIS will block list that malicious nodes and it will be updated in the routing table. So in the route discovery process, those nodes will not be taken as intermediate or it may take an alternate path. During the route discovery process Route Request RREQ packet is broadcasted by the source node and it will be received by a neighboring node then the Route Reply RREP packet will be receiving. BIIS will check each node's RREQ. If the number of Route requests sent by the node is less than the number of RREP given it will then check the trust value of the node given by the Neighbors. If the trust value is less than the threshold value which is given one as the value, then the node is found to be a malicious black-hole node. The optimum Power Consumption Range is 0.15W to 0.6W for the network.

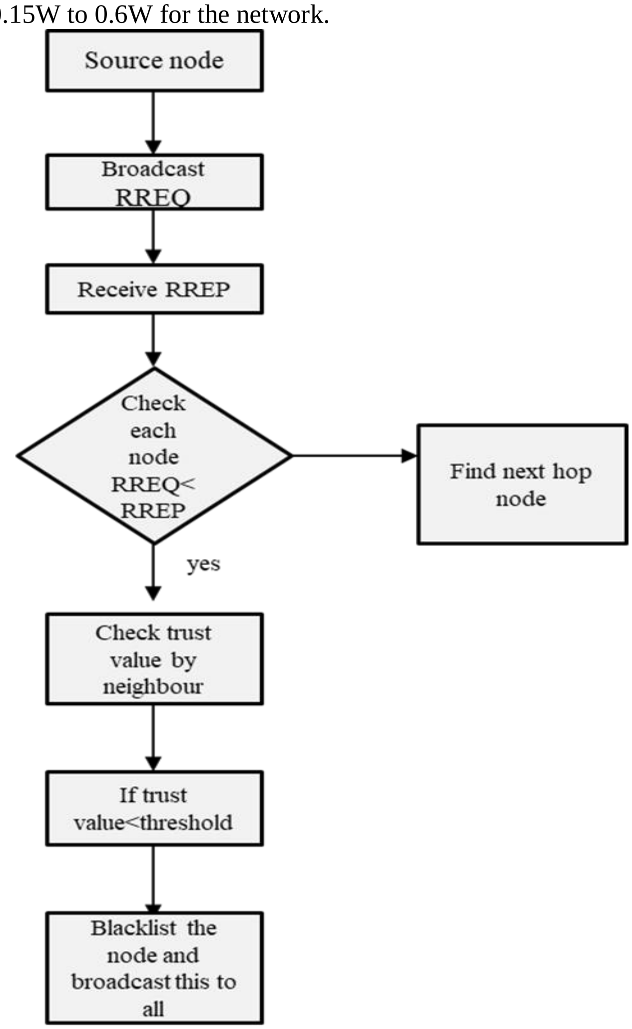

Figure 2 Black-Hole Identification and Ignorance Scheme (BIIS)

Algorithm 1 describes the reduced power consumption by optimizing the three important parameters Data Rate, Communication Range, Message size hence the name DCM Algorithm.

Step 1: Send Data

Step 2: Receive RREQ

Step 3: Send test data.

Step 4: Calculate Sender node and return node power consumption

Step 5: Check if power consumption is in range

if not

Adjust Communication range

Repeat step 3

Step 6: Check if the power consumption is in range

if not

Adjust Data rate

Repeat step 3

Step 7: Check if the power consumption is in range

if not

Adjust Message size

Repeat Step 3

Step 8: Send the rest of the data

Algorithm 1 DCM Algorithm for AODV to Reduce Power Consumption

Algorithm 2 describes the improvement of throughput by optimizing the three important parameters Data Rate, Communication Range, Message size. The optimum communication range is 10m-500m. The threshold value of throughput is 10Kbps.

Step 1: Send Data

Step 2: Check whether routes are available in routing Table

If the route is available

Check for node reachability

else

Start route discovery process

Step 3: Check node path is reachable in the route

if not

Start route discovery process

Step 4: Find an alternate path for destination in case of mobile nodes

Step 5: Receive Route reply packet (RREP)

Step 6: Send data and record the starting time &time for getting acknowledgment

Step 7: Calculate the data rate

Step 8: Check the communication range is optimum

if not

Increase the range

Step 9: Send test packet and calculate the throughput

Step 10: Check the throughput value is less than the threshold

if yes

Repeat step 6

else

Continue sending the data.

Algorithm 2 DCM Algorithm for AODV to Improve Throughput

3.2. Mathematical Model

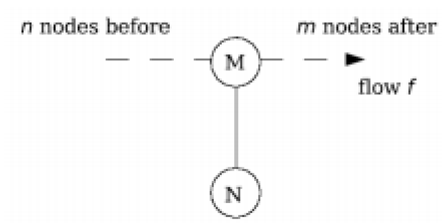

Figure 3 Effect of Mobility of Nodes

The required power level could be a performance of the following parameters: distance to its meant receiver, neighbors' distance (because we wish to reduce the interference), receiver's quality, and finally the remaining power level.

We have the subsequent generic equation:

$$P = \alpha D + \beta M + \varepsilon \sum_{i=1}^{N} Di + \gamma R$$

Where: $\alpha, \beta, \varepsilon, \gamma$ are weighting factors.

(1)

D: Distance between transmitting and receiving node.

M: quality functions of a receiving node. This represents mobility in terms of its rate and direction.

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Di: Distance to transmitting node neighbors.

R: Residual Energy level of the transmitting node.

The decay of signal can be explained by the mathematical model using this equation

$$P_R(d) = \frac{P_T}{d^{\alpha}} \qquad (2)$$

Figure 3 represents the effect of node on another node and describes about the mobility nature of the node. To adapt to the nature of mobile nodes, quality and mobility prediction mechanisms shall be embedded into the power management formula.

3.3. Simulation Environment

A network model is created which represents MANET and is simulated in OMNeT ++ (Optical Modelling Network using the C++ programming language) tool. This tool provides the public source with an open architecture for academic, educational, and research for the simulation of computer networks. OMNeT++ tools are used for modeling communication networks. First, the simulation is performed with the Standard AODV routing protocol. Then the designed DCM algorithm is used to enhance the standard AODV routing to implement Energy Efficient Routing and it controls the power consumption of the network and going to improve Throughput, Efficiency, and reduces packet loss. Thus the designed Algorithm will help to maximize the capacity of MANET. Important aspect mobility of the node is also considered in this design. Whenever a new node joins or leaves the network the network topology changes. MANETS are highly dynamic so the ability of this network to overcome the changes or failure of any node can be called Route Resilience. This aspect also considers in the design part to improve the throughput of the network.

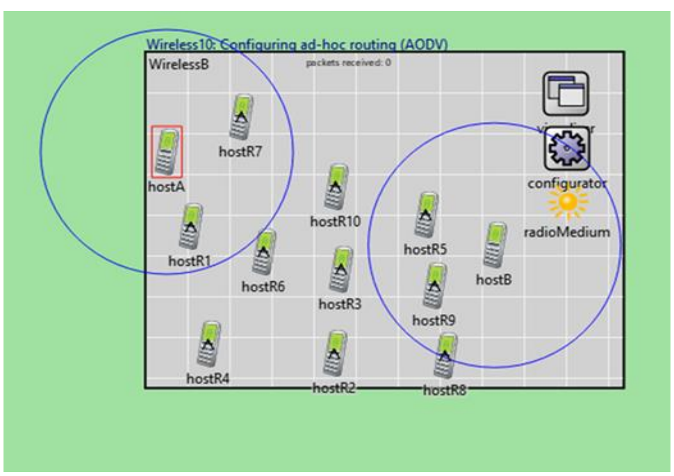

Figure 4 Designed MANET Configuration

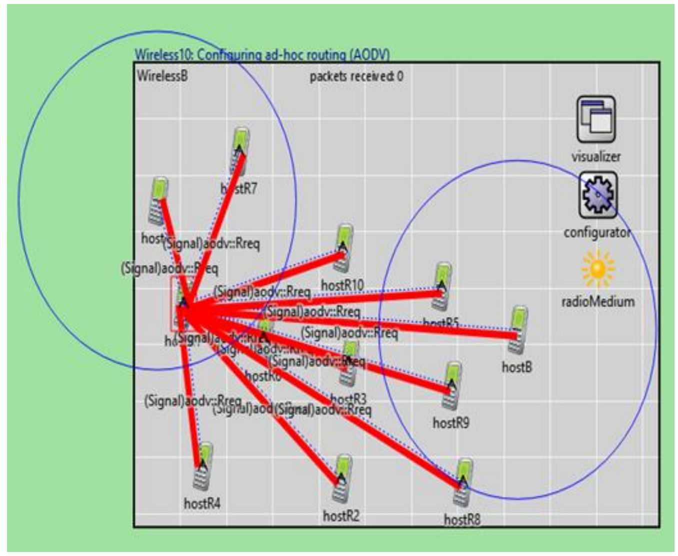

Figure 5 Route Request Packet

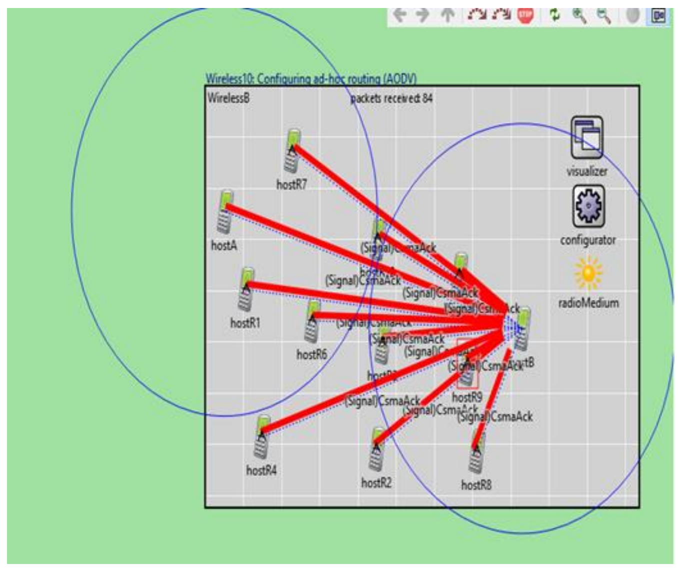

Figure 6 Route Reply Packet

This Enhanced version of AODV using the designed DCM algorithm is called Intelligent Energy Efficient Enhanced-AODV (IEEE-AODV) which improves throughput and reduces the power consumption when compared with standard AODV Routing. The network model consists of two hosts and one acts as a source node and another one as a destination node. It consists of ten intermediate nodes which act as a router as well. This network is designed with mobility as one of the important parameters and these nodes are free to move randomly as the nature of MANET. The configuration of MANET is shown in Figure 4. The same configuration is simulated for Standard AODV Routing protocol and as an Enhanced Network using the designed algorithm.

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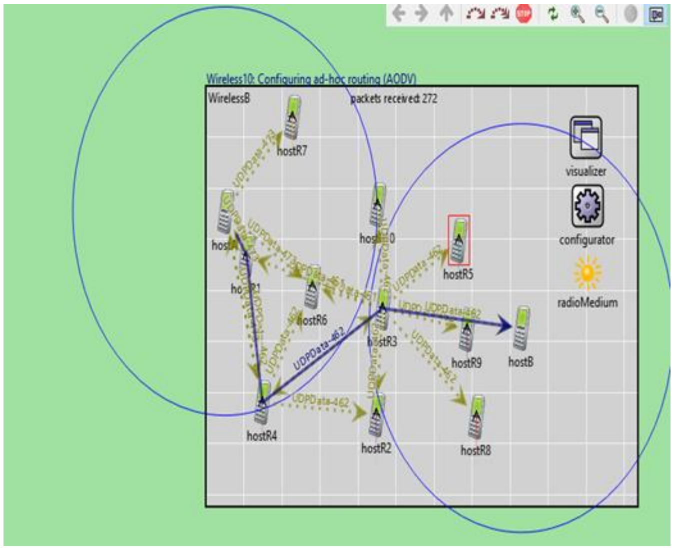

Figure 7 Communication Path

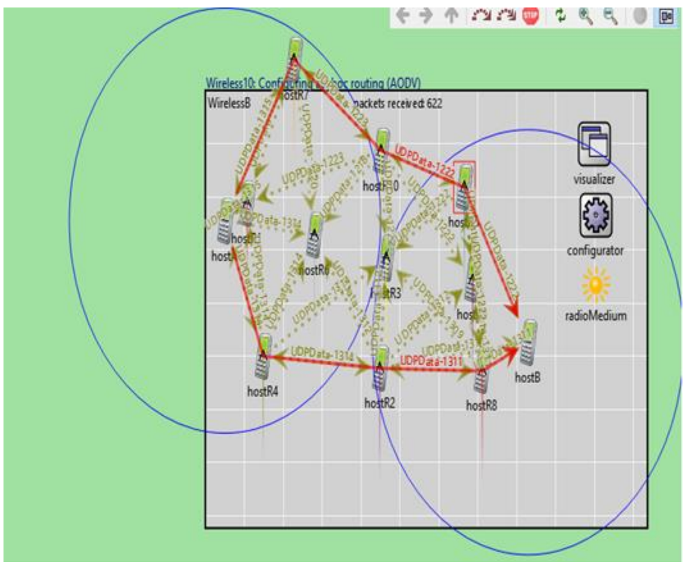

Figure 8 Data Transfer in the Form of Packets

The route has to be established between the source node and destination node using intermediate nodes as a hop. So to find the path and establish the communication between source and destination node first Route discovery process will start. So source will send Route Request (RREQ) packet to all nodes and get the path through Route Reply (RREP) packet as shown in Figures 5 and 6. once the optimal path has been found out and communication will start. The route discovery process will find the shortest path and starts the communication as shown in Figure 7 and Figure 8.

4. RESULTS AND DISCUSSION

This section discusses the results got by simulating various Parameters for MANET as shown in table 1. The DCM parameters are varied and observed for different values. The observation is done and obtained results are compared with standard AODV and IEEE-AODV.

4.1. Throughput Values and Comparison

The throughput values are determined by four different variables. Message Size, Data Rate, Communication Range, and Queue Cap.

S.No	Parameters	Va1ues
1.	Channe1	Wire1ess
2.	Propagation	Two Ray Ground
3.	Physical Medium	Wireless
4.	MAC type	802.11, CSMA CA MAC
5.	Queue capacity	50 and 80
6.	Antenna	Omni
7.	Antenna Gain	3 dB
7.	Number of Nodes	12
8.	Routing Protoco1	AODV, IEEE-AODV
9.	Time simulation	20 sec
10.	Packet size	780
11.	Message Size	100B, 200B, 500B, and 1000B
12.	Data Rate	1MBPS and 2MBPS
13.	Communication Range	300m and 500m

Table 1 Simulation Parameters

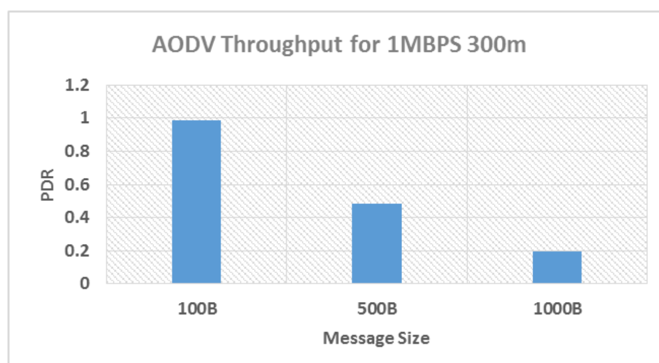

Figure 9 AODV Throughput for Different Message Sizes with 1MBPS and 300m Communication Range

In AODV Implementation we found that throughput is decreasing when the message size is increasing the results are shown in Figure 9 for 1MBPS data rate and 300 m range. The graphs (Figures 10 and Figure 11) clearly show that the throughput is increasing for increasing message size in enhanced networks. Throughput is directly proportional to message size. If the message size increases, the information to be transmitted in many packets will easily fit into the same

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data packet, making it easy for the transmission, thereby increasing the throughput (represented as packets received/packets sent ratio). Thus the number of packets received in a given time increases, the packet loss is decreased so the overall efficiency of the network and the packet delivery ratio increases.

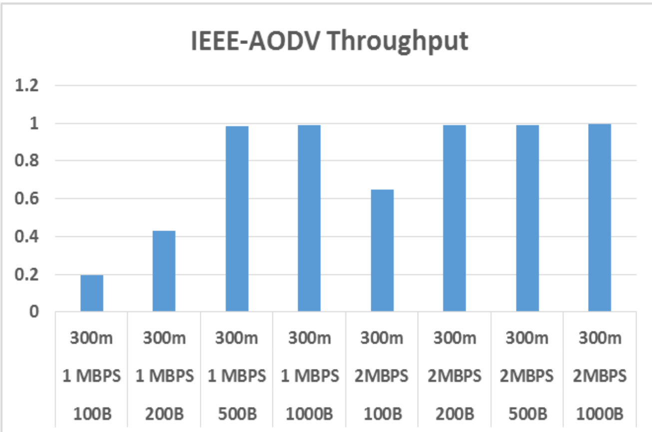

Figure 10 Throughput Comparison for Different Message Sizes, Data Rate 1MBPS and 2MBPS, and Communication Range of 300m

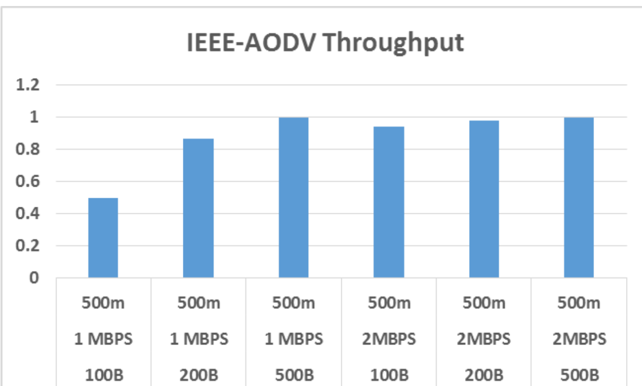

Figure 11 Throughput Comparison for Different Message Sizes, Data Rate 1MBPS and 2MBPS, and Communication Range of 500m

4.2. Power Consumption Comparison

The power consumption values for different packet sizes, data rates, and communication ranges have been tested using the simulation software, and these values were measured for both default and enhanced networks. The data size of 10B, 100B, and 1000B were tested with a data rate of 1 MBPS and 2MBPS for a communication range of 10 meters. The power consumption for different data sizes and data rates for different nodes (R1 to R5) is shown in Figures 12 and Figure 13. The graphs were plotted to compare the default (AODV) and enhanced network (IEEE-AODV) for different nodes (R6 to R10) as shown in Figures 14 and Figure 15. The graphs (Figures 16 and Figure 17) also show the comparison of total power consumption for both 1MBPS and 2MBPS data rates.

It is also clearly shown that there is a significant decrease in power consumption when AODV and IEEE-AODV are considered. The power consumption is found to be increasing for the increase in the message size because more power is required to transmit the data packets. Three message sizes, 10B, 100B, and 1000B, are considered in this comparison. The graphs show that the comparison of two parameters message size and the power consumption at different receiver nodes are combined. Power consumption is directly proportional to message size.

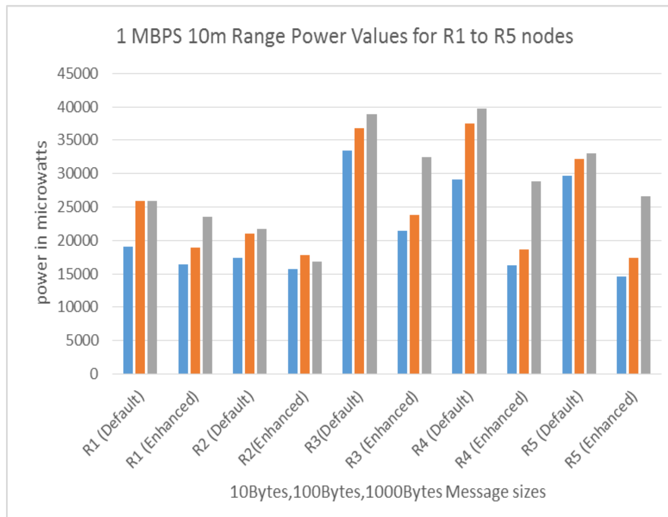

Figure 12 Power Values Comparison for R1 to R5 Channels for 1MBPS 10m Range

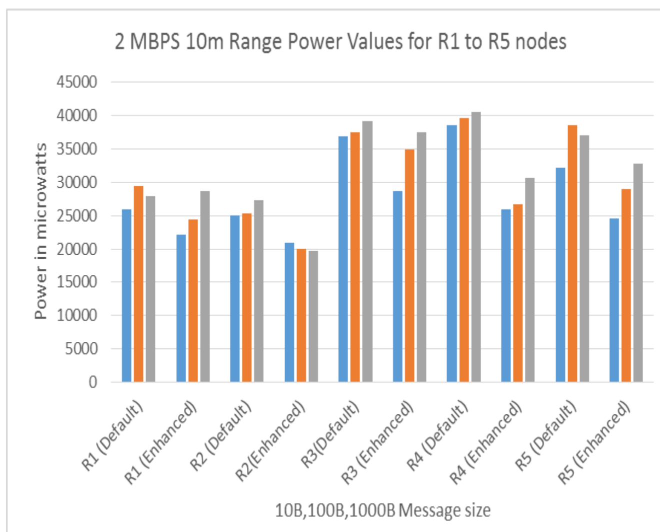

Figure 13 Power Values Comparison for R1 to R5 Channels for 2MBPS 10m Range

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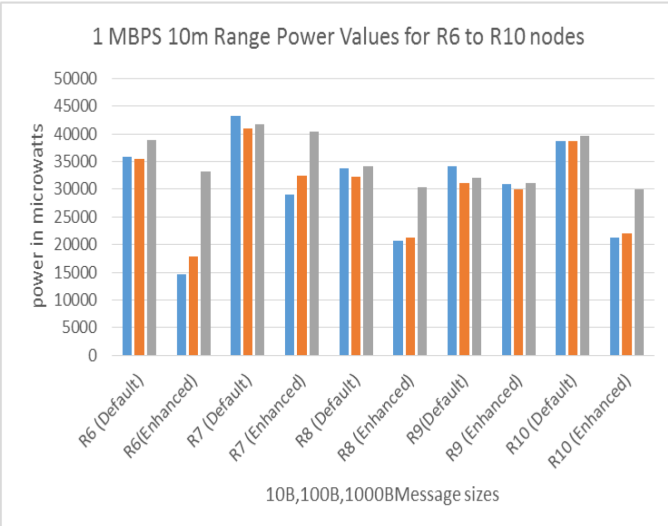

Figure 14 Power Values Comparison for R6 to R10 Channels for 1MBPS 10m Range

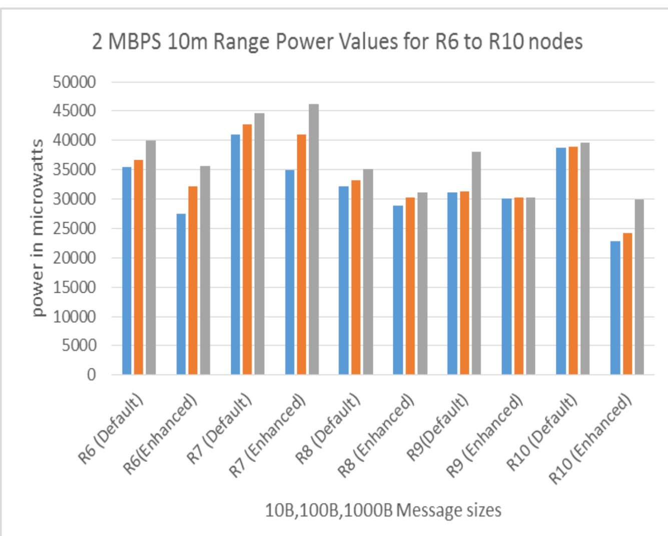

Figure 15 Power Values Comparison for R6 to R10 Channels for 2MBPS 10m Range

Figures 16 show the comparison of total power consumption for both AODV and IEEE -AODV for 1 MBPS data transfer rate and different message size 10B, 100B, and 1000B with a 10m communication range. Figure 17 shows a comparison as stated above for the 2MBPS data rate. Figures 18 and Figure 19 represent the IEEE-AODV power consumption at the sender and receiver nodes for different data rates. The Power consumption improvement of IEEE-AODV for 10B, 100B, and 1000B for 1MBPS data rate, and 10m communication range, when compared to AODV, is 65.78%, 70.82%, and 84.06% respectively. The Power consumption improvement of IEEE-AODV for 10B, 100B, and 1000B for 2MBPS data rate, and 10m communication range compared to AODV is 80.85%, 84.14%, and 86.14% respectively. The power consumption and residual energy for AODV and IEEE-AODV are compared and it is shown in Figures 20 and Figure 21.

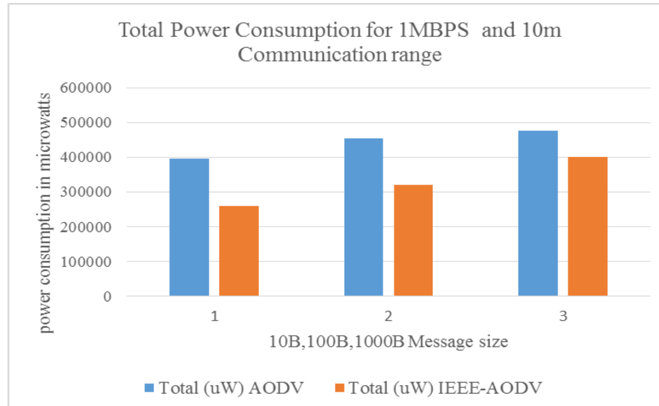

Figure 16 Total Power Consumption for Different Sizes (10B, 100B, and 1000B) and 1MBPS

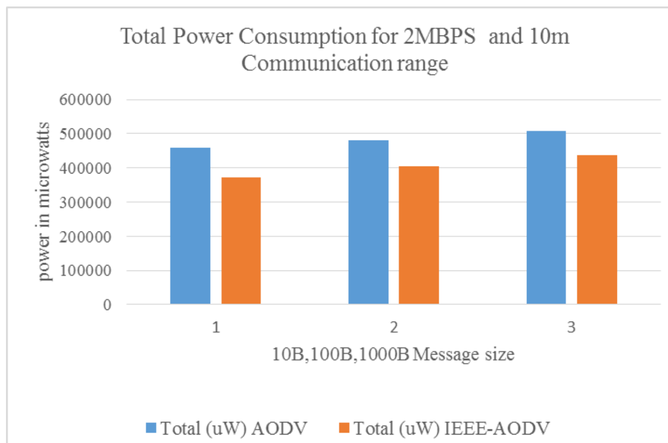

Figure 17 Total Power Consumption for Different Sizes (10B, 100B, and 1000B) and 2MBPS

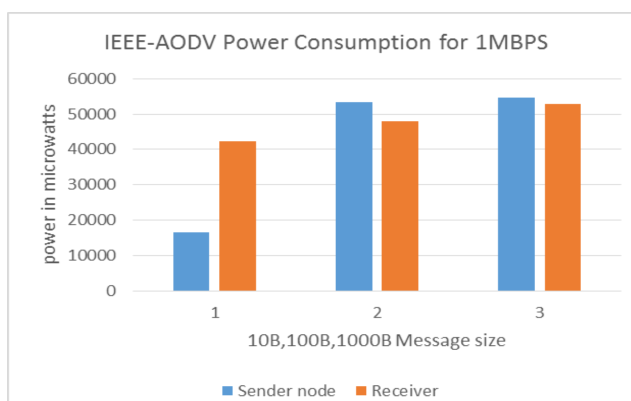

Figure 18 Power Consumption Comparison for the Sender and Receiver Node for Different Sizes (10B, 100B, and 1000B) and 1MBPS for 10m Communication Range

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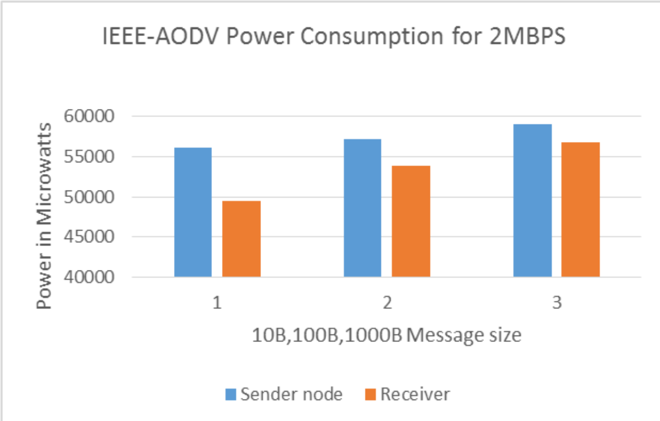

Figure 19 Power Consumption Comparison for the Sender and Receiver Node for Different Sizes (10B, 100B, and 1000B) and 2MBPS for 10m Communication Range

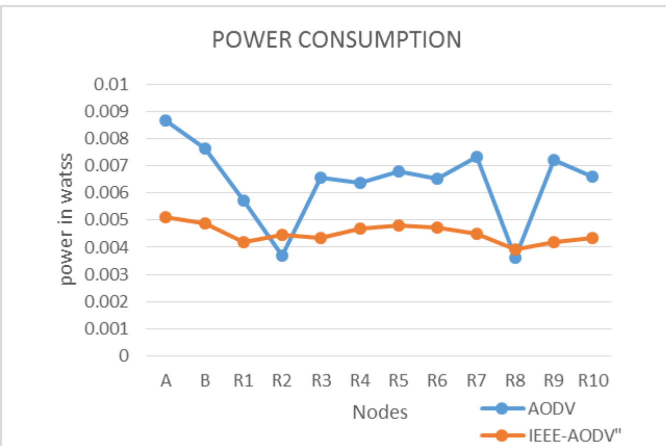

Figure 20 Power Consumption Comparison for AODV and Enhanced AODV

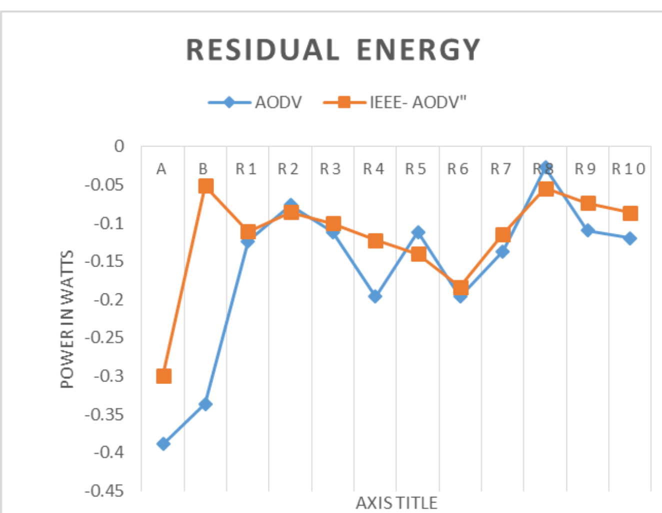

Figure 21 Residual Energy Comparison for AODV and Enhanced AODV

Residual energy is the energy that is remaining after the operation in the node. It gives the amount of energy saved in the network. IEEE-AODV is found to have more residual energy compared to AODV up to 77% improvement. The power consumption comparison between AODV and IEEE-AODV is plotted as graph for different message sizes and with 1MBPS and 2MBPS data rate with various communication ranges such as 10m in Figure 22, 300m range in Figure 23 and 500M communication range in Figure 24.

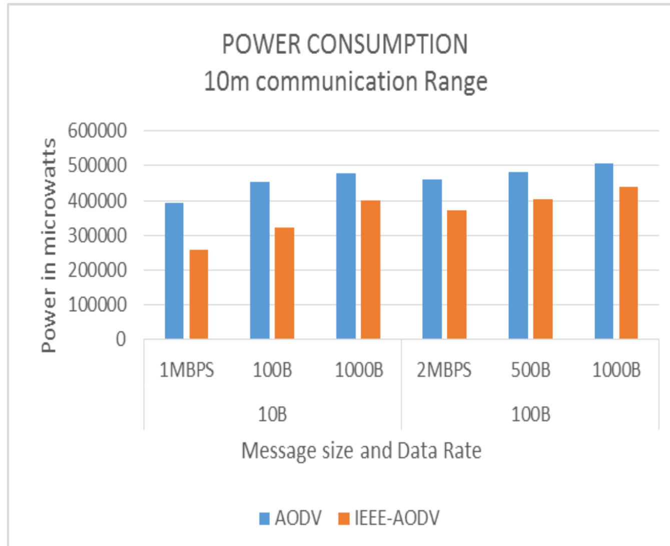

Figure 22 Power Consumption Comparison for AODV and Enhanced AODV with Different Message Sizes and Data Rate for 10 m Communication Range

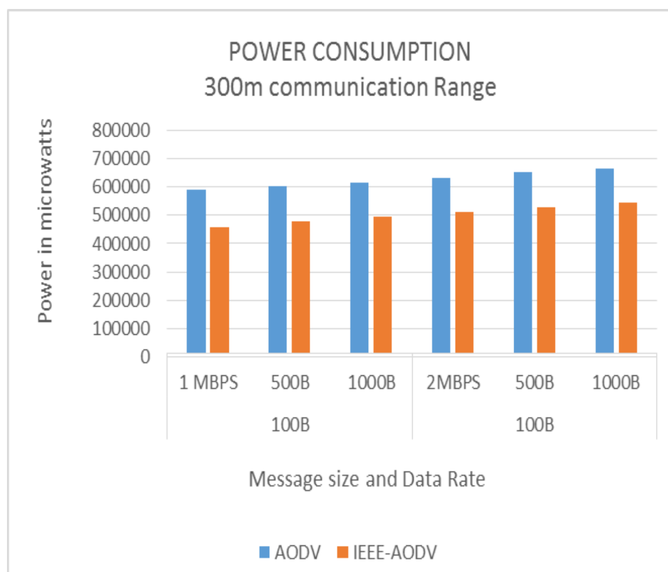

Figure 23 Power Consumption Comparison for AODV and Enhanced AODV with Different Message Sizes and Data Rate for 300m Communication Range

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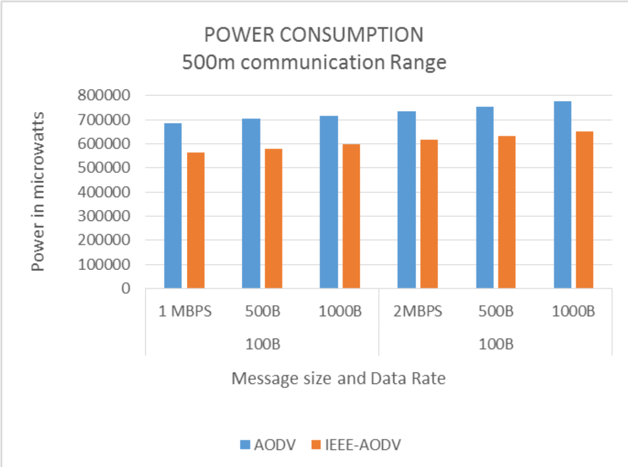

Figure 24 Power Consumption Comparison for AODV and Enhanced AODV with Different Message Sizes and Data Rate for 10 m Communication Range

5. CONCLUSION

Among the popular routing protocols, AODV has a special mention in the literature due to its robustness and flexibility. Literature studies have shown that there are many ways in which AODV could be enhanced. The solutions proposed in the literature have considered various characteristics of the protocol and compared with other solutions. This project, however, considered the parameters of power consumption and throughput and enhanced the standard protocol. The results were simulated, and the results with significant when compared to characteristics of the standard/default AODV algorithm. The optimum value power range for the overall network is 0.15W to 0.6W so the enhanced Algorithm check the power consumption is in range or not and it reduces the power consumption if the network consumes more power. There are huge improvements in throughput from 19% of AODV to 99% IEEE-AODV for optimized DCM Values and many reductions in power consumption by the designed IEEE-AODV algorithm and able to reduce up to 86% to that of standard AODV. In future work security and authentication can be employed in the designed algorithm.

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How to cite this article:

Deepika J, Rangaiah L, Jeyabalan S, "A DCM Algorithm for AODV to Implement Energy Efficient Routing in MANET with Capacity Maximization", International Journal of Computer Networks and Applications (IJCNA), 8(5), PP: 607-618, 2021, DOI: 10.22247/ijcna/2021/209991.