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Research paper

Power-load aware multipath routing protocols for MANET

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Abstract

The Mobile Ad Hoc Network (MANET) is a group of Wireless Mobile Nodes with restricted Power Supply that dynamically form a temporary network and can communicate each other without the support of any established infrastructure. It was noticed that the routing is one of the major challenges in MANET due to the mobility nature. This research work has identified recently proposed two Routing Techniques namely i. Fitness Function based Ad Hoc On Demand Multipath Distance Vector Routing Protocol (FF-AOMDV) and Secure Three Fish Distributed Routing (STFDR). These two techniques were implemented and studied thoroughly in terms of Throughput, Dropping rate, Packet Delivery Ratio, Packet Loss Ratio, Energy Consumption and End-to-End delay. The experimental results clearly demonstrate that the FF-AOMDV outperformed when compare with STFDR under major network per-formance parameters. This Research Work noticed that the FF-AOMDV unable to address Power Dissipation that leads link failure. This minimizes the life time of the MANET. This work proposed an efficient Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) to address the above-mentioned issue. The PLA-AOMDV is designed and implemented in QualNet 6.1 and results were studied thoroughly in terms of Throughput, Packet Dropping Rate, Routing Overhead, Energy Consumption, End-to-End De-lay, Life Time (Dead Nodes Count). From the experimental results, it was established that the proposed Power-Load Aware Multi-Path Routing Protocol (PLA-AOMDV) is performing well as compared with that of the existing FF-AOMDV.

Keywords: *Energy Consumption; Power Aware; Load Aware; Routing Overhead; Energy Efficient Protocol; Fitness Function; FF-AOMDV; MANET; Multipath Routing; PLA-AOMDV.*

1. Introduction

Mobile Ad Hoc Networks (MANET) is an Autonomous System with a group of Mobile Nodes without any support of Infrastructure. The Routing Protocols for MANETs are classified into Table-Driven and On-Demand Driven based on the timing when routes are updated. In Table-Driven Routing, it maintain consistent. It will forward up-to-date routing information to every other node in the network. Because of dynamism in routing, low and high quality links, change of radio channels, failure of node and the currently using route becomes invalid. Due to this new route need to be discovered which creates delay. To overcome this problem MANET [1], [3-5] introduce On-Demand Routing which identified Multiple Path between source to destination in a single route discovery.

In the recent years, many researchers have focused to contribute for the Multipath Routing. Some of the well-known and standard multipath routing protocols are AODVM [1-32], AOMDV [1], [33], SMR [1,34] and MSR [1,35]. The major design issue is dynamic energy consumption of multipath routing. To address this purpose, several Power-Aware and Energy-Efficient Multipath Routing Protocols were proposed [1-5].

Power-Aware Routing Protocols are dealing with a few smart approaches which reduced the energy consumption of the batteries of the mobile nodes. These schemes were performed by forwarding Packets through various Sensor Nodes those have higher Energy levels. This is considered as one of the best techniques that will maximize network lifetime.

From the literature survey, it was noticed that the Power-Aware Node-disjoint Multipath Source Routing (PNDMSR)[1,5] Protocol is different in the way approach for finding energy aware node-disjoint multipath from source to destination and noted that this model uses low overhead broadcast mechanism to optimize the overhead in different scenario.

From the literature survey, it was noticed that the Multipath routing protocols flood a route request packet to understand more possible routes to the destination which is used to forward packets between Source and Destination. It was understanding that the Multipath routing protocols have several issues such as Route Discovery and Maintenance, Disjoint Route, Route Selection, Route Failure, Bandwidth Allocation, Throughput, Power Consumption, End-to-End Delay and etc.

In this research paper, the FF-AOMDV Routing Protocol was enhanced by adding an efficient procedure for Power Aware and Load Aware Routing. That is the proposed Protocol is made to make intelligent decision to discover best optimal paths between source node and required destination node. The achievement of the proposed Protocol is to avoid nodes that have less than 25% of residual energy to participate route discovery processes. This will save Nodes' and Network power as well as long as possible.

The rest of this research paper is arranged as follows. Section 2 describes the features and methodologies of the existing Ad-Hoc On demand Multipath Distance Victor with the Fitness Function (FF-AOMDV). Section 3 defines the novelty of the Proposed Multipath Routing Protocol, Power-Load Aware Multipath Routing Protocol (PLA-AOMDV). Results of the proposed model are discussed and

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analyzed Section 4 and Section 5 delivers the conclusion of this research paper.

2. Ad-Hoc on demand multipath distance victor with the fitness function (FF-AOMDV)

The Ad-Hoc On-Demand Distance Vector (AODV) Routing Protocol is one the best Single-Path Routing Protocols and the Ad-Hoc On-Demand Multipath Distance Vector (AOMDV) [1], [4], [5] Routing Protocol is one the best Multi Protocols.
The Multipath AOMDV Routing Protocol is used to discover more possible paths with its efficient Path Discovery Process between the source and the destination.

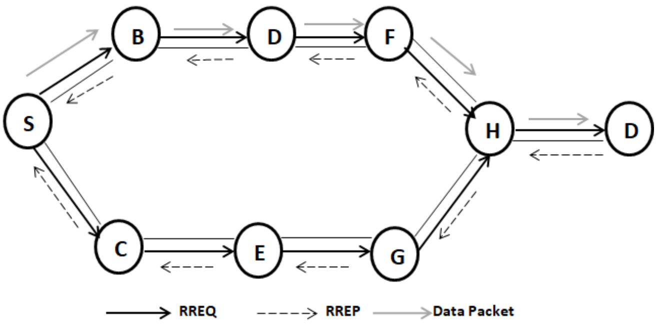

Fig. 1: Handling Duplicate Message by FF-AOMDV.

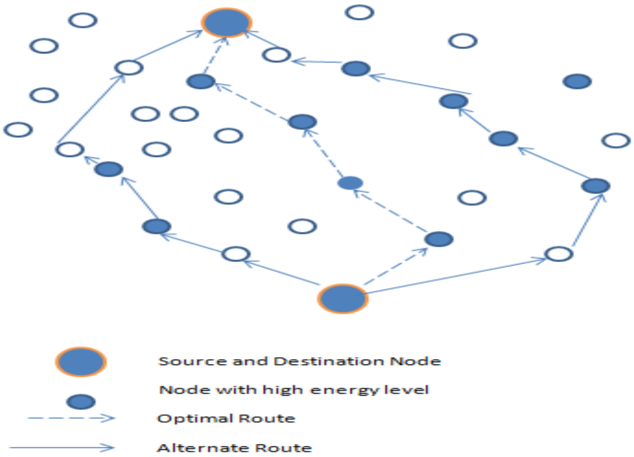

Fig. 2: Optimal Route Selection of FF-AOMDV.

As shown in the Fig.1, the Node S sends the RREQ to find the best path to its destination. The Node H was receiving the duplicate Propagation of Request (RREQ) message. This Node did not discard the duplicate message though it is duplicated one because the duplicated message was reserved and used for another path. That is without using Propagation of Request (RREQ) message, this protocol can establish a new connection. That is the reason why, it is maintaining multiple copies of Propagation of Request (RREQ) messages to understand all other possible Routes. This is one of the strengths of AOMDV.
Ad-Hoc On demand Multipath Distance Victor with the Fitness Function (FF-AOMDV) is a Multipath Routing Protocol which has the combination of Fitness Function and the AOMDV's Protocol. But in FF-AOMDV it uses an algorithm which performs Route Selection in different methodology. As discussed before in Fig. 2, when a RREQ is broadcast and received, the source node will use three types of information in order to find the Optimized and shortest route with minimal energy consumption. If all routes to the destination are failed then like other multipath routing protocols, this protocol will also initiates new route discovery process. Less distance to destination will consume less energy and it is called optimal route and it can be calculated as follows

$$\text{Optimal Router} = \frac{\sum v(n) \in r_{ene}(v(n))}{\sum v \in V_{ene}(v)} \qquad (1)$$

The FF-AOMDV implements the same techniques after selecting the route with the highest energy level least distance which is available in the routing. The calculation of the shortest route is as follows:

$$\text{Optimal Router} = \frac{\sum e(n) \in r_{edist}(e(n))}{\sum e \in E} \qquad (2)$$

Where e represents the edges (links) in the optimum route r and E represent all the edges in the network.
To have a better understanding of how the Fitness Function works with AOMDV Routing Protocol, the Fig. 2 shows the Route Selection of FF-AOMDV based on specific parameters. The FF-AOMDV start broadcasting a RREQ in order to collect information regarding the optimal routes towards the destination as shown in Fig. 2 and the Fitness Function performs a scan on the network in order to find nodes that have a greater energy level (blue nodes). The best route will specify the route that has the less distance and highest energy level. The discontinuous arrow will specify the Priority energy level, as seen on the route with the (Fig. 1 and Fig. 2).
The Flowchart which was drawn to demonstrate how this AOMDV is Functioning and it is also used for evaluating the FF-AOMDV. This is one of the Reactive Multi Path Protocol. The Routing Entries in this AOMDV Protocol consists of alternate next-hops loops with the help of Advertised Hop Count to identify maximum possible paths.
It consists of two components namely as demonstrated in the Fig. 3.

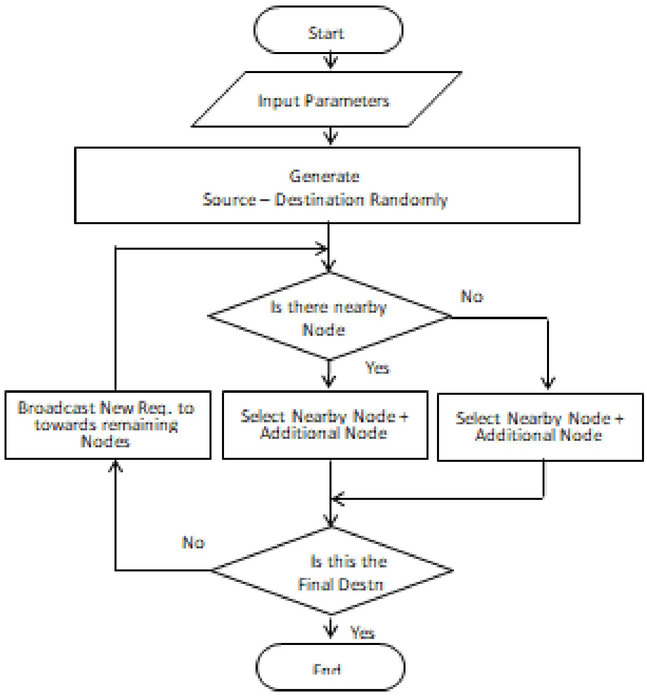

Fig. 3: Flowchart of FF-AOMDV (Optimal Route Selection).

- Maintaining Multiple Loop-Free Paths for Sources and Destinations
- To Avoid Multiple Broadcast
- Maintaining Multiple Link Disjoints Paths
- This is used to identify all possible paths and its counts of Hops. The Advertised Hop Count was used for this purpose
- It will help Network to select one of the paths to avoid common Nodes that will help to select unique disjoint paths

Even though the FF-AOMDV is finding and selecting best path for communication, it unable to address Power Dissipation. This is the major issue, and this is leading to link failure. We know that the Link Failure will minimize the life time of the MANET System. To address the above mentioned issue, this Research Paper proposed an efficient Power-Load Aware Multipath Routing Protocol (PLA-

AOMDV) which is discussed and described the strengths of the proposed model in the following section.

3. Power-load aware multipath routing protocol (PLA-AOMDV)

As discussed at the above section, FF-AOMDV discovers and selects best path for communication. However, it unable to address Power Dissipation causes link failure. To address this major issue this Research work proposed an efficient Power-Load Aware Multipath Routing Protocol (PLA-AOMDV).
Many Multipath Routing Protocols were designed to select the Paths with relatively less number of Nodes and Hops to frame Shortest Path for possible communication. As it is the repeated process to find shortest path for each and every communication, the battery will be overloaded and Energy of those will be depleted causes Node Failure and Network Partition as well. Thus needed balanced Power-Load distribution is mandatory to maximize network Lifetime.
Thus, this research work enhanced the existing Ad-Hoc On demand Multipath Distance Victor with the Fitness Function (FF-AOMDV) by modifying the structure of Propagation of Request (RREQ) message.

3.1. Cost function, route discovery and route selection

The prime objective of this proposed model is to identify various Optimal Paths with sufficient Power and Bandwidth as well. This procedure does not focus only shortest path. It will find shortest routes at the cost of both Residual Energy and Load of the Node concern as well.
The proposed Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) was designed by adding a few features to Ad-Hoc On demand Multipath Distance Victor (AOMDV). The proposed Routing Protocol consists of Composite Power-Aware Routing and Scheduling Procedure to facilitate Power-Load Aware routing to maximize Network Lifetime.

3.1.1. Cost function

The proposed Cost Function is considering both Residual Energy of a Node and incoming Traffic Rate as well. The estimation of Traffic Rate is revealed that it is directly proportional to the effect of Energy Consumption.
The cost function is designed to measure the cost of both i. Bottlenecked Intermediate Node Cost ie Path Maximum Cost ($Cost_{Max}$) and ii. Intermediate Nodes Costs of a path ($Cost_{Path}$).

Path Maximum Cost is measured as

$$C(P_i) = \max_{j=1} F(C_j(t)) \qquad (3)$$

Path Total Cost between Intermediate Nodes is measured as

$$C(P_i) = \sum_{j=1}^{m} F(C_j\ (t)) \qquad (4)$$

The above two Equations is helping to measure Energy Costs and Load as well between Source and Destination. Based on the inputs, the Route will be discovered and selected for communication.
This model is maximizing the performance of a Sensor Networks in terms of Lifetime, Throughput, Delay and Power Consumption. The Nodes will be selected for making route by this proposed model through Scheduler as follows.

3.1.1.1. Node selection for route discovery

The proposed Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) is managing and nominating Nodes to discover and select optimal routes with the following Energy Level of Nodes.

- If ELevel > 60% of Actual Level, Nodes considered as Normal Status for path selection
- If ELevel ≤ 60 % && ELevel > 25 % of Actual Level, Nodes considered as Warn Status for path selection
- If ELevel ≤ 25% of Actual Level, Nodes considered as Dancer Status and these Nodes will not be considered for Path selection

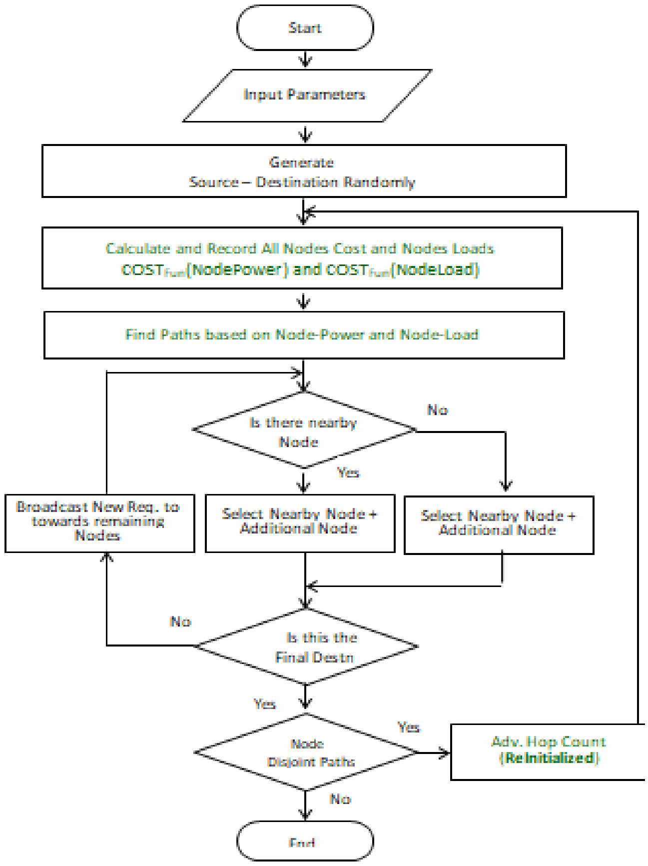

Fig. 4: Flowchart of Proposed PLA-AOMDV (Best Route Selection).

3.1.2. Route discovery and route selection

As discussed earlier, a Node if needed to communicate any other Node, it will request Routing Protocol to establish a optimal route for possible communication, the proposed model will search the setup to find the best possible routes in terms of Nodes' Energy and Load as well which is shown in the Fig.4.
As shown and discussed in the Section 3.1, the Cost Function for measuring Nodes Residual Energy $COST_{FUN}$(NodePower) and Nodes Load $COST_{FUN}$(NodeLoad) will be executed to discover route which is shown in the Fig. 4.

3.1.2.1. Route discovery process

The Format and Structure of Route Request Packet (RREQ) is modified with the Control Packets such as Route Request Packet (RREQ) , Route Reply Packet (RREP), Route Error (RERR), Route Request Table (RRT).
The Procedure of Route Discovery will be executed by broadcasting Route Request Packet (RREQ) on the created Sensor Network. This Route Request Packet (RREQ) message will be received by neighbour Nodes and these Nodes will broadcast again till the required destination Node receives.
Once the destination Node receives Route Request Packet (RREQ), it will reply to Source by broadcasting Route Reply Packet (RREP). When source Nodes receives Route Reply Packet (RREP), the Route Discovery Process will be terminated and Packets will be forwarded.

4. Result and discussion

The performance efficiency of the proposed Routing Protocol, Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) is carried out. It is studied the Power Efficiency of the proposed Model with Low Load and Heavy Load as well. Simulations are conducted in QualNet 6.1 and integrated with VC++ tool for creating APP (batch file) for the proposed PLA-AOMDV. In this simulation, the script has been coded to define the network parameters and topology, such as Traffic Source, Number of Nodes, Queue Size, Node Speed, FF-AOMDV APP Batch Code, PLA-AOMDV APP Batch Code and many other parameters.
The Simulation Area 500 X 500 m^2 is created with 75 Nodes. The different Packet Rates like 512 KBPS and 1024 MBPS are assigned with Static as well Dynamic Networks. It is also specified the Transmitted signal power 0.38 W, Transmission range 250 m, Initial energy of Node 200 J, Transmitting Power 1.4 W and Receiving power 1.0 W. We used our Queue Management Scheme called Fuzzy DSRED.

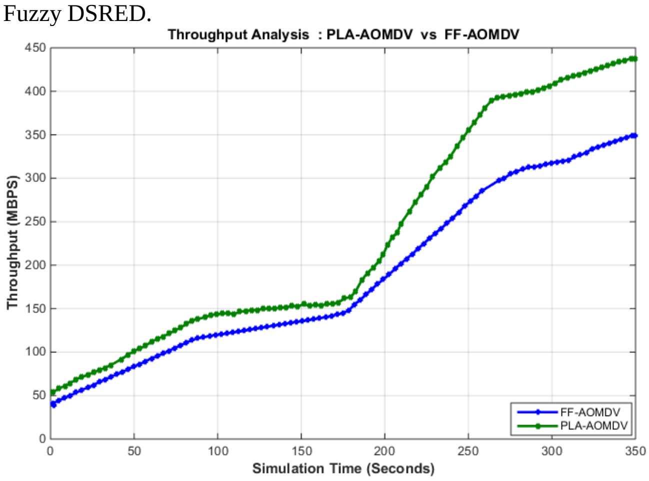

Fig. 4: Throughput Analysis of the Proposed PLA-AOMDV.

The Protocols CBR, TCP and UDP are used to analysis the proposed protocol. To study the proposed Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) thoroughly, the Packet Rate and Packet Size is changed when repeating experiments.
The proposed model is implemented in QualNet 6.1 and studied thoroughly. The experimental results were shown from the Figures Fig. 5 to Fig. 9.

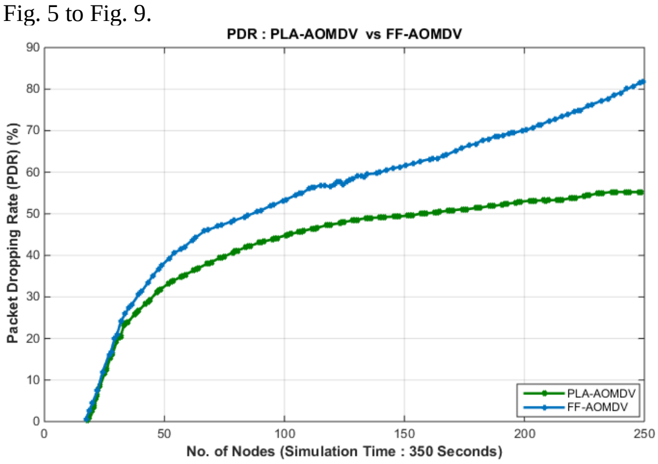

Fig. 5: Packet Dropping Rate Analysis of the Proposed PLA-AOMDV.

As shown in the Fig. 4, it is clearly noticed that the proposed Routing Protocol PLA-AOMDV is outperforming the existing FF-AOMDV in term of Throughput. This is happened because the proposed model achieves Fairness and it considerably reduced Link Failure which helps for more Throughput. Thus, the proposed Multipath Routing Protocol achieves better Packet Dropping Rate also which is shown in the Fig. 5.
As the proposed PLA-AOMDV Routing Protocol maintains Load balancing scenario, the Link Failure is reduced that help to minimize Partitioning and Rerouting when experiments were carried out. This encourages output in terms of Routing Overhead, which is shown in the Fig. 6.

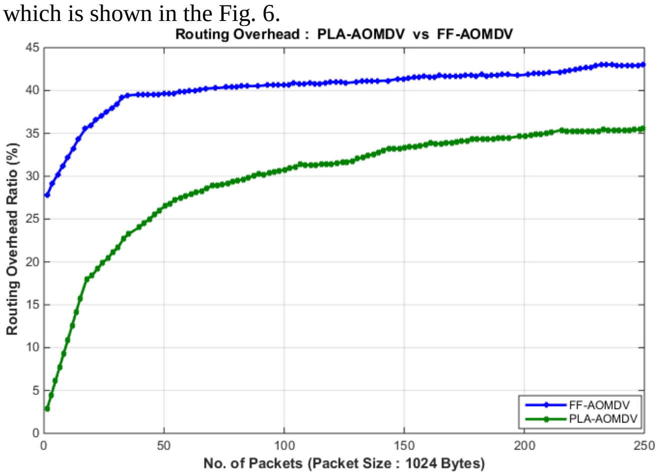

Fig. 6: Routing Overhead of the Proposed PLA-AOMDV.

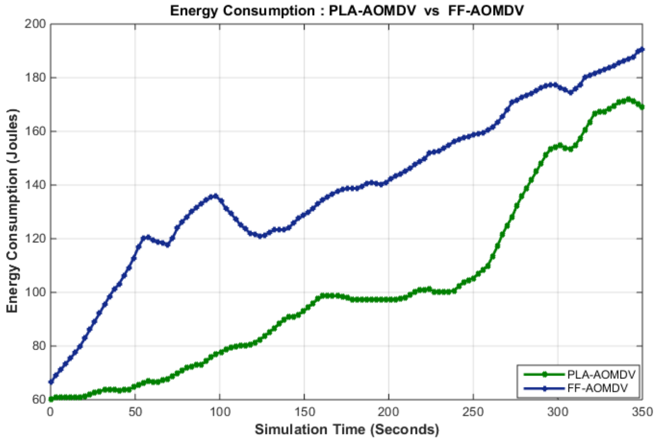

Fig. 7: Power Consumption Analysis of the Proposed PLA-AOMDV.

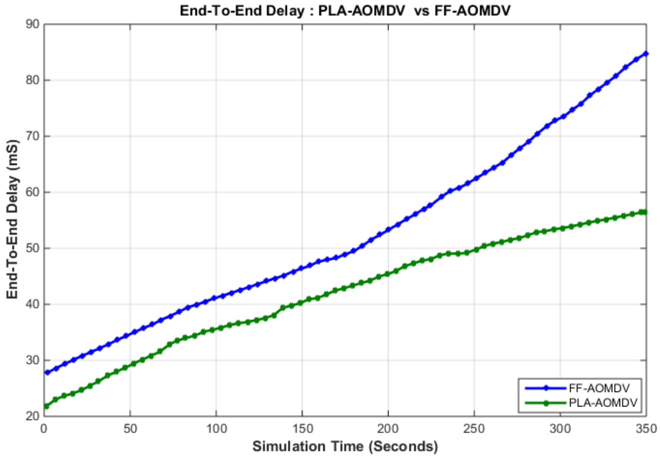

Fig. 8: Packet Delay Analysis of the Proposed PLA-AOMDV.

As shown in the Fig. 7, the proposed Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) performs better than that of the existing FF-AOMDV Routing Protocol in term of Energy Consumption. As less retransmission due to better Dropping Rate and less Partitioning, it consumes relatively less power for Transmission and Computation which will maximize the Network Lifetime. It reduces the Number of Dead Node also which is shown in the Fig. 9.

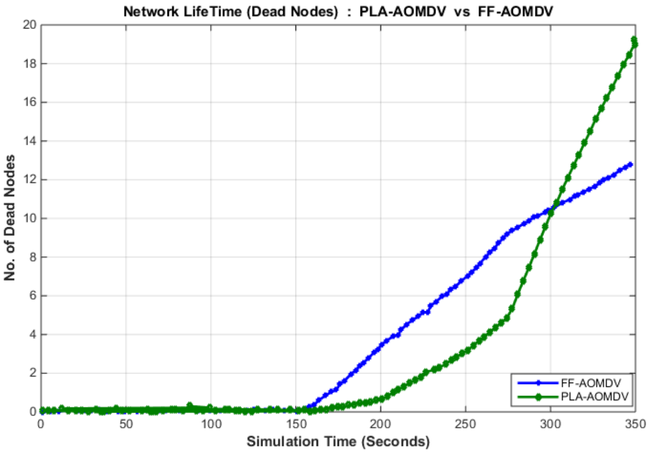

Fig. 9: No. Of Dead Node Analysis of the Proposed PLA-AOMDV.

5. Conclusion

This research work is proposed an efficient Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) to address the Power Dissipation issue which is leading to link failure. This work designed and implemented the PLA-AOMDV in QualNet 6.1 and results were studied thoroughly in terms of Throughput, Packet Dropping Rate, Routing Overhead, Energy Consumption, End-to-End Delay, Life Time (Dead Nodes Count). From the experimental results, it was established that the proposed Power-Load Aware Multipath Routing Protocol (PLA-AOMDV) is outperforming the existing FF-AOMDV in terms of Throughput, Packet Dropping Rate, Routing Overhead, Energy Consumption, End-to-End Delay, Life Time (Dead Nodes Count).

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