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Dynamic Optimization in Manets Using Queue Scheduling Techniques

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Abstract:- This research aimed at creating robust and efficient operation in mobile ad-hoc networks (MANETs) by incorporating energy efficient routing technique. MANETs are energy constrained. The Energy Skilled Ad-hoc on Demand Distance Vector (ESAODV) with Priority-Based Weighted Fair Queue (PBWFQ) routing scheme was developed and compared with Destination-Sequenced Distance-Vector (DSDV) with First-In-First-Out (FIFO) routing techniques using NS-3 (Network-simulator). WireShark Network Analyzer was used for file tracing and analysis of the simulation results in NS-3. The optimized technique significantly reduced the control traffic and packets congestions by lowering the end-to-end delay to an average of 25 X 10^{-3}s in a 50-100 nodes MANET. ESAODV-with-PBWFQ maintained throughput of 78.8 X 10^{3} pps. The technique met target Packet Delivery Ratio with 98.7% accuracy. ESAODV-with-PBWFQ saved 80-90% energy compared to DSDV-with-FIFO in 80-100 nodes dense MANET. In 50-70 nodes sparse MANET 70-75% less consumption of energy in ESAODV-with-PBWFQ compared to DSDV-with-FIFO.

Keywords:- *Mobile Ad Hoc Networks; Manets; Routing Techniques, Priority-Based Weighted Fair Queue; PBWFQ; Mobile Devices; First in First Out; FIFO.*

I. INTRODUCTION

The continuous increase in the use of mobile devices is a defining development for businesses and the society. Organizations and individuals now access important information and interact with customers, service providers, suppliers and friends wherever they are. The gap in communication has been reduces through Mobility. Poor citizens that cannot afford complex computing devices now use Smartphone to browse the Internet and download mobile applications. Traditional firms need to pursue mobile delivery channels that "meet people where they are" to promote their businesses. Mobile devices have become more rampant and powerful. These digital devices are replacing traditional means of accessing data, Internet and content like Sports news and fashion. Continuous use of mobile devices has changed how information and ideas are used. At the end of 2008 about 1% of the world's Internet traffic was on mobile devices; whereas, at the end of 2012, more than 12% of the world's Internet traffic occurred on mobile devices. In the middle of the last decade the number of connected devices surpassed the number of people on the planet: about 12.5 Billion devices for 6.8 Billion people (Ericsson Mobility Report, 2016). All these are proofs that mobile communication has recently increased in usage and popularity. MANET is an autonomous system of mobile routers connected by wireless links – the union of which forms an arbitrary graph (Mukherjee *et al*., 2007). Problems of the Study are as follow:

- Energy Saving
- Limited Power Supply
- Low range of wireless transmission
- Continuous packet Broadcast
- High level of errors in transmission
- Constant change of route
- Packet losses

The purpose of this study is to develop a robust and optimized energy efficient routing technique for MANETs. The objectives of the study are to:

- Model an Ad hoc wireless network environment.
- Model the Energy Skilled Ad-hoc on Demand Vector (ESAODV) route discovery protocol for the MANET.
- Develop appropriate Priority-Based Weighted Fair Queue (PBWFQ) packet classification and scheduling scheme to work with ESAODV route discovery protocol for energy efficient route discovery.
- Determine and set up entities of simulation in NS-3 environment, as well as input variables, active route time-out, route reply lifetime, mobility model speed and node energy threshold value.
- Conduct simulation runs for ESAODV-with-PBWFQ and an existing technique, Destination-Sequenced Distance-Vector with First-In-First-Out (DSDV-with-FIFO) and compare performance.

This paper developed the Energy Skilled Ad-hoc On-Demand Distance Vector (E2AODV) routing protocol with Priority-Based Weighted Fair Queue (PBWFQ) Scheduling mechanism for energy efficient operation. The scheme incorporated the techniques of AODV and DSR.

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II. RELATED WORKS

The whole existence of mobile ad hoc network from origin to present time can be categorized into first, second and third generation. Present ad hoc network are considered the third generation (Gang and Guodong, 2010). Earliest MANETs were called "packet radio" networks, sponsored by the Defence Advanced Research Project Agency (DARPA) in 1970. These first generation of ad hoc network are called Packet Radio Network (PRNET). These packet radio systems predated the Internet and were part of motivation of the original IP suite (Gang and Guodong, 2010). DARPA initiated research of using packet- switched radio communication to provide reliable communication between computers and urbanized PRNET. Basically PRNET uses the combination of Areal Location of Hazardous Atmospheres (ALOHA) and Carrier Sense Multiple Access (CSMA) for multiple access and distance vector routing (Ankur *et al*., 2013).

The PRNET is then evolved into the Survivable Adaptive Radio Network (SURAN) in the early1980's. SURAN, the second generation of MANETs provides some benefits by improving the radio performance (making them smaller, cheaper and power thrifty). This SURAN also provides resilience to electronic attacks. Around the same time, United State Department of Defence (DOD) continued funding for programs such Globe Mobile Information System (GloMo) and Near Term Digital Radio (NTDR) (Humayun, 2005). GloMo make use of CSMA/CA and TDMA molds, and provides self-organizing and self-healing network (i.e. ATM over wireless, Satellite Communication Network). The NTDR make use of clustering and link state routing and organized an ad hoc network. NTDR is worn by US Army. This is the only "real" ad hoc network in use. By the growing interest in the ad hoc networks, various other great developments took place in 1990's. In the 1990s we had the advent of inexpensive IEEE 802.11 radio cards for personal computer (Humayun, 2005).

The third generation known as the functioning group of MANET was born in Internet Engineering Task Force (IETF) who worked to standardized routing protocols for MANET. These gave rise to the development of various mobile devices like PDA's, palmtops, notebooks, etc. Meanwhile the Development of Standard IEEE 802.11 (i.e. WLAN's) benefited the ad hoc network. Some other standards are also developed that provide benefits to the MANET like Bluetooth and HIPERLAN (Ankur *et al*., 2013). Current MANETs are designed primarily for military utility; examples include JTRS (Joint Tactical Radio System) and NTDR (Near-Term Digital Radio). Mobile ad-hoc network (MANET) is widely applicable in various areas like military services, civilian environments and emergency operations.

Sun *et al.* (2014) designed a modified proportional fairness model with multi-hop queue scheduling for cognitive radio-based MANETs. The model is cross layer-based model that restricts QoS for end users in MANETs. The model is MAC layer-based service distributor that ensures that QoS is not affected during transmission. It computes the availability of channels and buffer. Then, it uses MAC analyzer to compute packet priority and packet scheduling before selecting the transmission strategy. Along with it, performance measurement is also carried out during the end to end transmission. The major drawback in the model is that no estimation is carried out during transmission, also in the case of addition of intermediate nodes, it requires regular updating of channel list that causes increased overhead. Wen *et al.* (2012) derived a queuing theory-based approach for service discovery in MANETs. The approach includes a model for service discovery on MANETs nodes. The model uses control variables that predict the system through-put to analyze the system behaviour. The approach is adaptive to variations in MANETs. The whole MANET is divided into zones comprising backbone and mobile nodes with mobile nodes operating on queuing theory. Thus, it was analyzed that performance depends on admission control algorithm as well as scheduling technique for a network that encounters congestion. Also, the QoS scheduler should be efficient enough to be incorporated into system model without causing any additional overheads. A cross-layer approach to offer multimedia services over MANETs was implemented by Kuo *et al.* (2013). It is link to link connectivity-based implementation. The model integrated dynamic hash table and IPV6 to provide multimedia transmission over a network that has frequent topology changes and unreliable wireless links. Furthermore, Bouk *et al.* (2012) emphasized on the selection of appropriate gateway node to provide seamless QoS to end users over MANETs. Taking into account the path dynamics, a feedback system is incorporated into the network that is capable enough to handle end to end delays. The model focused on link expiration time i.e. time to live (TTL) to evaluate the gateway during path planning on basis of system dynamics in MANETs.

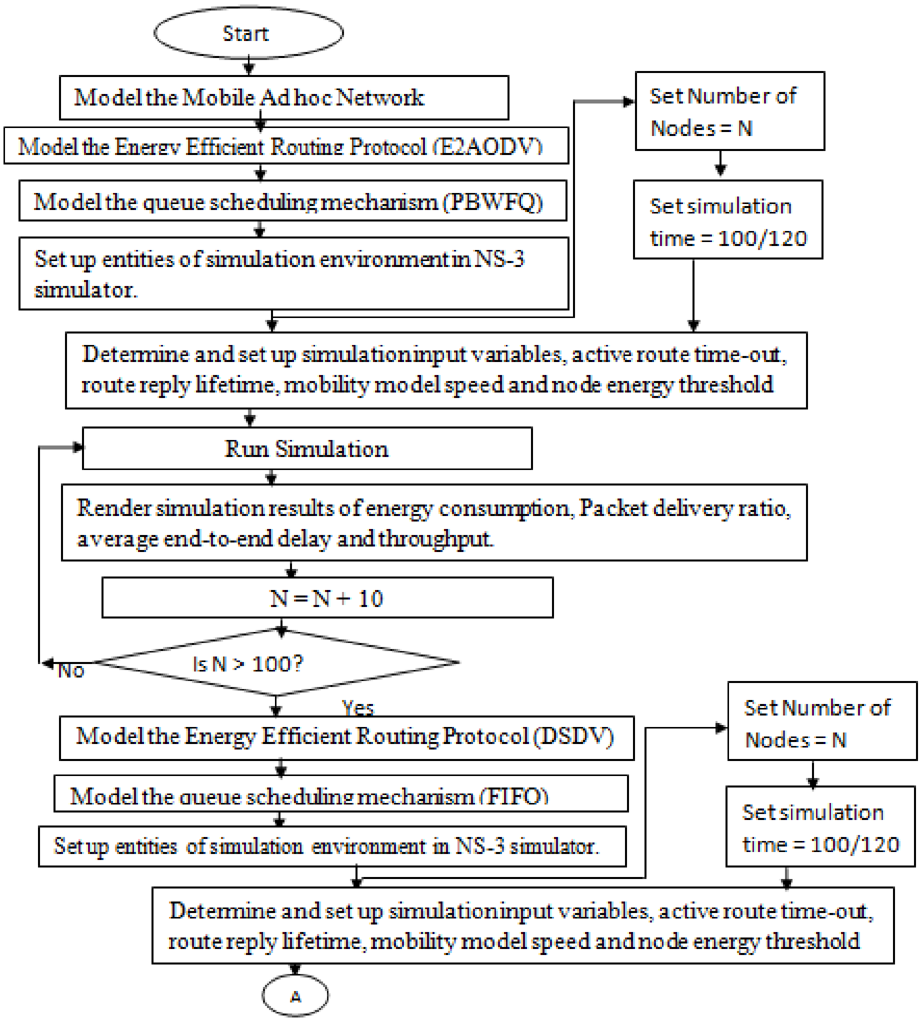
Unlike, Priority Based Weighted Fair Queue (PBWFQ) with Energy Skilled AODV (ESAODV) routing protocol, these reviewed models used absolute differential service-based methods of data transmission for real-time packets. The differential service-based models cannot be relied upon in terms of optimal performance under intensive conditions such as dynamic topology and congestions. The developed model uses both differential service-based models and computed-time schedule for real-time packets transmission. The proposed technique handles large traffic congestions through packets classification and scheduling using PBWFQ scheme. This ensures optimal energy performance.

III. MATERIALS AND METHOD

The methodology adopted in this research is graphically presented in Figure 1 and the processes therein are subsequently described.

Modeling of the Mobile Ad-hoc Network determines the mobile routing devices that will form the MANET and the nature of the MANET using C++, while modeling the Energy Skilled Routing Protocol ensures the development of ESAODV route discovery protocol in the MANET (Onyemaobi and Ajah, 2017). The PBWFQ is subsequently developed Model, the Queue Mechanism process to work with ESAODV for packet classification and scheduling. The modeled MANET entities are set up in NS-3 Simulation environment. Then, the simulation input variable such as: active time-out, route reply lifetime, mobility model speed and node threshold energy are determined and set up in the NS-3 environment. Several simulation runs are carried out varying the MANET entities and simulation variables.

All the earlier mentioned processes are repeated using DSDV-with-FIFO as the routing technique. The simulations run results are compared with the initial results of ESAODV-with-PBWFQ as the routing technique. We compared the performance of the techniques in terms of the average energy consumption, average end-to-end delay, packet delivery ratio and throughput. These four performance metrics were used to evaluate the energy efficient schemes. Secondly, the performance comparison of DSDV-with-FIFO and ESAODV-with-PBWFQ was done for dense and sparse MANET testbed such as 50, 60, 70, 80, 90 and 100 nodes respectively by varying the node speed from 0 m/s to 10 m/s. Rendered simulation results of both routing techniques (ESAODV-with -PBWFQ and DSDV-with-FIFO) were analysed using WireShark Network Protocol Analyzer and Network Animator (NetAnim) in NS-3 Environment. Further testing of the developed optimized energy efficient routing technique scheme was done at this stage in comparison with other known energy efficient routing technique (DSDV-with-FIFO). WireShark was used in comparative analysis of captured simulation packets, while NetAnim was used in animation of the simulation runs for further analysis. The captured packets of data were used in plotting the graphs, which enhanced good understanding of the parameters used in comparing both routing techniques (ESAODV-with-PBWFQ and DSDV-with-FIFO).



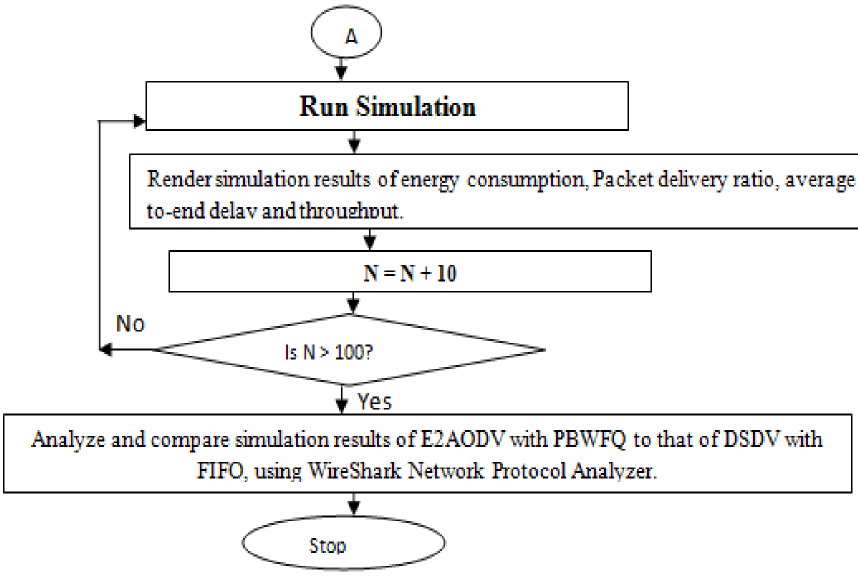


Fig 1:- Flow Chart of the Research Process

IV. MODELING THE OPTIMIZED ROUTING TECHNIQUE

The data traffic design concentrated on the transmission and reception of packets. The model of the optimized technique is shown in Figure 2.

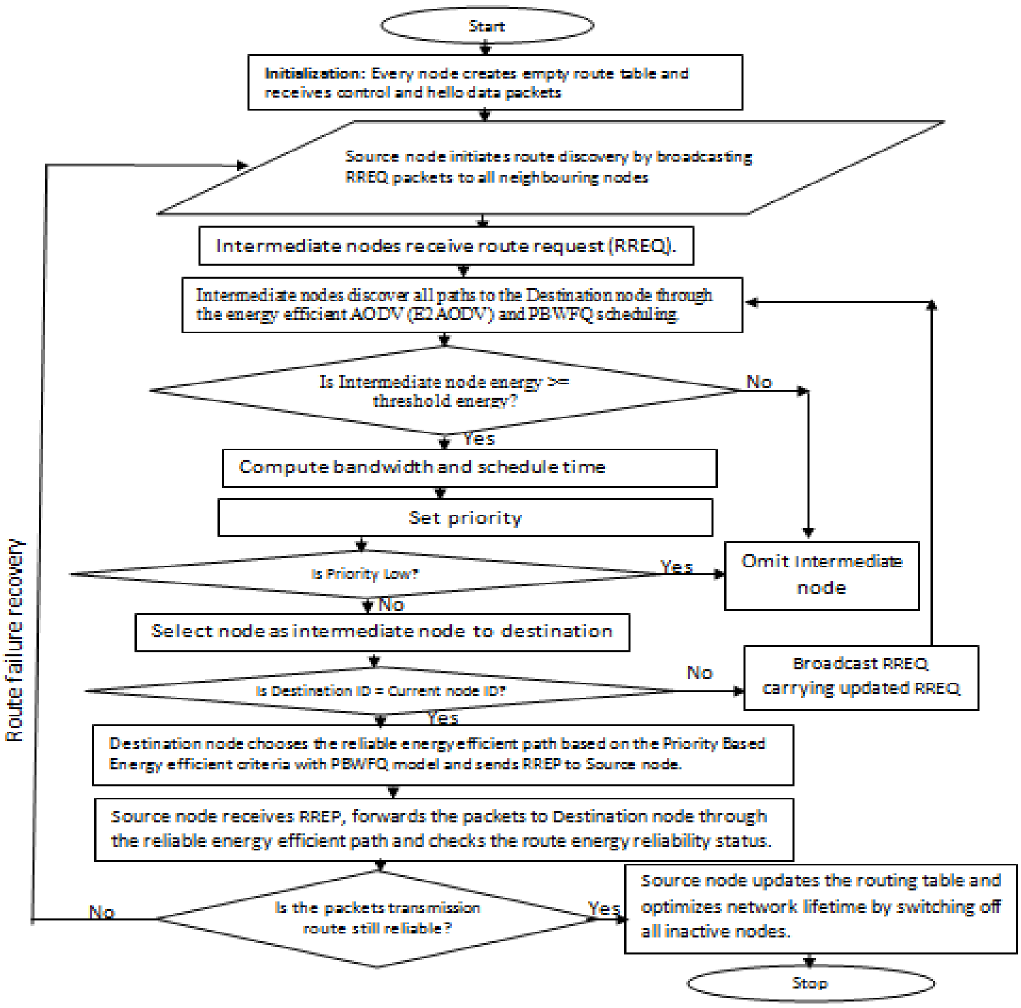


Fig 2:- Program Flowchart of the Optimized Energy Efficient Routing Technique

The routing model was designed to send and receive packets along the link with the greatest energy and signal strength. It routes packets through the path that emerge unwavering for a long time. The model is designed to choose the best link based on some metrics, mostly energy efficient path. Energy is utilized each time packets are transmitted within the nodes. Whenever packets are transmitted, the different power arrangement of neighbouring nodes is affected. Nodes with diminishing energy appear self-centered in MANET. This self-centered in MANET attracts routing operating cost (Jung *et al.*, 2005). The Energy Skilled AODV (ESAODV) was designed to improve energy efficiency of the MANET by dropping control messages using supporting nodes. It performs inherent path revitalization process as shown in Figure 2. We use PBWFQ scheduling mechanism as the fair queue scheduler assurance, in order that the packets waiting in queue do not wait for a long time. The PBWFQ scheduling mechanism takes into cognizance issues like using the distance metric, fairness and appropriate dual roles of nodes as both routers and data sources. This routing model design portrays numerous real-time military and disaster rescue missions applications (such as voice, video and multimedia).

➤ *Modeling the Energy Skilled Routing Protocol (ESAODV)*

The fact that the available bandwidth on a wireless link currently is orders of magnitude smaller than that available in wired networks, requires that a protocol be carefully designed to reduce the amount of control traffic generated and conserve energy. In the design of the research ad hoc network, nodes are not familiar with the topology of their networks. Instead, they have to discover it as shown in figures 3 and 4: typically, a new node announces its presence and listens for announcements broadcast by its neighbors. Each node learns about others nearby and how to reach them, and may announce that it too can reach them. The algorithm for energy efficient route discovery is presented in figure 3 below and the pseudo code of RREQ handling at the intermediate and destination nodes are presented in figure 4.

```
SOURCE NODE:
First check the source node routing table for destination Link
IF destination Link is not available on the source node routing table THEN
Include Destination ID in RREQ packet                    // Route Request (RREQ)
Include minimum power required to transfer the packet in RREQ packet // i.e. Threshold energy
Initiate route discovery request by broadcasting RREQ packet   // i.e. initial broadcast packet
Store the RREQ packet in the source node buffer
        IF Source node receives RREP from Destination node THEN // Route Reply (RREP)
        Source node delivers the packet from buffer to Destination node through the RREP link
        Source node maintains data transmission by checking the link energy reliability status
        ELSE
         Source node rebroadcast RREQ packet
        ENDIF
ELSE IF Destination link available for data transmission
Source node forwards hello data packet to the Destination link
Source node Select next hop based on required energy level
Source node delivers the packet from buffer to Destination node through the destination link
Source node maintains data transmission by checking the destination link energy reliability status
ENDIF
```

Fig 3:- Algorithm for the Optimized Energy Efficient Route Discovery

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INTERMEDIATE NODE:
Verify transmission Strength of Intermediate node based on the Residual energy of the node
Verify Intermediate node Residual energy level
IF Residual Energy level of the Intermediate node is >= the threshold Energy THEN
Compute packet transmission schedule time
Verify sequence number and route request id for freshness
Verify the timer for reply message
Send route reply message with available links
ENDIF
ELSE
 Exclude the Intermediate node for transmission
ENDIF

DESTINATION NODE:
// When RREQ packet comes to the Destination node
IF Destination ID = current node ID and Residual Energy of current node is >= the threshold
Energy THEN
RREP is sent from Destination node to the Source node via the efficient energy selected link.
ELSE
 Error Message is sent from Destination node to the Source node via the efficient energy selected
link.
ENDIF
```

Fig 4:- Algorithm on how Intermediate Nodes and Destination Nodes Process RREQ in the Optimized Energy Efficient Route Discovery

V. SIMULATION RESULTS AND DATA ANALYSIS

In our MANET testbed simulation, we have a simple topology with 50 to 100 nodes. The nodes are interconnected wirelessly. The MANET is modeled from a script in ns-3, which was modified and used as a base script. Mobility of The nodes are produced by the mobility model in the script. Each node assumes a random position at the beginning of every simulation and navigates toward arbitrary destination with indiscriminate velocity as programmed in the random waypoint mobility model. NS-3 Implemented Energy Model as an attribute, which is we configured in the simulation environment. The energy model signifies the level of energy in a mobile device (Woonkang and Minseok, 2008). At the beginning of the simulation, every node has an initial energy value given to it by the energy model in NS-3. The nodes also have given energy usage for every packet they transmit and receive. Each node consumes energy in receiving and transmitting packets of data. The Energy Skilled Ad Hoc on Demand Distance Vector with Priority-Based Weighted Fair Queue (ESAODV-with-PBWFQ) technique maintains a routing table. Each node has a routing table. A node sends a route reply (RREP) to a source node, if it knows the route to the destination. Neighbouring Nodes can communicate directly with one other. They keep track of their neighbours by paying attention to “HELLO” messages that new nodes broadcast.

❖ *Comparing Simulation Results of the two Routing Schemes (ESAODV-with-PBWFQ and DSDV-with-FIFO).*

We compared the performance of the techniques in terms of the average energy utilization, average end-to-end delay, packet delivery ratio and throughput. These four performance metrics were used to assess the energy efficient schemes. Secondly, the performance comparison of DSDV-with-FIFO and ESAODV-with-PBWFQ was done for dense and sparse MANET testbed such as 50, 60, 70, 80, 90 and 100 nodes respectively by changing the node speed from 0 m/s to 10 m/s.

A. Average Energy Consumption:

Energy Consumption is the total energy consumed for transmitting and receiving packets by all the nodes in the MANET (Mukherjee *et al.*, 2008). The Energy Skilled Ad Hoc on Demand Distance Vector with Priority-Based Weighted Fair Queue (ESAODV-with-PBWFQ) is a hybrid routing technique. The technique integrates the on-demand path detection from DSR and the node to node sequence jumping from OLSR. Table 1 gives the ESAODV-with-PBWFQ simulation factors used in the MANET testbed simulation. The scalability of the schemes is calculated by the escalation in the energy utilization for dense MANET.

Entity	Simulation Parameter
Active link time-out Allowed Hello packet loss Time before broken path is removed from routing table Time to hold packets awaiting routes MAC splintering detection Hello Interval RREP lifetime RREQ retries	50s 3 3s 30s Yes 1s 60s 3

Table 1:- ESAODV-with-PBWFQ Simulation Parameters

Energy utilization is habitually high in the dense MANET. However, through making some nodes inactive, the ESAODV-with-PBWFQ saves 80- 90% of energy compared to DSDV-with-FIFO in the MANET. When we reduced the number of nodes, we had 70-75% energy utilization in ESAODV-with-PBWFQ, compared to DSDV-with-FIFO. We considered cases where nodes are dispersed across the simulation environment. These different cases indicated changeable node densities, connection alterations, and mobility disparities. Escalating the number of nodes in ESAODV-with-PBWFQ MANET does not raise energy utilization compared to DSDV-with-FIFO. ESAODV-with-PBWFQ permits lofty optimization by dropping the intermittent path update communication in the dense MANET (see Table 2 and Figure 5). Invariably, the energy utilization due to the path update flooding is circumvented. Under the same mobility and interchange rate, varying the MANET nodes from 50 to 100, the raise in energy utilization using ESAODV-with-PBWFQ is about 15% of energy utilization using DSDV-with-FIFO.

Nodes	ESAODV-with-PBWFQ Average Energy Consumption (J)	DSDV-with-FIFO Average Energy Consumption (J)
50	1	9.4
60	0.9	3.8
70	0.8	4.1
80	1	10.2
90	0.9	5.8
100	0.92	4.8

Table 2:- Nodes Vs Average Energy Consumption using ESAODV-with-PBWFQ and DSDV-with-FIFO as Routing Schemes

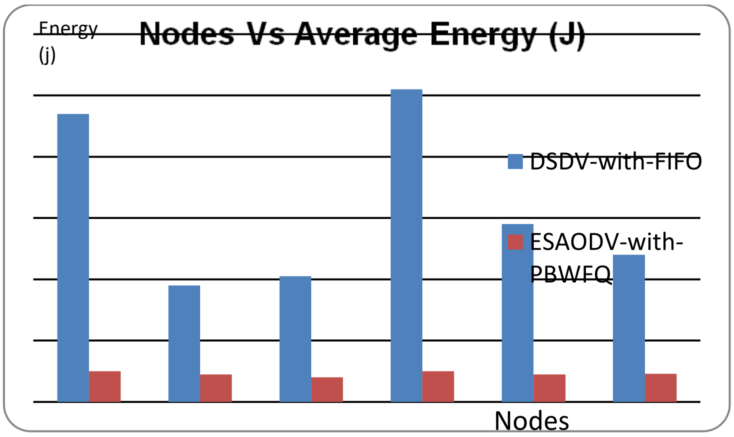

Fig 5:- Average Energy Consumption

Table 2 and Figure 5 demonstrate the simulation outcome obtained in ESAODV-with-PBWFQ as compared with DSDV-with-FIFO. Varying the number of nodes, the developed routing technique utilizes less energy compared to the other routing technique.

B. Average End-to-End Delay:

This gives us the normal delay in communication between two nodes. Table 3 and Figure 7 depict that the normal packet delay of DSDV-with-FIFO in the random waypoint mobility model used is more than that of the ESAODV-with-PBWFQ. Spatial constraint forced more hops to be used in the DSDV-with-FIFO than ESAODV-with PBWFQ in the random waypoint mobility model. Thus, ESAOD-with-PBWFQ achieves lower delay in random waypoint mobility model than DSDV-with-FIFO, even with more hops needed. While the delay of ESAODV-with-PBWFQ was due to buffering of undeliverable packets, the large number of node tot node skips plays a vital role in DSDV-with-FIFO. The large number of nodes raises the chances of ESAODV-with-PBWFQ locating intermediate nodes to transmit packets.

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Nodes	ESAODV-with-PBWFQ Average End-to-End Delay(Delay X 10^{-3}s)	DSDV-with-FIFO Average End-to-End Delay(Delay X 10-3s)
50	25	175
60	24	380
70	20	160
80	20	155
90	30	30
100	25	35

Table 3:- Nodes Vs Average End-to-End Delay using ESAODV-with-PBWFQ and DSDV-with-FIFO as a routing schemes

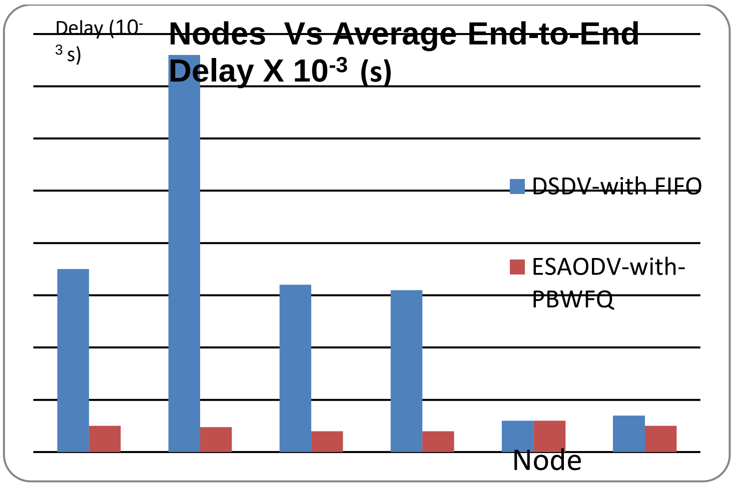

Fig 6:- Average End-to-End Delay

Figure 6 and table 3 show the simulation results achieved for ESAODV-with-PBWFQ as compared to DSDV-with-FIFO. Results show that, the developed routing technique has reduced end-to-end delay than the other routing scheme.

C. Packet Delivery Ratio (PDR):

This is the ratio of total number of packets successfully received by the destination nodes to the number of packets sent by the source nodes throughout the simulation:

PDR= number of received packets/number of sent packets.

This estimate gives us an idea about how successful the technique is in delivering packets to the application layer. A high value of PDR indicates that most of the packets are being delivered to the higher layers and is a good indicator of the technique performance. For ESAODV-with-PBWFQ, the packet delivery ratio grows exponentially for the transmission ranges up to 80m. ESAODV-with-PBWFQ has higher delivery ratios compared to DSDV-with-PBWFQ. The lowest delivery ratios are observed in the random waypoint scenario of DSDV-with-FIFO. ESAODV-with-PBWFQ in the random waypoint mobility scenario achieved highest delivery ratio. PDR for ESAODV-with-PBWFQ technique was evidently different and higher in the random waypoint model compared to DSDV-with-FIFO.

Nodes	ESAODV-with-PBWFQ Packet Delivery Ratio (PDR)	DSDV-with-FIFO Packet Delivery Ratio (PDR)
50	100	98.2
60	99.6	30.0
70	99.5	73.2
80	99.0	96.6
90	98.1	98.0
100	98.0	98.0

Table 4:- Nodes Vs Packet Delivery Ratio (PDR) using E2AODV-with-PBWFQ and DSDV-with-FIFO as Routing Schemes

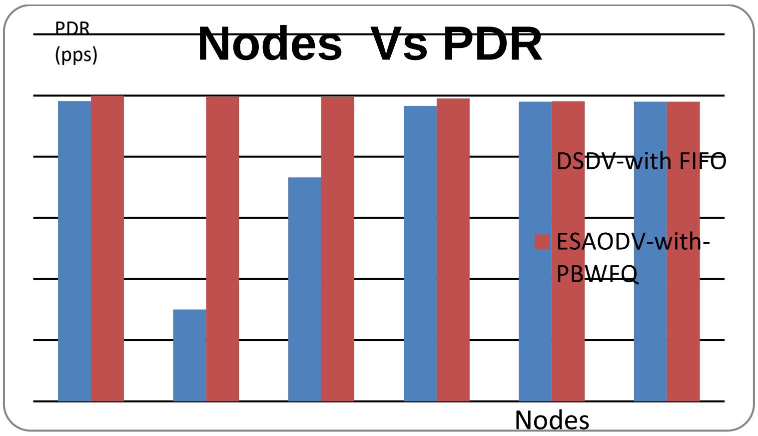

Fig 7:- Packet Delivery Ratio

Figure 7 and table 4 present the packet delivery ratio achieved by varying the number of nodes in the simulation environment. Results show that, the developed technique achieves better packet delivery ratio than the other routing process.

D. Throughput:

Network throughput is the amount of data successfully sent and received (without errors) by the entire network within the simulated data transfer time. In energy terms, the higher the throughput, the better performing the technique. This metric gives an estimate of how efficient the routing technique is since the number of routing packets sent per data packet gives an idea of how well the technique maintains the routing information updated. Nodes ensuring high network throughput are considered optimum with their energy sources, meaning that the underlying scheme algorithm is running efficiently.

Nodes	ESAODV-with-PBWFQ Throughput X 10^3	DSDV-with-FIFO Throughput X 10^3
50	79	79
60	79	40
70	78.9	72
80	78.8	78.8
90	78.7	78.7
100	78.7	78.7

Table 5:- Nodes Vs Throughput using ESAODV-with-PBWFQ and DSDV-with-FIFO as Routing Schemes

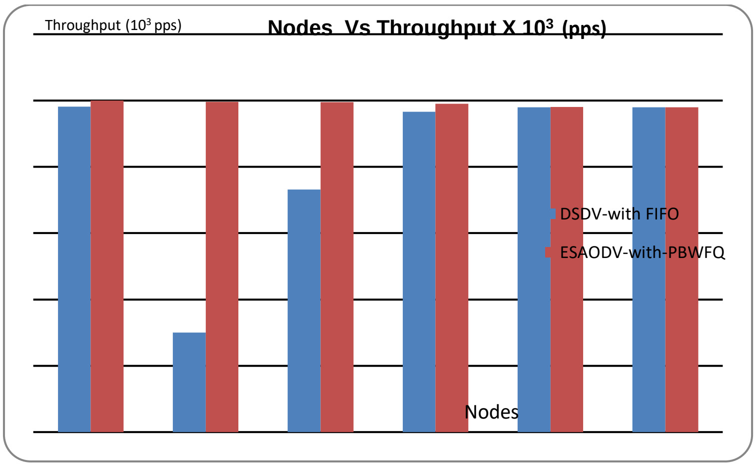

Fig 8:- Average Throughput

Table 5 and figure 8 show the simulation results achieved for ESAODV-with-PBWFQ as compared to DSDV-with-FIFO. The total number of packets that arrived the destination in the developed routing technique showed that it is a better techniques compared to DSDV-with-FIFO.

VI. CONCLUSION

In this research simulation, we varied the number of nodes in the MANET between 50 and 100. When the number of nodes is increased, figure 5 shows ESAODV-with-PBQFQ, consumed less energy compared to DSDV-with-FIFO. Figure 6 depicts that delay occurred in ESAODV-with-PBWFQ and DSDV-with-FIFO. As we can see from the figure, the delay is less for ESAODV-with-PBWFQ, compared to DSDV-with-FIFO. Figure 7 shows the packet delivery ratio for both ESAODV-with-PBWFQ and DSDV-with-FIFO. From the figure, the packet delivery ratio was high for ESAODV-with-PBWFQ, compared to DSDV-with-FIFO. Figure 8 shows the throughput that occurred for both routing schemes. As shown by the figure, throughput is high for ESAODV-with-PBWFQ, compared to DSDV-with-FIFO. We clearly state that the developed technique (ESAODV-with-PBWFQ) is a very energy efficient routing technique. The simulation results had significantly and sufficiently proved that ESAODV-with-PBWFQ is very reliable energy efficient routing scheme that can be employed to optimize routing techniques in MANETS. Consequently, the developed technique does better than DSDV-with-FIFO in sparse and dense MANETs. This results from the reality that the developed system checks link energy before choosing a path for transmission. While DSDV-with-FIFO chooses the shortest path not minding the link energy. The developed routing technique reduced the frequency of hello messages make and the calculation difficulties in choosing routing links.

RECOMMENDATIONS

- Start error checking from the unit coding. Do not model a network of 100 nodes only to realize that the MANET is not functioning. Initially, load few nodes into the MANET environment to test them.
- Also start debugging from the lower OSI- reference model layers. The application layer cannot work, if the link layer fails to work.
- The developed energy efficient routing technique can be analyzed for different parameters other than the ones mentioned.

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