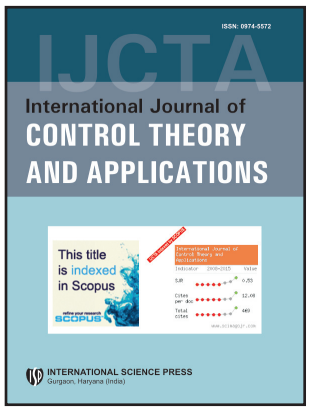

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A Novel-Real Time Energy Efficient Routing Protocol for Heterogeneous Wireless Sensor Networks

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Abstract: In recent trends, more researchers are coming with new protocols in Wireless sensor Networks. Most of them presented hybrid protocols, those were mainly focused in the area to enhance network lifetime. Resource availability and best utility of nodes being an important issue, not discussed in detail so far. In this paper, we implement a network, where each node accompanied with two different bandwidth frequencies and hence heterogeneous network are formed. In addition to that, we implemented a Poisson distribution based selection of next hop and routing path. Each node designed with two frequency resources helps to compensate channel lagging issues. The knowledge of residual energy helps to improve the lifetime. In this research, we implemented our proposed model in real time and recorded results have shown an improved lifetime and better resource utility than earlier methods and also simulation analysis is done to prove our proposed model with existing DSR protocol.

Keywords: DSR, Routing Protocol, Heterogeneous WSN, Poisson distribution.

1. INTRODUCTION

Random mobility of nodes challenges the design of Mobile Ad-Hoc Network. Fundamentally Ad-hoc Routing has two types such as proactive and reactive. Earlier type provides faster access in route identification and selection. These types of protocols suddenly respond to topology changes and frequent updates by beacon signal. Due to that every node should spend more power, even it does not involve in any data transmission. Later type consumes more time to find route on demand and does not need of beacon signal and hence we reduced power consumption. Energy constraints of wireless node are an important performance affecting factor. Many protocols and research works have been proposed in the area of WSN and Ad-hoc in recent days to prolong lifetime.

Memory constraints can be eradicated completely by inculcating external memory to node. Adding memory unit to a node does not burden the network and it is easily affordable. Energy and bandwidth constraints of a node have to be limited. Some hybrid protocols were proposed but they are not heterogeneous. They are hybrid in terms of added features in both proactive and reactive protocols. Repeated beacon signal at certain time interval were generally discussed in hybrid protocol. In case of hybrid protocol, it does not offer any additional

bandwidth to user. Moreover, cluster head based protocol was discussed to drive the network longer. Even there is no data packet sharing between the contributing nodes the selection for head itself adds more contention to the network. It further drops energy of a node which seeks for head. Further more on cluster head, node should carry the data packets of all other contributing nodes via the network. It causes the cluster head to dry earlier and sometimes it will be cornered or isolated from the network.

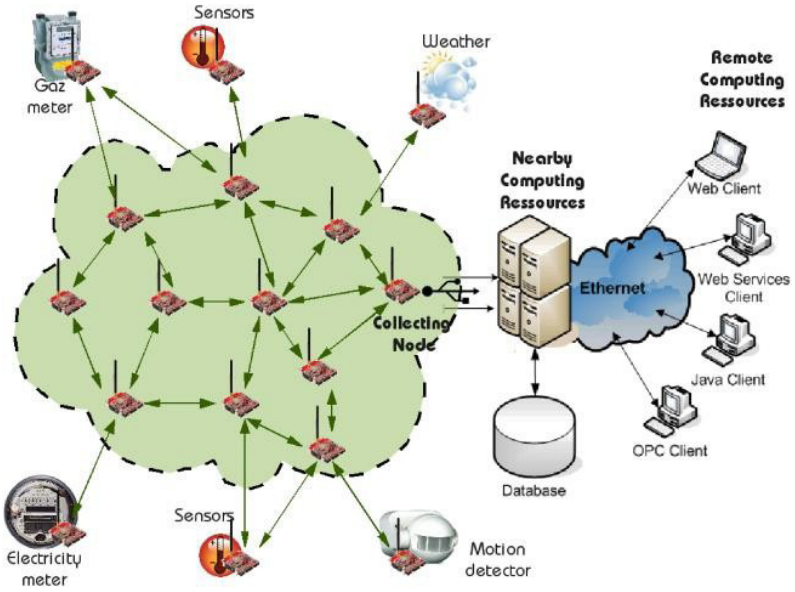

Figure 1: Wireless Sensor Networks

2. RELATED WORKS

In paper [1], the author approached a scheme is called efficient data gathering that guarantees end-to-end reliability in wireless sensor networks, that belongs to optimization and Quality of Service in the network performance. Numerical simulation shows optimal approach to enhance the network lifetime by 18% and increase the reliability level and utility by 17%. This mainly solves the energy consumption issue while transmitting data and increases the network lifetime per unit deployment in maximum utilization of efficiency and minimum energy consumption.

To overcome the power consumption in sensor networks because of their limited power battery is used. When more than one node is connected in sensor network, it consumes more power and it reduces the network lifetime. A Particle Swarm Optimization (PSO) is used to make the network more energy efficient and relay node to communicate. This experiment improved 40% of the energy in the network. [2]

In wireless sensor network (WSN), energy saving optimization is one of the important parameter, when node communicates in routing protocol design with limited battery power. In paper [3], researcher concentrated on power saving in network using data relay in one dimensional (1-D) queue network. Opportunistic Routing (ENS_OR) algorithm is also protecting the nodes from energy consumption and measure the power lost during data relay. [3]

In cellular networks, due to the increasing number of mobile devices in network causes traffic demand and significant energy cost. To formulate the energy cost of base stations and traffic demands, the researcher employed Lyapunov Optimization theory. This theory reformulates and drives upper and lower bounds and provides stronger network stability. [4]

In scheme discussed in paper [5], the advanced proactive path Request (PREQ), effectively implemented in large-scale advanced metering infrastructure (AMI) for reasonable cost is studied. From this PREQ specifically utilize MAC address resolution at IEEE 802.11 is to maintain creation of routing tree and eliminate ARP request at broadcasting. Simulation results are performed on NS2 in parameters of throughput and packet delivery ratio. [5]

To improve the wireless sensors network's lifetime, energy-efficient method is developed for limited energy. In clustering algorithms, sensor nodes are divided into different modules at the same energy consumption on each node. The clustering algorithm not only extends the lifetime, but also applicable to the multi-level heterogeneous WSNs. [6]

For monitoring physical world, the emerging wireless sensor networks prolonging the energy of a sensor node is an important goal in various protocols. This clustering technique surveys different energy efficient techniques for heterogeneous

WSNs and compares with various clustering methods, location awareness, clustering attributes and heterogeneity. Hart (2006), Bokareva (2006), Quaritsch (2010) and Dudek (2009) also explained the networking in clustering for highlighting their complexity, features and objectives. [7] [8].

3. METHODOLOGY

A. Heterogeneous Network

The heterogeneous network became very familiar in today's world. Mobile phones, Computers or any communicating devices has made inbuilt with as much as communication possible like Bluetooth, and Wi-Fi. Similar features are most widely used in smart phones. Even all of them built in a single device, it works independently. i.e., two or more devices could form a network and share their data in a certain bandwidth, even they facilitated with more number of bandwidth communication, and they could not communicate with other bandwidth.

Let X, Y are the two different bandwidths for users at a small network. User A can seek the available channel in either X or Y bandwidth and can communicate. User B cannot transmit the message received from A at bandwidth X to another user via bandwidth Y. it could be done only via same bandwidth. In this paper, a best utilization of all availed channels irrespective of what bandwidth they really belong is proposed. Here a new method to improve efficiency and best utilization of channels in a small area deployed with a wireless network is shown. In which a pool of channels is created and they may or may not lie in same bandwidth S (X, Y). Here node seeks free channels in entire bandwidth both X and Y communicates via free channel found. This network is not limited to single bandwidth. In entire transmission from source to destination the data can travel in X bandwidth up to a certain node and can take on bandwidth Y afterwards. This conversion and channel availability have done by Poisson process.

The user might think what is the necessity of pool creation and unifying networks? How will it be helpful? Yes, it is really. Suppose a node 'I' have more number of neighbors, then it might receive more data. Some neighbor node has occupied bandwidth and the rest left without access and would not be able to communicate. So if the node sense channel is not available in particular bandwidth, then it can start communicating with the available channel in new bandwidth and no need to free the earlier channel. A node sees all channels in both bandwidths are busy, it can sense both bandwidth and could pick the one get freed earlier. The aim is to build heterogeneous smart network in Mobile Ad-hoc Network. If more channels are available to the network then that particular node becomes most preferred by others and gets overused. It puts an individual node and entire

network is at risk. Certain amendment has to be done before starting the communication. So, apart from channel sensing, finding the residual energy of a node also has to be considered.

B. Next Hop Selection

In ad-hoc network the contribution of all nodes is needed for successful delivery of packets. Minimum number of hops between source and destination is most preferred in ad-hoc network. Earlier on-demand reactive routing protocols were designed to find minimum hop count. This minimum hop count may not be healthy in terms of battery, residual energy etc. If those nodes further treated as next hop by any node would cause a node to die earlier. So battery consumption, transmitting power and receiving power of the node are added as parameters to shape the routing.

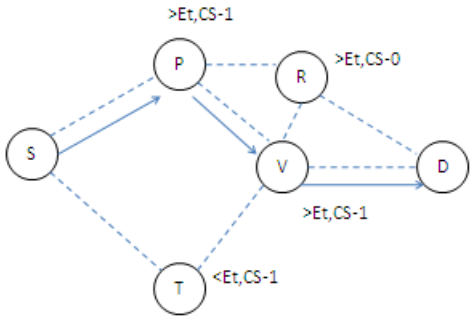

Figure 2: Route discovery

Route discovery process as per the proposed Poisson method has been demonstrated in Figure 2. Source node floods its request to all its neighbors and this process would be repeated till it reaches its destination. After finding the available nodes in between the source and the destination, each node selects its neighbor based on two factors. One is residual Energy (E) and another factor is rated above certain threshold level (Et) then it might be selected as next hop. CS indicates the channel select. If it is set then particular node can be chosen. Source node S finds P and T available next to it. Node T has low residual energy, so it is avoided and P was preferred. Similarly node P has two nodes R and V; here node V will be chosen since node R does not have any channel free. Any node with sufficient residual energy and channel availability in any of available bandwidth would be chosen as next hop and ensure the end to end delivery and prolonged lifetime. There is only one single intermediate node is available and multiple users or nodes need to interact with that, it is achievable by implementing heterogeneous node.

C. PB-EEP Algorithm

1. Flood Request packet wait till TTL (TL) expire.
2. If route reply received, find the energy efficient next hop NE. Where NE € {Emax, ETmax, CS}
3. Each node Ni finds energy efficient neighbor Ni + 1.
4. Carry data packet at selected best route.
5. Sense number of packets carried by intermediate node Ni + 1.
6. If traffic handled Th > Tl, send congestion indication to node Ni - 1, else continue step 5 for every certain period.
7. If Th is high then stop sending new packets to that node and continue with step 1.

4. HARDWARE IMPLEMENTATION

Number of wireless ad-hoc network has been created in real time for experimentation. Each node composed of PIC16f877a, MC1322x inbuilt Tarang- p20 and RF transceiver module. Heterogeneous network has been created by Tarang free scalar and RF module. While RF module communicates at 433MHz, Tarang communicates at Zigbee wireless protocol and lies at bandwidth 2.405 GHz to 2.485 GHz. Tarang is the low power device drive at 40mA current and 3.3v and consumes less than a watt power. It internally has MC1322x, a 32 bit arm 7 processor and it offers 16 channels in available bandwidth.

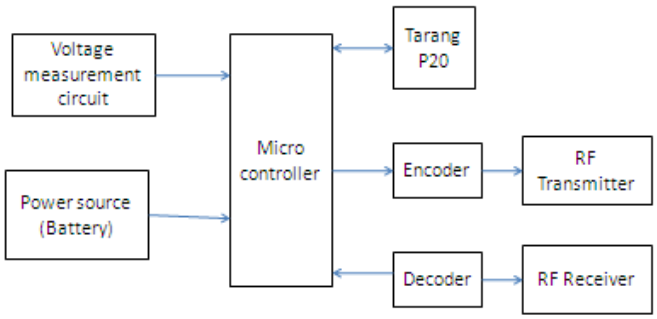

Figure 3: Node setup

RF module is an 8 bit addressable encoder HT12E in transmitter side. Encoder takes data, parallel-in and sends serial-out to transmitter module. Serially received data by RF receiver and sent to decoder HT12D. Decoder converts serial in data to parallel-out. These parallel-out data can be directly given as parallel-in to the controller in receiver side. Both the wireless modules are communicating at two different frequencies such as 2.4GHz and 433MHz connected to every node in network and form heterogeneous network. If any node is busy with the channel in 2.4 GHz then it can be called and communicated via 433MHz. (Figure 4)

Micro controller acts as master controller and it is programmed to perform next hop selection based on Poisson algorithm. PIC16F877a is an 8 bit microcontroller has been programmed using Poisson algorithm. It has 8K flash memory and 368 byte data memory. It affords serial interrupt and the data received at wireless gets into the controller serially and manipulated and computed, then resulting data sent serially out from controller in Tarang. During implementation UART (Universal asynchronous receiver transmitter) communication were used between tarang-p20 and controller.

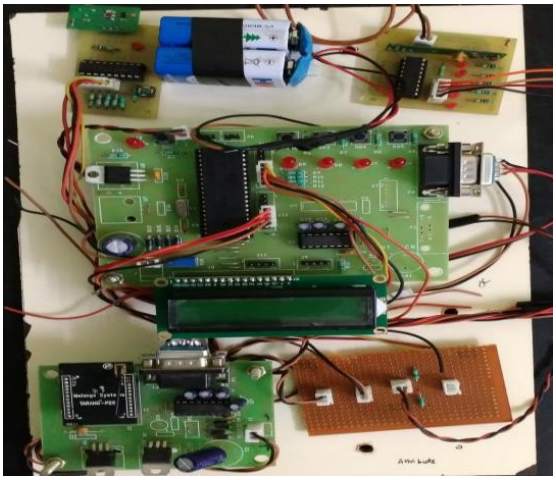

Figure 4: Hardware Setup

A level converter was used to manage two different voltage signals from P-20 and controller. 18V battery was used to drive the entire hardware. Residual energy of a node can be predicted by voltage divider circuit and these results in analog signal. This analog signal is converted by ADC (Analog to Digital converter) and subjected to the next hop selection process. (Figure 4)

5. RESULT & DISCUSSION

Network parameters depend on the global parameters in all nodes. The network characteristics are relying on each and every node in the network. Node located at the centre of the network would be saved to drive longer. In MANET, even play off of a single node can cause network division. Network life time is related to the existence of an intermediary node, which has more number of neighbors and a node, which has carried more number of packets. i.e. time over which, first drain node stays active in the network.

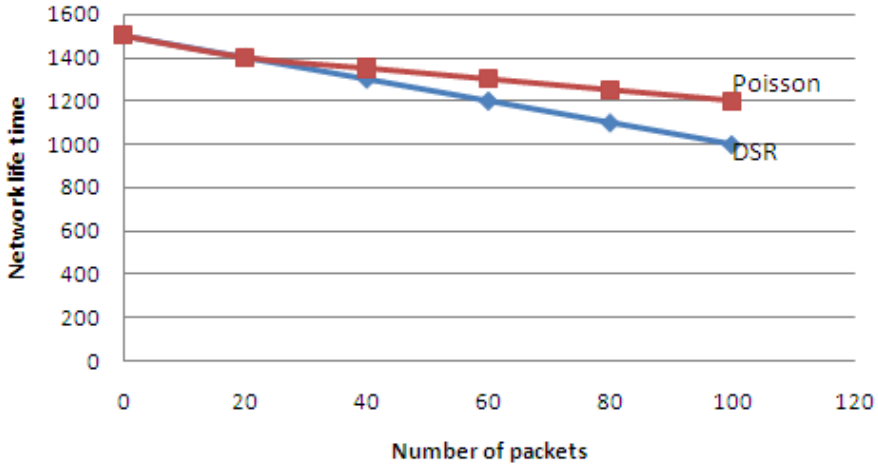

Figure 5: Network Lifetime

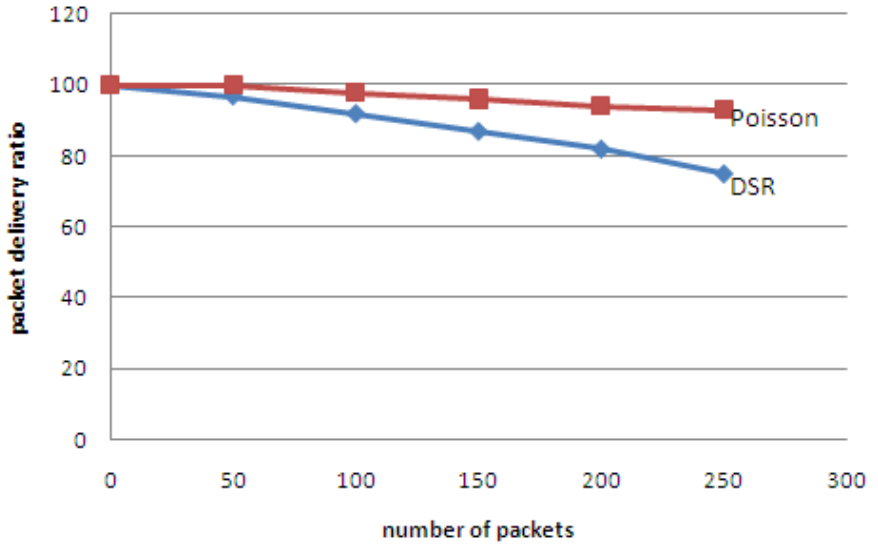

Figure 6: Packet delivery Ratio

The residual energy decides how long a node will be active. The aim is to avoid sending data packets via low power node. A high power node can best utilized by accessing two bandwidth zones. Figure 5 shows the

network life time increases as number of packets increases using Poisson algorithm. The result shows considerable improvement than earlier DSR. Data packet with constant size has been sent from in frequent interval and their delivery ratio were recorded and plotted in Figure 6 Smart heterogeneous route selection based on Poisson process had worked efficiently in wireless network.

6. SIMULATION RESULTS

Analysis of Performance between PB-EEP and DSR

NS-2 simulator is used to evaluate the performance of proposed algorithm. The simulation is carried out with 30 mobile nodes which move in a 500 meter × 500 meter rectangular region for 300 seconds simulation time. It is assumed that every node in the mobile network moves independently with the same normal speed. All nodes have the similar broadcast range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). The random waypoint model is used to simulate nodes movement.

The motion is characterized by two factors: the maximum speed and the pause time. The pause time is defined as the period of time a node stays stationary before heading for a new random location. Each node starts moving from its initial position to a node speed is uniformly distributed between zero and the maximum speed. The following table lists the simulation parameters and the environment used. The packet delivery ratio, delay, throughput and energy level have been analyzed for the proposed algorithm PB-EEP with conventional DSR algorithm. Observed results are discussed below.

Table 1
Simulation Scenario

Simulation Terrain Dimension	500 x 500 meters
Transmission Range	230m
Mobility model	Random way point
Number of Nodes	30
Node speed	0-10 m/s
Routing protocols	DSR, PB-EEP
Traffic Source Model	Constant Bit Rate
Channel Data Rate	2 Mbps
Initial Energy	20 Joules

Results Obtained

Packet Delivery Ratio: It is the ratio of amount of data packets received by the destination and the total number of packets sent by the source. It is observed that the proposed protocol which has the better PDR compared to DSR and provides good performance.

$$\text{Packet Delivery Ratio} = \text{Packets Received/Packets Generated}$$

Throughput: Throughput is defined as the amount of valuable packets that expected at all the destination nodes in a unit time. Throughput of a source node to destination node is:

$$\text{Throughput} = \text{No. of bits from source node to destination node/Duration}$$

Throughput is measured for PB-EEP and comparison result is shown below.

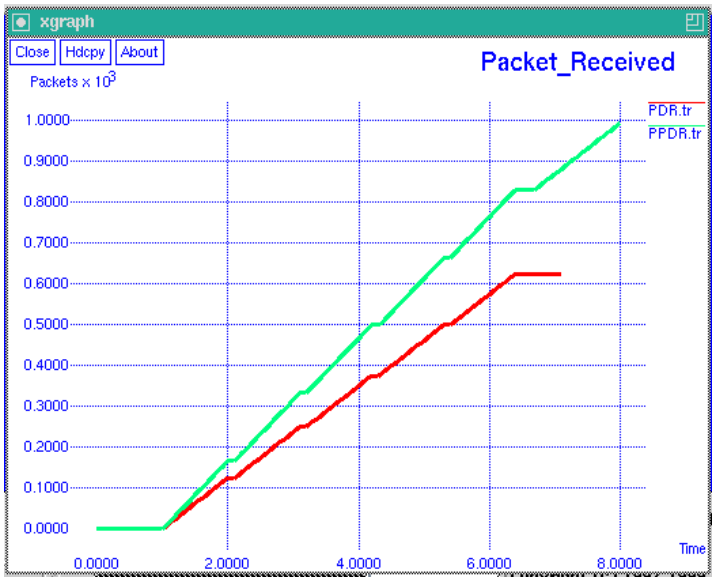

Figure 7: Packet Delivery Ratio of PB-EEP and DSR

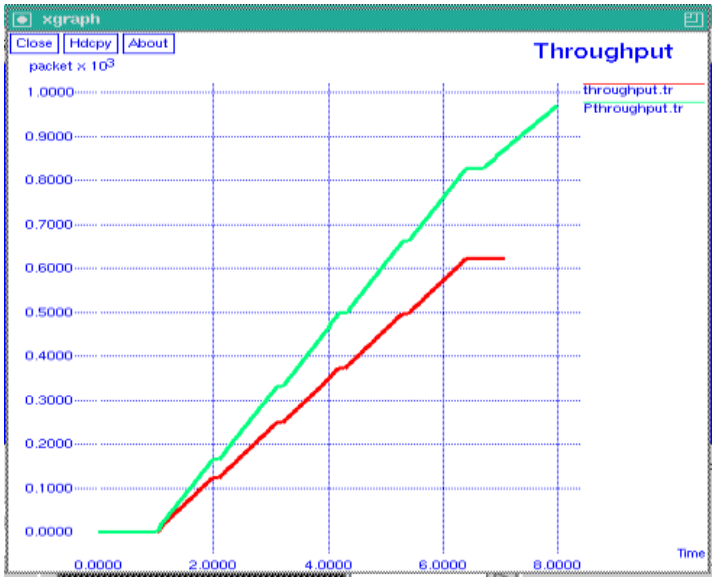

Figure 8: Throughput of PB-EEP and DSR

End-to-End Delay: It is the interval time between sending data by the source node and receiving data by destination node. The PB- EEP takes less time for sending data from source to destination node and proved that it is better than DSR protocol and provides good results.

$$\text{End to End Delay} = \Sigma(\text{Arrival time-sent time})/\Sigma(\text{No of Connections})$$

Energy: The energy in a node has a primary value that is the point of energy the node has at the beginning of transmission. This energy is termed as initial_Energy. It is the ratio of the amount of energy consumed per successfully delivered packet over that of topology control. In simulation, the value of initial_Energy is passed as an input. A node looses a specific amount of energy for each packet communicated and every packet received. The current value of energy by applying PB- EEP with DSR is observed using NS-2. It is proved that PB-EEP outperforms DSR.

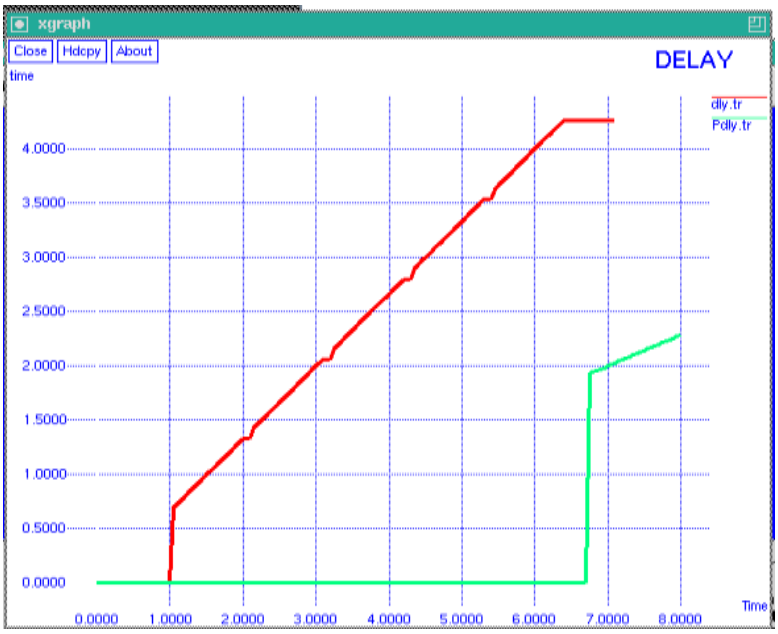

Figure 9: End-to-End Delay of PB-EEP and DSR

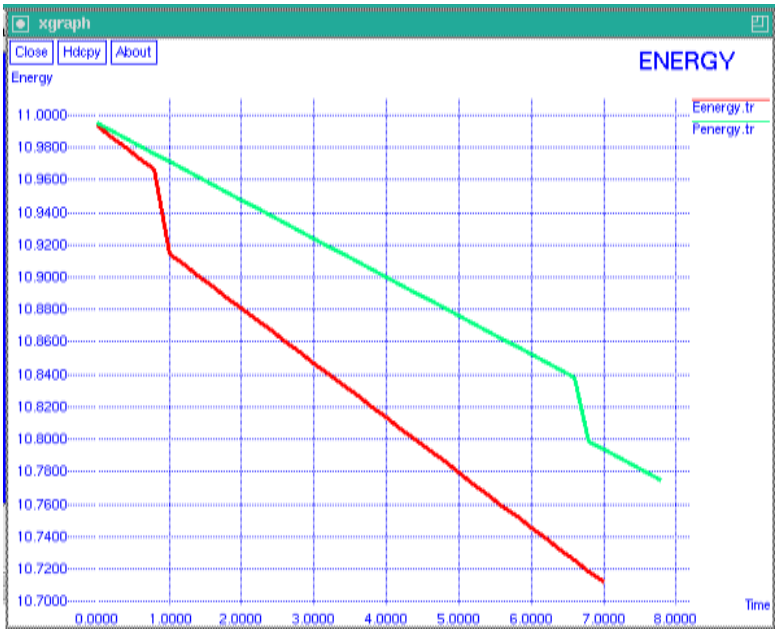

Figure 10: Comparison of Energy with PB-EEP and DSR

7. CONCLUSION

The Energy-Efficient optimized routing is proposed in this paper improves the QoS characteristics like throughput, packet delivery ratio and end-to-end delay. The proposed algorithm selects the energy efficient path with minimum delay and maximum energy nodes using Poisson distribution. The PB-EEP produces better results than the traditional DSR in terms of packet delivery ratio, end-to-end delay, and residual energy at nodes and optimized routing load. The hardware implementation is also tested in real time and observed that PB- EEP outperforms DSR routing protocol.

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