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# Performance Evaluation and Investigation of Energy in AODV, OLSR Protocols through Simulation

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## Abstract

***A mobile ad hoc network (MANET) consists of mobile wireless nodes. The communication between these mobile nodes is carried out without any centralized control. The nodes forming a temporary network without using any centralized access point or administration. MANET protocols have to face high challenges due to dynamically changing topologies, low transmission power and asymmetric links of network. MANET is an unstructured network. The main classes of MANET routing protocols are Proactive, Reactive and Hybrid. In this paper we compare performance evaluation of energy in terms of transmit, receive and ideal modes using proactive routing protocol by focusing on Optimized Link State Routing (OLSR) and reactive Routing Protocol, Ad Hoc On Demand Distance Vector (AODV). It is useful when dealing with wireless devices in which some of the devices are part of network only for duration of a communication session. An attempt has been made to compare the performance of three protocols AODV and OLSR. Comparison is made on the basis of Average Jitter, End to end delay, energy in transmit, receive and ideal modes and the simulator used is QualNet 5.0. In this paper we have taken all the scenarios for simulation and then analyzed the results and are given with graphical representation. AODV shows the best performance with its ability to maintain connection by periodic exchange of information required for TCP network and also best in case of Average Jitter, End to end delay, energy in transmit, receive and ideal modes. In addition we suggest one power aware technique which will reduce power consumption as well as increase the lifetime of node and network.***

**Keywords:** MANETS, IETF, AODV, OLSR, Energy Aware, QualNet

## 1. INTRODUCTION

Wireless networks have continued to play important roles in day to day communication. It is broadly used in military applications, industrial applications and even in personal area networks. It has been very popular in different applications in view of its different valuable attributes which includes simplicity of installation, reliability, cost, bandwidth, total required power, security and performance of the network. Ad-hoc networks can be classified into three categories depending on their applications: Mobile Ad-hoc Networks (MANETs), Wireless Mesh Networks (WMNs) and Wireless Sensor Networks (WSN). A MANET is an autonomous collection of mobile nodes; these nodes are struggling to manage with the normal effect of radio communication channels, multi-user interference, multi-path fading, shadowing etc. MANET is an infrastructure less collection of mobile nodes that can arbitrarily change their geographical locations such as these networks have dynamic topologies which are composed of bandwidth constrained wireless links. Nowadays, next generation wireless ad-hoc networks are widely used because of user base of independent mobile users, need for efficient and dynamic communication in emergency/rescue operations, disaster relief efforts, and military networks and also for different applications. Ad-hoc networks are the quick remedy for any disaster situation [1]. MANET is a collection of mobile network nodes with the capability of transmitting & receiving information wirelessly. Three types of mobile wireless networks exist: infrastructure-networks, ad-hoc networks and hybrid networks. An infrastructure-network consists of a group of mobile nodes with some bridges. These bridges called base-stations connect the wireless network to the wired network. Communication takes place between two or more nodes by first searching for the nearest base-station and information flow takes place between the two nodes with the base-station as a bridge between them. In ad-hoc networks, there are no centralized base-stations, fixed routers and central administration. All nodes move randomly and are capable of discovering and maintaining the routes between them. A hybrid-network makes use of both the networks: infrastructure and ad-hoc networks. The nodes in ad hoc network have routing capabilities and forward traffic for other communicating parties that are not within each other's transmission range. They are characterized by lower computing and energy resources. Therefore, ad hoc routing is challenged by power and bandwidth constraints, as well as by frequent changes in topology, to which it must adapt and converge quickly [2].

**Applications:**
- Emergency search and- rescue operations
- Decision making in the battlefield

- Data acquisition operations in hostile terrain, etc.

**Challenges:**

- Dynamic topology
- Multi-hop communication
- Limited resources (bandwidth, CPU, battery, etc.)
- Limited security

These above characteristics put special challenges in routing protocol design. The one of the most important objectives of MANET routing protocol is to maximize energy efficiency, since nodes in MANET depend on limited energy resources. Devices used in the ad hoc wireless networks in most cases require portability and hence they also have size and weight constraints along with the restrictions on the power source. Increasing the battery power may make the nodes bulky and less portable. The energy efficiency remains an important design consideration for these networks. Routing is the process of establishing path and forwarding packets from source node to destination node. It consists of two steps, route selection for various source-sink pairs and delivery of data packets to the correct destination [3] [4] [5].

**Objectives of MANET Routing Protocols saving energy:**

- To maximize network throughput
- To maximize network lifetime
- To minimize delay
- To minimize battery consumption.

The network throughput is usually measured by packet delivery ratio whereas the most significant contribution to energy consumption is calculated by routing overhead which is the number or size of routing control packets. A major challenge that a routing protocol designed for ad hoc wireless networks faces is resource constraints. The power level basically affects many features of the process in the network together with the throughput of the network. Power control also affects the conflict for the medium and the number of hops and it will change the delay time. Transmission power also influences the important metric of energy consumptions. Therefore the energy efficient protocol is must to increase the lifetime of node as well as the lifetime of network. So the designed Ad Hoc routing protocol must meet all these challenges to give the average performance in every case. Routing is the process of path establishment and packet forwarding from source node to destination node. It carried out in two steps, first selecting the route for different pair of source-destination and delivers the data packets to the target node. Various protocols and data structures are available to maintain the routes and to execute this process. Routing in ad-hoc networks has some distinct characteristics such as, Energy of node which depends on the limited power supply of battery, Mobility of the nodes which may reason of the frequent route failures and Wireless channels required variable bandwidth compare to wired network. The key solution for the above requirements is energy efficient routing protocols [6].

In the protocols the energy efficiency can be achieved by using efficient metric for selection of route such as cost, node energy, and battery consumption. The energy efficiency is not proposed only on the less power consumption, it is also focuses on increasing the life time of node where network maintains certain performance level. Recently it is reported in the literature that energy efficiency can be made at all layer of the network protocol stack. Various study recommended different techniques for handling the energy issue. In this paper we investigates the features of few protocols (AODV and OLSR ) which increase the network lifetime and performance and propose a technique to minimize the consumption of energy as well as increase the lifetime of network. The technique recommended pertain power control at node level to condense the transmission power of a node and energy-inefficient nodes are detached to increase network lifetime. The rest of the paper structured as follows. Section 2 proposed power aware technique. Section 3 addressed on the classification of routing techniques based on different approaches and conventional properties of various routing. Section 4 proposed energy efficient technique is discussed. Section 5 simulation setup and result analysis and finally Section 6 concludes the paper.

## 2. PROPOSED POWER AWARE TECHNIQUE

In this part we present the outline of our proposed power aware technique. The algorithm which combines both energy consumption and shortest path for route algorithms and it also consider the node's residual capacity. In this regard as a network we consist of N nodes organized at randomly in the given area 1500X1500m$^2$. We assume that all nodes may transmit at any power level P which is ≤ Pmax [4].All nodes that wish for transmission in the current session should have the minimum residual energy that is 15% of maximal battery capacity. We also assume that all nodes maintain their residual capacity at all the time and have maximum bandwidth resources. When the node has capacity which is less than 15% of initial capacity, we push the node become in the sleep mode and marked it as rationally dead. It cannot forward packets to any further extent, but still it has enough energy to send packets. The node which marked as rationally dead can forward the high priority packet when this node is the only node that can forward the packet to destination node. After boost few packets in this emergency stage the node to become referred as actually dead [7] [8]. The algorithms proposed so far are minimize energy consumption per packet, consequently it minimize the total power needed to transmit a packet in a established route, or the algorithms focus on load distribution where the objective is to extend the minimum lifetime for the node. On the other hand, minimizing energy consumption is not taking care of the residual capacity of nodes, which decreases the life time of node when the traffic through the node is higher. Thus using power aware algorithm may exhaust all their energy very fast and die within a short period of time. On the other hand, when load distribution algorithms are used with the main consideration of power by each node, not taking into account the cost inspired during transmissions. It may lead to involve more number of nodes in the route. As a result, we suggested that always using the path that consists of nodes having enough residual capacity which is larger than some predefined threshold. The objective of applying both techniques is to minimize the total power consumption by avoiding nodes with minimum battery lifetimes as well as increase the lifetime of network [9].

## 3. CLASSIFICATION OF ROUTING PROTOCOLS

### *3.1 Ad-hoc on demand vector distance vector (AODV) Routing Protocol*

AODV is a reactive protocol. The reactive routing protocols do not periodically update the routing table. As an alternative, when there is some data to send, they start route discovery process through flooding which is their main routing overhead. AODV is a well known distance vector routing protocol and actually works as follows. Whenever a node wants to start communication with another node, it looks for an available path to the destination node, in its local routing table. If there is no path available, then it broadcasts a route request (RREQ) message to its neighbourhood. Any node that receives this message looks for a path leading to the destination node. If there is no path then, it re-broadcasts the RREQ message and sets up a path leading to RREQ originating node [10]. This helps in establishing the end to end path when the same node receives route reply (RREP) message. Every node follows this process until this RREQ message reaches to a node which has a valid path to the destination node or RREQ message reaches to the destination node itself. Either way the RREQ receiving node will send a RREP to the sender of RREQ message. In this way, the RREP message arrives at the source node, which originally issued RREQ message. At the end of this request-reply process a path between source and destination node is created and is available for further communication. In scenarios where there is no route error (RERR) message is issued for nodes that potentially received its RREP message. This message helps to update or recalculate the path when an intermediate node leaves a network or loses its next hop neighbour. Every node using AODV maintains a routing table, which contains the following information: a next hop node, a sequence number and a hop count. All packets destined to the destination node are sent to the next hop node. The hop count represents the current distance between the source and the destination node. It is important to understand that AODV does not introduce routing overhead, until a RREQ is made [11] [12].

### *3.2 Optimized Link State Routing (OLSR) Protocol*

OLSR is the proactive routing protocol which we are evaluated and implement here. Proactive routing protocols continuously update the routing table, thus generating continued routing overhead. Basically OLSR is an optimization of the classical link state algorithm adapted for the use in wireless ad hoc networks. In OLSR, three levels of optimization are achieved [13].

- Multipoint Relays (MPRs) to broadcast the messages during the flooding process. Every node broadcasts the messages and generates too much overhead traffic.
- Optimization is achieved by using only MPRs to generate link state information. This results in minimizing the "number" of control messages flooded in the network.
- Optimization an MPR can choose to report only links between itself and those nodes which have selected it as their MPR.

OLSR periodically exchanges topology information with other nodes at regular intervals. MPRs play a major role in the functionality of the protocol. Every node selects a subset of its one hop neighbour nodes as MPR. MPRs periodically announce in the network that it has reach ability to the nodes which have selected it as an MPR. Nodes which are not selected as MPR by any node, will not broadcast information received from it. The functionality of OLSR lies in the exchange of HELLO and TC messages [12]. The periodic dissemination of HELLO packets also enables a node to know whether a node or a set of nodes have selected it as MPR. This information is known as 'Multipoint Relay Selector Set', and is critical to determine whether to broadcast forward the information received from a node(s) or not. In a dynamic and rapidly changing environment, this set of nodes can change over the time. HELLO messages are also used for link sensing and neighbourhood detection. TC messages are used to provide every node enough link-state information for the calculation of routes. Basically, a TC message is sent by a node to advertise a set of links, which includes the links to all nodes of its MPR selector set. TC message is only broadcast forwarded by MRPs and offers controlled flooding of the topology information into the whole network. OLSR is designed to support large and dense wireless networks. Due to its proactive nature, OLSR periodically generates overhead traffic. Although it is helpful in avoiding initial latency involved with route discovery, it uses precious network bandwidth for its control traffic. But it is a sustained overhead, and does not start suddenly as is the case with reactive protocols, when they start flooding the network with their control information with some application data packets waiting.

Over the years, both reactive and proactive routing protocols have been used to enable communication in wireless ad hoc networks [13].

**TABLE 1:** COMPARISON OF DIFFERENT ROUTING PROTOCOLS

| | AODV (REACTIVE) | OLSR (PROACTIVE) |
|---|---|---|
| Hello message requirement | Yes | No |
| Update Destination | Source | Neighbors |
| Routing Strategy | Distance vector | link state |
| Method of Communication | Unicast | Broadcast |

## 4. TECHNIQUES OF ENERGY AWARE ROUTING PROTOCOLS

Power Management, Transmission power control and load sharing are the approaches to minimize the energy on active communication and inactive /power-down move toward to minimize energy during immobility. The protocols are designed based on the energy related metrics like energy consumed per packet to provide the minimum power path which is used to minimize the overall energy consumption for delivering packet. The next important metric is inconsistency in nodes power level which is a simple indication of energy balance and in turn it can be used to extend network lifetime [12].

**TABLE 2:** TECHNIQUES BASED ON DIFFERENT ENERGY AWARE CONVENTIONAL PROPERTIES

| CONDITIONS | NAME OF PROCESS | PURPOSE |
|---|---|---|
| Minimize Active Communication Energy | Power management | Minimize the energy consumption by using separate channels for data and control |
| | Transmission power control | The total transmission energy is minimized by avoiding low energy nodes. |
| | Load sharing | Share load to energy in comfortable nodes. |
| Minimize immobility Energy | inactive/power-Down mode | Minimize the energy consumption when node in an idle state. |

The routing protocols available under the technique transmission power optimization is maintain additional information at each node other than that acquired during operation such as link costs of all edges , costs of all nodes and data generation rate at all nodes . With the help of the information available the protocol select the max -min path among a number of best min-power paths and few protocols regulate the transmission power just enough to reach the next hop node in the given routing path. The objective of the load distribution approach is to balance the energy usage of all nodes by selecting a route with nodes which are not used frequently instead of the shortest route. The result of this approach may involve more nodes in a route but packets are routed only through energy comfortable intermediary nodes. Protocols based on this approach are not necessarily offer the lowest energy route, but prevent certain nodes from being overloaded, and guarantees for longer network lifetime. One of such protocol is named as Localized Energy-Aware Routing (LEAR). The LEAR routing protocol is conflict from reactive routing protocol (RRP) in the process of route discovery procedure for balanced energy consumption. In reactive routing protocol (RRP), when a node receives a route-request message, it attaches its identity in the header of message and forwards it in the direction of destination. Therefore, an intermediate node always relay messages if the corresponding route is selected. On the other hand, in LEAR, a node has to decide whether to forward the route -request message or not depends on its residual energy. If the residual energy is higher than a threshold value, then the node forwards the route-request message. Otherwise, it abandons the message and decline to participate in transmitting packets. Consequently, the destination node will receive a route-request message only when all intermediate nodes in the route have good energy levels, and nodes with low energy levels can preserve their battery power [11].

The Power Management Based Protocols are focused to achieve the energy efficiency goal by using two separate channels, one channel for control and another for data. RTS/CTS signals are transmitted through the control channel while data are transmitted over data channel. The protocol named power aware multi-access protocol (PAMAS) in which the nodes sends a RTS message over the control channel when it ready to transmit and waits for CTS, if the CTS message not receives within a precise time then node enters to a power off state. In the receiving end, the node transmits a busy tone over the control channel to its neighbors when its data channel is busy. The control channel is used to determine when and how long the node to be in power off state. After turn to active state, a node can transmit data over the data channel. Conversely, once CTS is received, then the node transmits the data packet over the data channel. Contrasting the previous techniques discussed, the inactive/power-down mode approach focused on inactive time of communication. In MANET when all the nodes in an inactive mode packets cannot be delivered to a destination nodes [12].

## 5. SIMULATION SETUP AND RESULT ANALYSIS

The adopted methodology for the results of this work is based on simulations near to the real time packages before any authentic implementation. This work is done by simulating the scenario with the help of simulation tool QualNet. QualNet is a comprehensive suite of tools for modeling large wired and wireless networks. It uses simulation and emulation to predict the behaviour and performance of networks to improve their design, operation and management. QualNet enables users to optimize new and existing models, design and develop new protocol models. QualNet work on design large wired and wireless networks using pre-configured or user- designed models, analyze and investigations on the performance of networks and perform to optimize them. QualNet is the commercial preferable simulator for network operation and solution. So, we found QualNet be the best choice to implement our scenarios which as each and every feature possible [14].
QualNet is a commercial simulator that grew out of GloMoSim, which was developed at the University of California, Los Angeles, UCLA, and is distributed by Scalable Network Technologies. The QualNet simulator is C++ based. All protocols are implemented in a series of C++ files and are called by the simulation kernel. QualNet comes with a java based graphical user interface (GUI).It must be noted that QualNet is a discrete event simulator which provides a good balance between ease of use and extensibility and power in terms of what scenarios can be simulated [14]. Table 2 shows the parameters and values which we are taking for our designed scenario.

**TABLE: 3** PARAMETERS USED FOR DESIGNING A SCENARIO OF ENERGY ANALYSIS

| **Parameters** | **Value** |
|---|---|
| Channel Type | channel/wireless channel |
| MAC type | IEEE 802.11 |
| Antenna Type | Omni-directional Antenna |
| Network Layer | LL |
| Network Layer | PHY wireless |
| MAC protocol | Mac/802.11 |
| Network interface type | Physical/ Wireless Phy |
| No of Nodes | 40 |
| Radio-propagation model | Two Ray Ground |
| Topological area | 1500 x 1500 $m^2$ |
| Simulation time | 300 sec. |
| Energy Model | MICA-MOTES (Linear Model) |
| Routing protocols | AODV and OLSR |
| Initial energy of a Node | 1000.0 Joules |
| Radio type | 802.11b Radio |
| Packet Reception Model | PHY 802.11b Reception Model |
| Data Rate | 10 Mbps |
| Mobility Model | Random Way Point |
| Pause Time | 30 sec. |
| Battery Model | Linear Model |
| Item to send | 100 |
| Item Size (bytes) | 512 |

The node is moving in the random motion in the area of 1500x1500 $m^2$. When comes in specific transmission range it starts transmission between the different nodes. Here it is shown that the packet is transmitting. When overlapping of that & specific range is finish stops data transmission. The fig. 1 showed the output.

### *5.1 DESIGNING OF SCENARIO*

The QualNet simulator is used for implementing, which is having a scalable network library and gives accurate and efficient execution .The scenario is designed in such a way that it undertakes the real traffic conditions. We have chosen 60 fast moving nodes in the region of 1500X1500 $m^2$ with the random way point mobility model. There is also well defined path for some of the nodes. It shows wireless node connectivity of few nodes using CBR application. Pathloss model is two rays with maximum propagation distance of 100m. Battery model is Duracell 1500-AA.The simulation is performed with different node mobility speed and CBR (Constant bit rate) traffic flow. CBR traffic flows with 512 bytes are applied. Simulations is made in different speed utilization with IEEE 802.11 Medium access control (MAC) and Distributed Coordination Function (DCF) ad hoc mode and the channel frequency is 2.4 GHz and the data rate 2mbps. The network protocol here applied is Internet Protocol version four (IPv4). By this proposed topology the failure of node can be easily detected and it gives the way for the accuracy in their performance. The snapshot of the simulated scenario is shown in Fig 1.

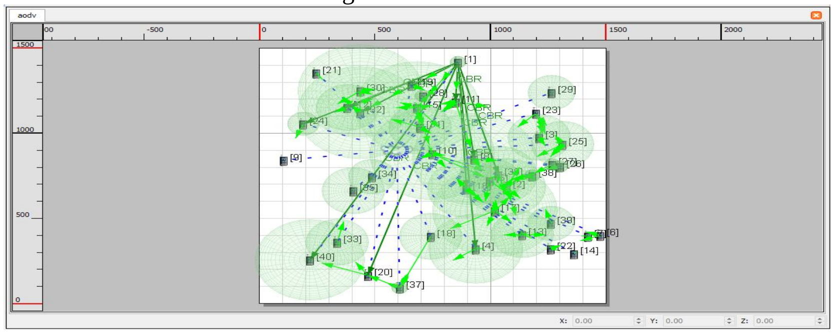

**Figure 1** shows the snapshot of AODV routing protocol (1-40) nodes.

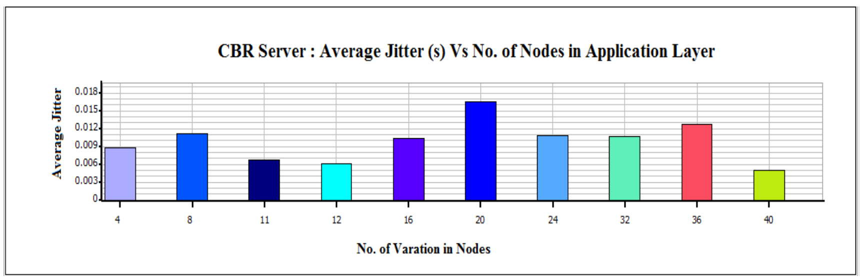


**Figure 2** Shows the Average jitter in application layer of OLSR routing protocol CBR.

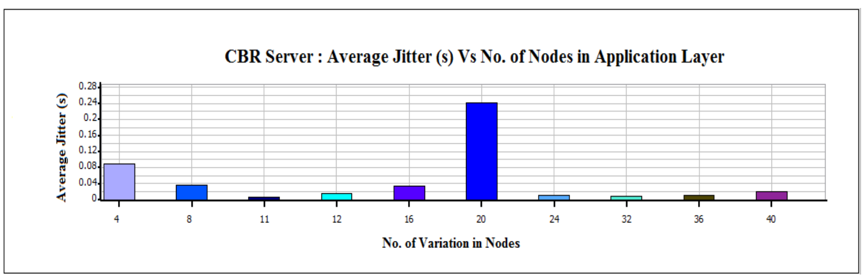


**Figure 3** Shows the Average jitter in application layer of AODV routing protocol CBR.

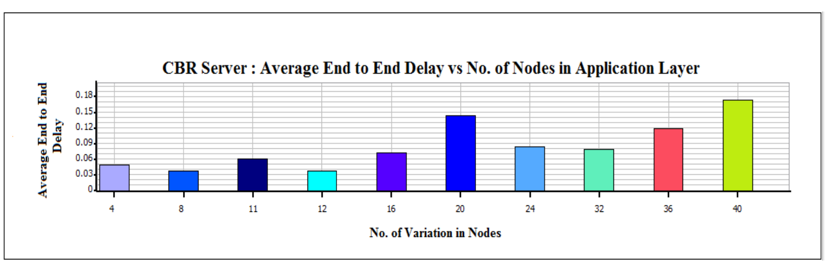


**Figure 4** Shows the Average End to End Delay in application layer of OLSR routing protocol CBR.

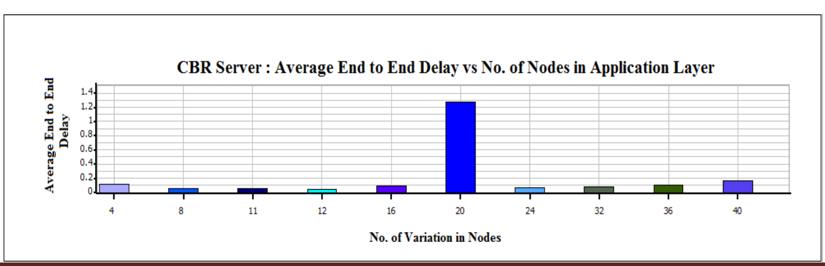

**Figure 5** Shows the Average End to End Delay in application layer of AODV routing protocol CBR.

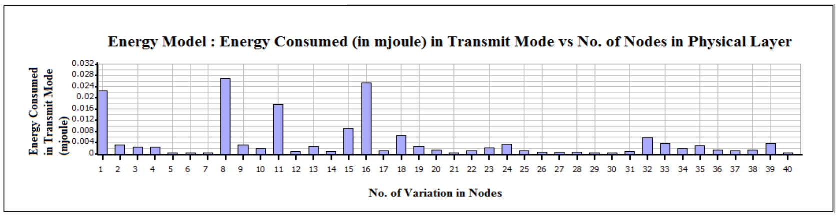


**Figure 6** Shows the Energy consumed in transmit mode in physical layer of OLSR routing protocol.

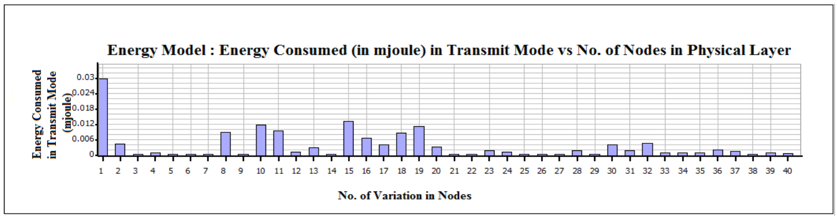


**Figure 7** Shows the Energy consumed in transmit mode in physical layer of AODV routing protocol.

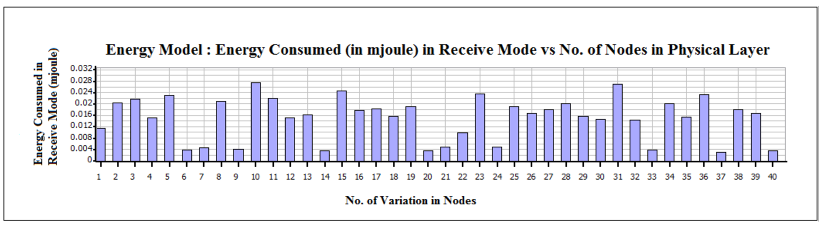


**Figure 8** Shows the Energy consumed in receive mode in physical layer of OLSR routing protocol.

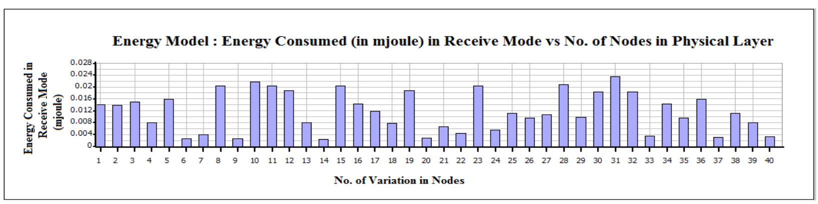


**Figure 9** Shows the Energy consumed in receive mode in physical layer of AODV routing protocol.

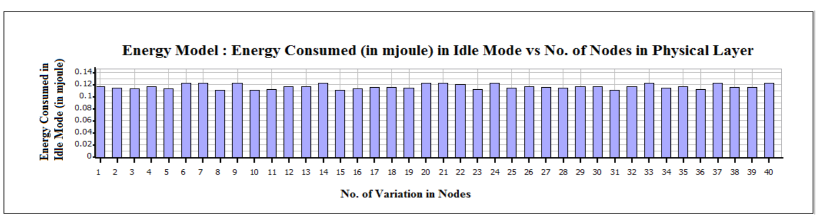


**Figure 10** Shows the Energy consumed in idle mode in physical layer of OLSR routing protocol.

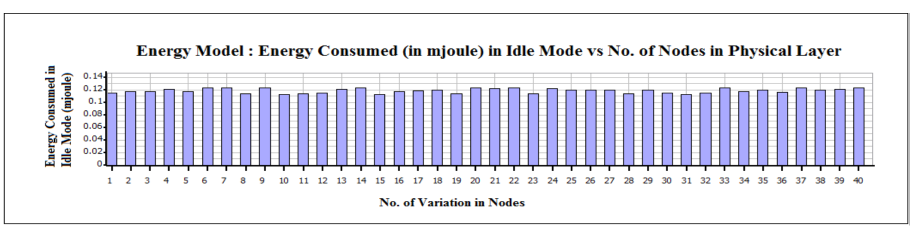


**Figure 11** Shows the Energy consumed in idle mode in physical layer of AODV routing protocol.

## 6. Conclusion

In Mobile Ad Hoc network (MANET) energy efficiency is one of the main problems, particularly in designing a routing protocol. In this paper, we surveyed and classified a number of energy aware conventional routing techniques. Each technique has its own assumptions and different objectives and different methodologies in the implementation. For instance, in the transmission power control approach the power level is essential but the cost is not considered. The load distribution approach is efficient to improve the energy imbalance problem. There are different channels for sending data and control packets to reduce the energy consumption in power management approach but it increase the network traffic. The output shows the AODV is better than OLSR in terms of Average Jitter, Average End to End Delay and Energy consumption in all modes of physical layer in the network so, in terms of performance efficiency is also higher compare to OLSR routing are shown in graphical representation.

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