Power Management in Optimized Link State Routing (OLSR) Protocol

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Abstract: *In most pioneering topics in computer communications is wireless networking. One area in wireless networking is mobile ad hoc networking. The concept of mobile ad hoc networking is based on the fact that users can communicate with each other in network, without any form of centralized administration. In a mobile ad hoc network, nodes are often powered by batteries. Every message can send and every computation performed drains the battery life. One solution for power conservation in mobile ad hoc network is power management. This means that routing decisions made by the routing protocol should be based on the power-status of the nodes. Nodes with low batteries will be less preferably for forwarding packets than nodes with full batteries, thus increasing the life of the nodes. A routing protocol should try to minimize control traffic, such as periodic update messages to improve the lifetime of the nodes and network. Power management in wireless networks deals with the process of managing energy resources by means of controlling the battery discharge, adjusting the transmission power, and scheduling of power sources. We efforts to solve this problem here we can describe the power management issues in mobile nodes to modified Optimized Link State Routing (OLSR) protocol and it was designed on QualNet 5.0 simulator. The modification is done in effect of power management issue in modified OLSR and existing OLSR routing protocol with the metrics like power consumes in all three modes transmit, received and ideal modes, TC message received, Hello message received, signal received and forward to MAC, signal received but with errors and power consumption have been used. For simulation purpose QualNet5.0 has been used as the tool.*

Keywords: *Ad hoc wireless Networks, Power Management, Optimized Link State Routing (OLSR), QualNet 5.0 simulator.*

I. INTRODUCTION

Wireless sensor networks (WSN's) have attracted a great deal of research attention due to their wide-range of prospective applications. Applications of wireless sensor networks contain battlefield surveillance, medical monitoring, biological detection, inventory tracking and home security. This type of network consists of collection of nodes and each node has limited battery power capacity. There may be many possible routes available between two nodes over which data can be able to flow. Assume that each node generated some information and this information needs to be delivered to a destination node. Any node in the network can easily transmit their data packet to a distance node, if it has enough battery power. If any node is far from its neighbour node then large amount of transmission power is required to transmit the data from source to destination. After every transmission, remaining power of this node decreases and some amounts of data transmission of this node will be eliminated from the network because of empty battery power and in similar situation there will be a condition that no node is available for data transmission and overall lifetime of network will decreases [1].

Existing power awareness routing protocols can generally classified as a power management or power control protocol. In IEEE 802.11 there is already a type of power management implemented. The implantation of power awareness routing in this task is only focusing on power control management schemes. However, to make power management schemes for mobile ad hoc networks is most effective, an efficient message routing algorithms, coupled with good solutions for optimizing power consumption during the transmit, received and idle modes of data. In power control routing protocols several metrics can be used to optimize power management in routing. Minimizing the energy consumed for each message is an evident solution that optimizes locally the power consumption. An effective routing protocol should not only focus on individual nodes in the system but also focus on the system as a whole. The nodes have high residual power but the system is not connected because some critical nodes have been depleted of power. Different routing schemes can be utilized, but the two most extreme solutions to power awareness routing for a message are [1] [2]:

- Compute a path that maximizes the minimal power consumption; the path that requires the least power to transmit and receive a message, hereby keeping the power consumption needed to communicate as low as possible [3].
- Compute a path that maximizes the minimal residual power in the network; the path according to the residual energy of the nodes, hereby maximizing the lifetime of all nodes and the lifetime of the network.

In particular, Section II presents the need for power management in mobile ad-hoc networks and optimization of power. Section III briefly discusses the MANET routing protocols and functionality of Optimized Link State Routing (OLSR). Section IV Simulation platform and models, result analysis are discussed in Section V. Finally, Section VI conclusion and future work.

II. NEED FOR POWER MANAGEMENT IN MANETS

The nodes in an ad hoc wireless network are constrained but limited battery power for their operation. Hence, power management is an important issue in ad hoc networks. Power management is the process of managing power resources by means of controlling the battery recharge, adjusting the transmission power, and scheduling of power sources so as to increase the lifetime of the nodes of an ad hoc wireless network. The power efficiency of a node is defined as the ratio of the amount of data delivered but the node to the total power finished [3] [12].

The reasons for power management in ad hoc wireless networks are:

- Increasing gap between the power consumption and requirements of power availability, so need to the power management.
- Difficult to replace or recharge the batteries. Hence, power conservation is necessary in such scenarios.
- The relay traffic allowed through a destination node is more, and then it may leads to a faster depletion of the power source for that node.
- The best possible value for the transmission power increases the number of real-time transmissions.
- Power control is essential to maintain the required signal to interference ratio at the receiver and to increase the channel capability.
- Power consumption of a wireless radio depends on the operation mode. Four types of operation modes of a radio can be categorized: (i) transmit mode, (ii) receive mode, (iii) idle mode, and (iv) sleep mode.
- Batteries are likely to increase the size and weight of a mobile node, to reduce the size of the battery, power management techniques are necessary to utilize the maximum battery capacity in the best potential way.
- The power level of a battery is finite and limits the lifetime of a node. Every message sent and every computation performed drains the battery, need to power management in network.

A. Classification of Power Management Schemes:

To increase the life of an ad hoc wireless network, it is required to be aware of the capabilities and limitations of the power resources of the nodes. For longer lifetime of the node can be achieved by increasing the battery capacity. Increasing the capacity of the battery at the nodes can be achieved by either battery management, which concerns the internal characteristics of the battery, or power management, which deals with maximum utilization of battery capacity [4].

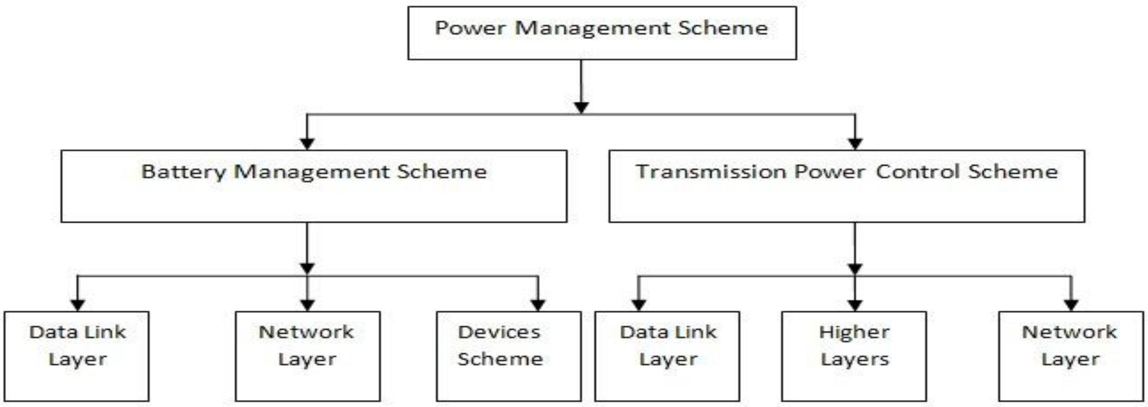

Fig. 1 Classification of Power Management Schemes

The routing protocol must be designed such a way to reduce the amount of information exchanged among the nodes, since communication incurs loss of power. Increase in the number of communication tasks also increases the traffic in the network, which results in loss of data, retransmissions, and hence more energy consumption. The power consumption occurs at the network layer is because of communication and calculation operations. The power conserved in communication operations is due to transmit-receive module present in the source and destination nodes [4] [11].

B. Optimization of power [3][8]:

In mobile ad hoc networking the optimization of power consumption can be divided according to functionality into:

- The maximum power utilized for the transmission of a message.
- The maximum power utilized for the reception of a message;
- The minimum power utilized while the system is idle.
- Reducing the access amount of data transmitted across the network.
- Lower the transceiver duty cycle range.
- Lower the frequency of data transmission.
- Reduce the frame overhead.
- Implementation of reliable power management techniques.
- Reduce redundant transmission.

- Reduce calculation overhead.
- For powerful routing protocol, reduce the number of retransmission across the network can be controlled effectively.
- Evaluating node density, congestion and network availability.
- For utilizing effective routing algorithm, network life time and energy will be conserved and redundant transmission will be reduced [13].

We suggest two corresponding optimization technique for control and manage the power consumption in ad-hoc networks:

- Optimized minimum power consumption during the idle time by switching to sleep mode; this is known as Power Management [5].
- Optimized minimum power consumption during communication, that is, while the system is transmitting and receiving messages; this is known as Power Control [5] [14].

III. MOBILE AD HOC NETWORK ROUTING PROTOCOLS

There are lots of ways to classify the MANET routing protocols depending on how the protocols to hold the packet and to deliver from source to destination. But Routing protocols are broadly classified into three types such as Proactive, Reactive and Hybrid protocols.

A. Proactive Protocols

These types of protocols are also called table driven protocols in which, the route to all the nodes is maintained in routing table. Packets are transferred over the predefined route specified in the routing table. These protocols have lower latency because all the routes are maintained at all the times. Example of Proactive protocols: Bellman Ford, DSDV, EIGRP (Enhanced Interior Gateway Routing Protocol) OLSR (Optimized Link State Routing) [6] [7].

B. Reactive Protocols

These types of protocols are also called as On Demand Routing Protocols where the routes are not predefined for routing. A Source node calls for the route discovery phase to determine a new route whenever a transmission is needed. This is a repetitive technique until it reaches the destination. Reactive techniques have smaller routing overheads but higher latency. Example of Reactive Protocols: DSR, AODV, DYMO etc [5].

C. Hybrid Protocols

Hybrid protocol is the combinations of reactive and proactive protocols and takes advantages of these two protocols and as a result, routes are found rapidly in the routing zone. Example Protocol: ZRP (Zone Routing Protocol) [10].

1) OPTIMIZED LINK STATE PROTOCOL:

The Optimized Link State Routing (OLSR) protocol, developed by the French National Institute for Research in Computer Science and Control (INRIA), was developed for mobile ad-hoc networks. It operates in a table-driven and proactive manner, i.e., topology information is exchanged between the nodes on periodic basis. Its main objective is to minimize the control traffic by selecting a small number of nodes, known as Multi Point Relays (MPR) for flooding topological information. In route calculation, these MPR nodes are used to form an optimal route from a given node to any destination in the network. This routing protocol is particularly suited for a large and dense network. OLSR generally proposes four types of periodic control messages, namely [6] [15]:

- Hello messages
- Topology Control (TC) messages
- Multiple Interface Declaration (MID) messages
- Host and Network Association (HNA) messages.

a) Hello messages:

OLSR [18] uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are periodically exchanged within the one-hop neighborhood to obtain the neighborhood information. Using this neighborhood information, each node in the network selects a subset of one-hop away neighbors known as the MPR set. In the MPR set, all two-hop away neighbors are reachable through any member of the MPR set. Hello messages are used for finding the information about the link status and the host's neighbours. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbours has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. the Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbours which includes at least the MPR Selector list.

b) Topology Control (TC) messages:

TC messages are generated and retransmitted for flooding topological information in the whole network only through MPR nodes. Also, MID and HNA messages are relayed only by MPR nodes. Therefore, OLSR optimizes the control traffic overhead by minimizing the size of the MPR set. An MPR member generates and retransmits TC messages. These messages provide each node in the network with sufficient link-state information to allow route calculation [17] [18].

c) Multiple Interface Declaration (MID) messages:

MID messages are generated by an OLSR node with multiple OLSR interfaces to notify other OLSR nodes about its interfaces participating in the OLSR routing domain. There is also Multiple Interface Declaration (MID) messages which are used for informing other host that the announcing host can have multiple OLSR interface addresses. The MID message is broadcasted throughout the entire network only by MPRs [18].

Apart from these OLSR control messages, a node associated with OLSR MANET and non-OLSR MANET periodically issues HNA messages notifying the connected non-OLSR Networks. These HNA messages are also flooded throughout the OLSR domain by the MPR nodes so that the external routes are learned by all the OLSR nodes.

Table 1 Description of OLSR parameters:

Parameters	Description
OLSR-HELLO-INTERVAL	Specifies the time interval between two consecutive HELLO messages within one-hop neighborhood to obtain the neighborhood information.
OLSR-TC-INTERVAL	Specifies the time interval between two consecutive TC messages.
OLSR-MID-INTERVAL	Specifies the time interval between two consecutive MID messages. MID messages will be broadcasted only when an OLSR node has multiple OLSR interfaces.
OLSR-HNA-INTERVAL	Specifies the time interval between two consecutive HNA messages. HNA messages will be broadcasted only when an OLSR node has non-OLSR interface.

So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes.

d) Host and Network Association (HNA) messages:

There is also a “Host and Network Association” (HNA) message which provides the external routing information by giving the possibility for routing to the external addresses. The HNA message provides information about the network- and the net mask addresses, so that OLSR host can consider that the announcing host can act as a gateway to the announcing set of addresses. The HNA is considered as a generalized version of the TC message with only difference that the TC message can inform about route canceling while HNA message information is removed only after expiration time [9].

(1) Multipoint Relays Selection:

In this section the proposed algorithm for the selection of Multipoint Relay set is described. This algorithm is found from [9]. Hello message can be chosen to act as MPR. The neighbour must be symmetric in order to become an MPR. Proposed algorithm for selecting Multipoint Relay set:

- Take all the symmetric one hop neighbours which are willing to act as an MPR.
- Calculate for every neighbour host a degree, which is a number of the symmetric neighbours, that are two hops way from the calculating source and does not include the source or its one hop neighbours.
- Add the neighbour symmetric host to the MPR set. If it is the only neighbour from which is possible to get to the specific two hop neighbour, then remove the chosen host neighbours from the two hop neighbour set.
- If there are still some hosts in the two hop neighbour set, then calculate the reach ability of the each one hop neighbour, meaning the number of the two hop neighbours, that are yet uncovered by MPR set.
- Repeat previous step until the two hop neighbours set is empty.
- For the optimization, set the hosts in the MPR set in the increasing order basing on the willingness. If one host is taken away and all the two hop neighbours,

(2) Topology Information [15]:

In order to exchange the topological information and build the topology information base the host that were selected as MPR need to sent the topology control (TC) message. The TC messages are broadcasted throughout the network and only MPR are allowed to forward TC messages. The TC messages are generated and broadcasted periodically in the network. The TC message is sent by a host in order to advertise own links in the network. The host must send at least the links of its MPR selector set. The TC message includes the own set of advertised links and the sequence number of each message.

(3) Control traffic [15]:
All OLSR control traffic is to be transmitted over UDP. This traffic is to be broadcasted when using IPv4, but no broadcast address is specified.

(4) Routing Table Calculations:
The host maintains the routing table, the routing table entries have following information: destination address, next address, number of hops to the destination and local interface address. Next address indicates the next hop host. The information is got from the topological set (from the TC messages) and from the local link information base (from the Hello messages) [15].

IV. SIMULATION PLATFORM AND MODELS

In QualNet 5.0 [16] [17], a precise network topology is referred to as a scenario. A scenario allows the user to denote all the network components and environment under which the network will operate. This includes: terrain details, channel propagation effects including path loss, battery model, fading, and shadowing, wired and wireless subnets, network devices such as hubs, switches and routers, the whole protocol stack selection of standards or user-configured network components, and applications running on the network. In this work QualNet 5.0 network simulator has been used to design modify OLSR routing protocol or an existing OLSR routing protocol of mobile ad-hoc networks. The physical medium used is 802.11 PHY with a data rate of 2 Mbps. The MAC protocol used is the 802.11 MAC protocol, configured for MANET mode. In this work wireless module of IEEE 802.11b is used to enable mobility of the wireless nodes. IEEE 802.11b support more accurate wireless models for propagation, path loss, multi-path fading and reception on wireless networks. The simulations are carried out for network densities of 100 nodes respectively in 10 intervals. The area considered for the above network densities are 1500m * 1500m. Simulations scenarios is design for modification in OLSR and existing OLSR routing protocol for power management with the metrics like power consumes in all three modes transmit, received and ideal modes, TC message received, Hello message received, signal received and forward to MAC, signal received but with errors. The parameters and description is given in table1. Fig. 2 shows the running designed scenario for modify OLSR routing protocol with number of CBR's and nodes.

Table 2: Traffic and Mobility parameters for modified OLSR routing protocol.

Parameter	Short Description	Value/Type
Topological Area	Represents topology or arrangement of mobile nodes. Determined in x & y axis. Also known as network size or dimensional area. Measured in	1500 *1500 m^2
No. of nodes	Nodes are communication devices or routers.	1-100
Pause time	The maximum amount of time, a node stays before a new direction and speed is selected	10, 20, 40
Max. speed	Maximum mobility speed of a node. Measured in meter/second.	20 m/s
Transmission range	Radio transmission range allows a mobile node to send & receive radio signals. Measured in meters	250 m
Mobility pattern	Define movement of nodes, which is characterized by speed, direction, and rate of change	Random way point
Application	Denote the traffic type to be used i.e. CBR stands for constant bit rate. Used for real time traffic.	CBR
PHY	PHY stands for physical layer. 802.11b is basically IEEE wireless standard	802.11b
Packet size	Node sends & receives data in the form of packet. Measured in kilobytes.	512 kB
Packet transmission rate	Every traffic source sends a packet at specific rate that is measured in packet/second.	2 Packets/second
Simulation time	Total duration for which simulation runs.	400 s
No. of CBR	Total number of CBR connections that can be established among different mobile nodes for communication.	10
Nodes	Mobile or fixed routers with wireless receivers or wireless transmitters which are free to move arbitrarily	100
Battery Model	Battery rate capacity effect: the model which precisely estimates non-linearity effect of rated capacity versus discharge current load.	Linear Model
Start/ End Time	Time when the conversation ends. If end time is specified as 0, then conversation continue until the end of simulation.	Variable
Simulation time	Length of simulation and time when scenario complete task.	1800 seconds

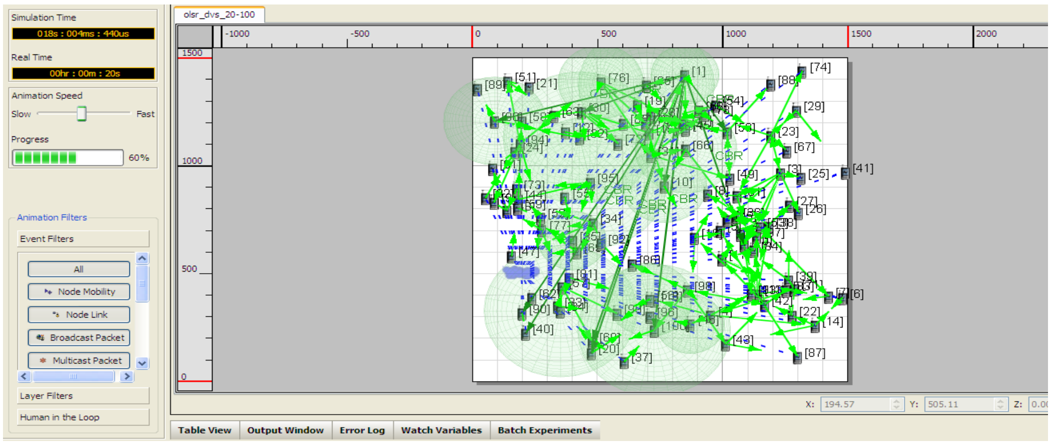

Fig. 2 Snapshot of running designed scenario for modifies OLSR routing protocol with number of CBR's and nodes.

V. RESULT AND ANALYSIS

A. TC Message Received:

Specifies the time interval between two consecutive TC messages. The TC messages are broadcasted throughout the network and only MPR are allowed to forward TC messages. The TC messages are generated and broadcasted periodically in the network. Host can increase its transmission rate to become more sensible to the possible link failures. When the change in the MPR Selector set is noticed, it indicates that the link failure has happened and the host must transmit the new TC message as soon as possible

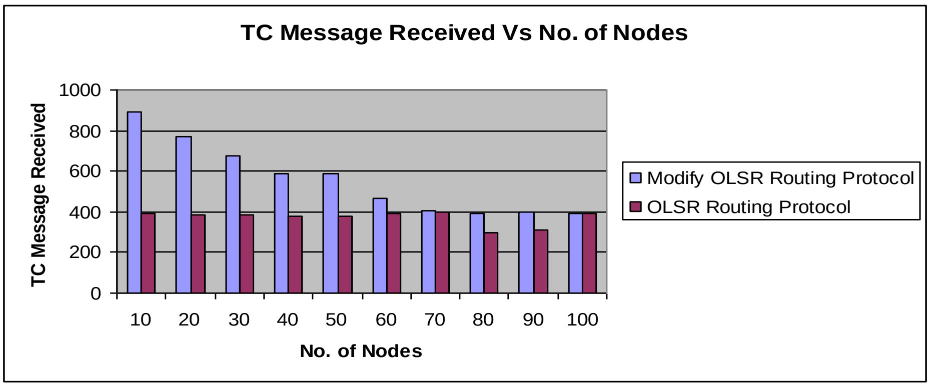

Fig. 3 TC Message received with varying nodes and OLSR routing protocols.

- Fig. 3 shows the impact variation of TC Message received with in modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- By observation from graph and analysis of designed scenario observation efforts trying minimize the link failures between nodes, so lifetime of nodes increases, and also saves power consumption. Hence overall performance of power may increases. In modified OLSR link failure less as compare OLSR routing.
- The maximum transmission rates also increase in modified OLSR and consume less power by OLSR.

B. Hello Message Received:

Specifies the time interval between two consecutive HELLO messages within one-hop neighborhood to obtain the neighborhood information.

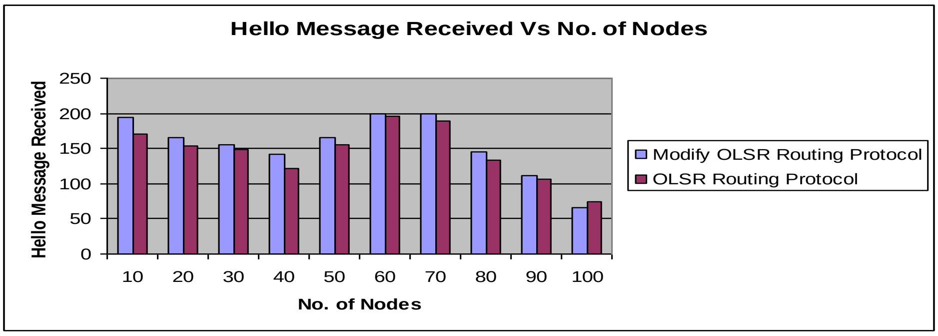

Fig. 4 Hello Message received with varying nodes and OLSR routing protocols.

- Fig. 4 shows the impact variation of Hello message received with in modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- By observation from graph and analysis of designed scenario observation efforts for trying minimize the time interval between the nodes for sending information, so lifetime and scalability of nodes increases, and also saves power consumption. In modified OLSR the message send ratio increases with time and also increases message sending ratio as compare OLSR routing.

C. Signal Received but with errors:

Number of incoming signals the radio failed to receive. PHY model is a simple radio model that supports either Signal-to-Noise Ratio (SNR) or Bit Error Rate (BER) based reception.

- Fig. 5 shows the impact variation of Signal Received but with errors in modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- By observation from graph and analysis of designed scenario observation efforts for trying minimize the errors when 1 mbps data received from source node to destination. In modified OLSR the errors less then as compare OLSR routing.

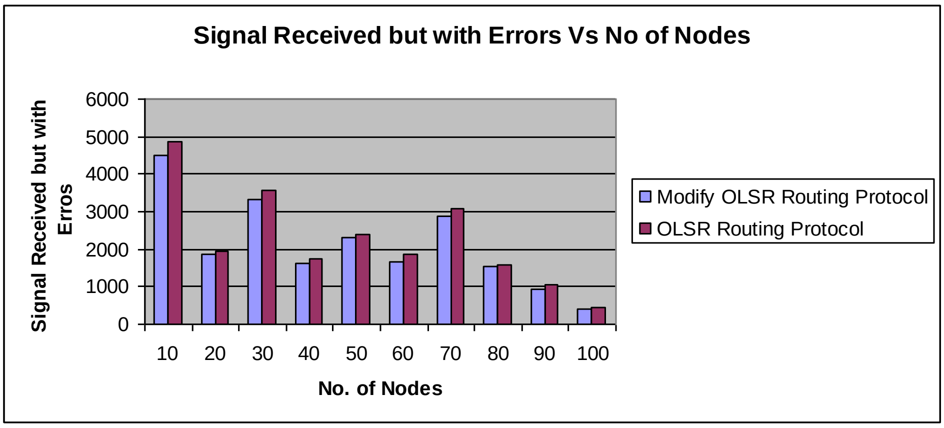

Fig. 5 Signal received but with errors with varying nodes and OLSR routing protocols.

D. Signal Received and Forwards to MAC:

Number of incoming signals successfully received and forwarded to MAC.

- Fig. 6 shows the impact variation of Signal received and forwards to MAC in modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- By observation from graph and analysis of designed scenario observation efforts for trying incoming signals received from source node to destination node are successfully received and forwarded to MAC. In modified OLSR the received signals more then as compare OLSR routing.

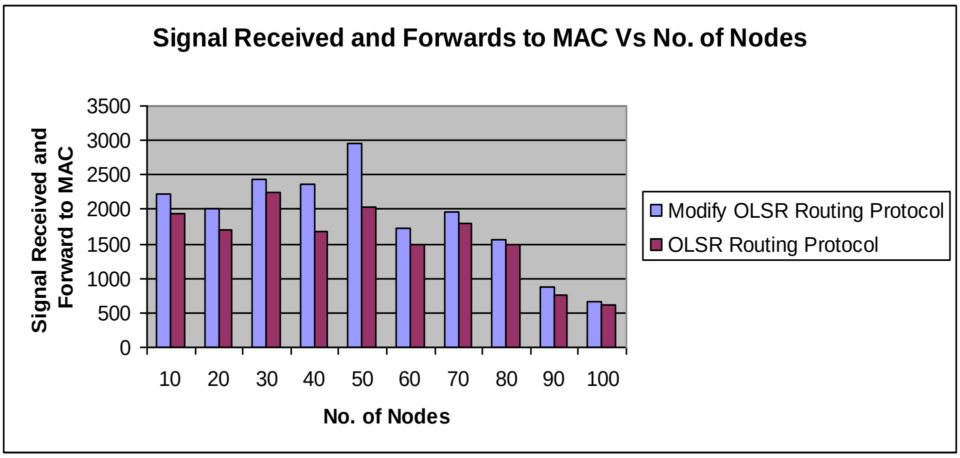

Fig. 6 Signal received and forwards to MAC with varying nodes and OLSR routing protocols.

Power Consumption:

This is the ratio of the average power consumed in each node to total power. The lifetime, scalability, response time and effective sampling frequency, all of these parameters of the wireless sensor network depend upon the power. Power failure regularly breaks in the network. Energy is required for maintaining the individual health of the nodes, during receiving the packets and transmitting the data as well.

E. Power Consumed in Transmit Mode:

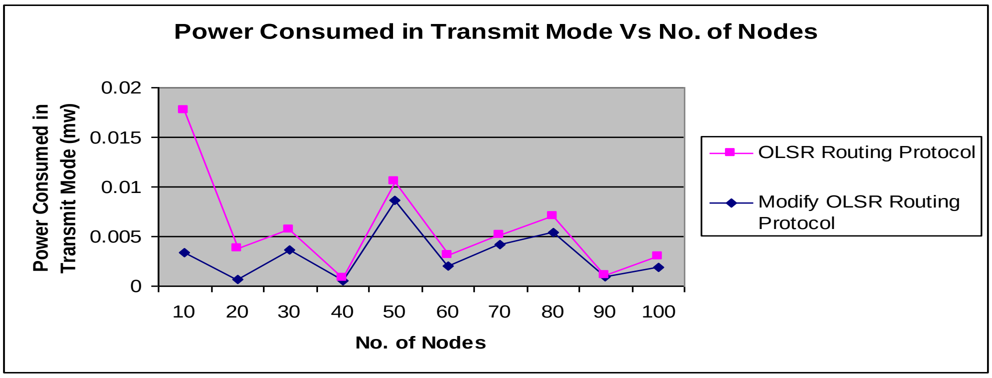

Fig. 7 Power consumed in transmit mode with varying nodes and OLSR routing protocols.

- Fig. 7 shows the impact variation of Power consumption in transmit mode with modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- By observation from graph and running scenario the maximum power consumed when distance of nodes is longer, hence overall performance of power manage of modified OLSR consumes less power as compare OLSR routing.
- The maximum power consumes by OLSR which is tailed by manage OLSR routing protocol.

F. Power Consumed in Received Mode:

- Fig. 8 shows the impact variation of Power consumption in transmit mode with modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:
- On analyzing the results for energy consumption in receive mode it has been concluded that modified OLSR consumes less power as compare to OLSR routing protocol.
- Maximum average power consumes when long distance nodes communicate each other as observing graph and scenario in figure 2.

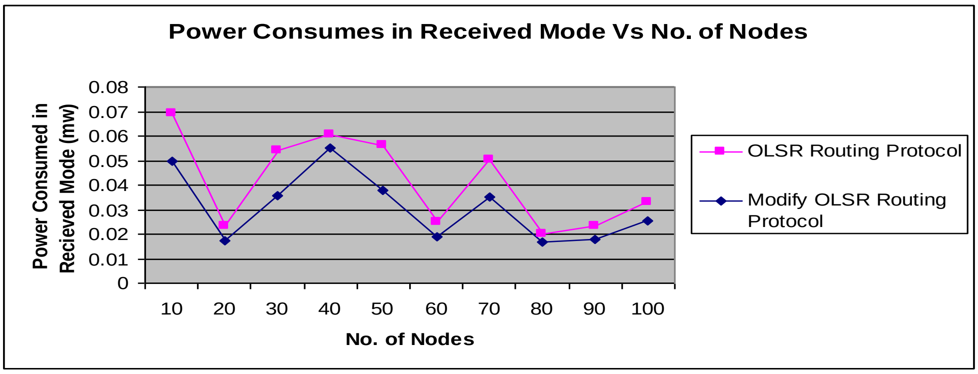

Fig. 8 Power consumed in received mode with varying nodes and OLSR routing protocols.

G. Power Consumed in Ideal Mode:

- Fig. 9 shows the impact variation of Power consumption in transmit mode with modified OLSR routing protocol as parameter and also variation in no. of nodes. Following inference can be made:

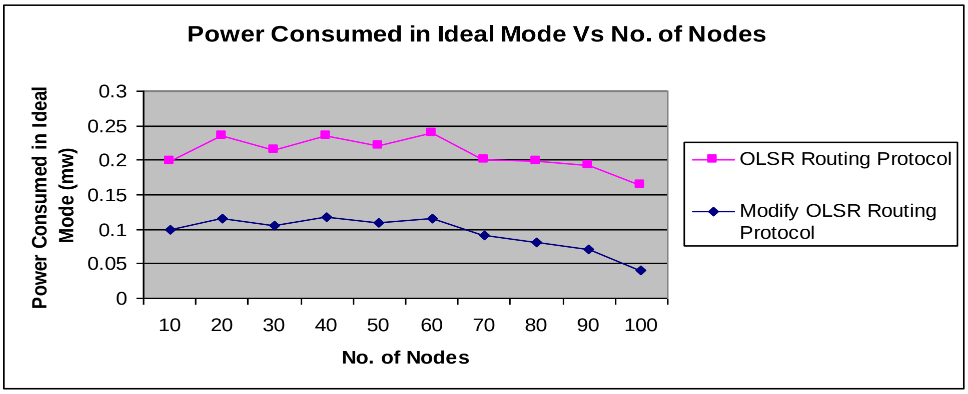

Fig. 9 Power consumed in ideal mode with varying nodes and OLSR routing protocols

- By observation from graph and running scenario the over all power consumed when distance of nodes is longer, hence overall performance of power manage by modified OLSR consumes less power as compare OLSR routing.
- The maximum power consumes by OLSR which is tailed by manage OLSR routing protocol.

VI. CONCLUSION

In this article, the important issue of power management in Optimized Link State Routing (OLSR), mobile ad-hoc wireless network is discussed. Since mobile nodes have limited battery lives, mobile networks should consume battery power more efficiently to maximize the network life, battery power capacity, transmission power consumption, stability of routes etc. We efforts to solve the problem of reduce the power consumption through power management issues in mobile ah hoc network by modified Optimized Link State Routing (OLSR) protocol and results shown as above. The modified OLSR routing protocol to minimize control traffic, periodic TC messages update, remaining battery power capacity, controlling the battery discharge to improve the power consumption in all modes. The future scope of this protocol is to successfully simulate it for a very large network and implement it with a voice application. For feature work we proposed to reduce the power consumption in Reactive routing protocol is tested with less number of packets and only for packet level power consumption for a very large network.

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