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# Performance Analysis of Energy Efficient Routing for Mobile Ad-hoc Networks

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*Abstract* — **Now days, energy efficient is important role in wireless communication world because all node can execute limited battery power. In this research paper I proposed new routing algorithm named Energy Saver Path Routing algorithm using Optimized Link State Routing (ESPR_OLSR) protocol for energy efficient routing in Mobile Ad-hoc Network (MANET). MANET is associate with rising space of analysis in the communication network world. MANET most often a cluster of wireless mobile nodes dynamically establishing a brief live network without use of network infrastructure. This ESPR_OLSR algorithm takes minimum energy to find the path between source to destination using high potential score edge node selections. This potential score calculation through based on the Distance Calculation (DC), Direction of Motion Identification (DMI) and Link Stability (LS) between the nodes. The same procedure execute until reach the destination and also hop1, hop2 and so on. Finally adjust the parameter after using ESPR_OLSR algorithm, provide better performance compare to ordinary OLSR protocol and also improved Throughput above 90%, reduced End-to-End delay below 60%, reduced transmission power to finding path between source to destination, reduced Overhead below 60%.**

*Keywords*—**Routing Algorithm, Energy Efficient, End-to-End, Overhead, Throughput**

## I. Introduction

Recently, network researcher's area unit for learning networks supported in new communication techniques, particularly wireless communication. Mobile networks have been serious interest within the decade of year during which years owing to their improved flexibility and reduce cost. Compare to wired network, mobile networks have distinctive characteristics and dissent at intervals the style of communication. Wired networks transfer data packets through physical cable. Whereas, in mobile network, the communication between wholly totally different devices is also either wireless or wired. In mobile networks, node quality makes the topology modification often, which is rare in wired network. Mobile network have a high error rate, information measure limitations and power restrictions. Due to the impacts from transmission power, receiver sensitivity, noise, attenuation and interference, wireless link capability oftentimes varies. A wireless network is also deployed quickly and easily, and users keep connected to the network whereas they are on the road. Also, they play a very important role in each civilian and military field. We have seen nice developments in Wireless networks infrastructure, convenience of wireless application, and proliferation of Wireless devices everywhere like laptop, PDA, and cell phone.

According to the preparation of network infrastructure, Wireless networks are divided into two sorts. The first kind is Infrastructure-based wireless networks and thus the second area unit infrastructure-less mobile networks [1] [2], commonly brought up as mobile ad-hoc networks. Infrastructure networks area unit those networks with mounted and wired gateways. The bridges for this kind of networks area unit brought up as base stations. A mobile node connects to the highest base station that is at intervals its communication radius. Because the mobile travels out of vary of one base station and into the vary of another, a "handoff" happens from the previous base station to the new, and thus the mobile is ready to continue communication seamlessly throughout the network.

A Mobile Ad-hoc Network (MANET) [3] can be a gaggle of wireless mobile nodes dynamically establishing a short live network with none use of network infrastructure or centralized administration. In addition to the high degree of quality, MANET nodes unit distinguished by their restricted resources like power, bandwidth, processing, and memory. If two mobile nodes have to be communicate with one another, they are going to communicate directly if they are among the transmission vary of every other; otherwise intermediate nodes (nodes in between) got to forward the packet from one altogether them to the other. Thus, every node among the network acts every as a number and router and will thus be willing to forward packets to different nodes. All nodes in mobile networks unit liberated to move, and also the link between two nodes is broken once one altogether them moves out of other's transmission vary, and thus the constellation might modification typically.

## II. Literature Review

Based on the literature review, one can understand various energy efficient routing mechanism based on various life time of node. Performance and comparison of Mobile Ad-hoc Networks routing protocols merits and demerits from Perkins .C.E [1], Prabu et al [3] and C.K. Tho [2]. Performance of proactive Optimized Link State Routing Protocol merits and demerits from Clausen et al

[5]. Potential score calculations of per node and direction of node velocity and select the edge node calculation from Jiayu Gong et al [8]. Reduced routing request in OLSR using MPR from Thomas Kunz [14]. Transmission power calculation from Sanjaya gajurel [13]. Various energy efficient power calculations from Pushpalatha et al [12]. Different energy level metrics in OLSR from Floriano De Rango et al [6]. Select efficient forward node in MANET from Murugesan el al [9] and Thomas kunz [15]. Performance of heterogeneous power consumption in OLSR protocol for MANET from Behnam Malakooti et al [4], Prabu et al [11] and Nicola Costagliola et al [10]. Select forward capacity node from Govindaswamy Kalpana et al [7].

Based on this survey, the following points are proposed for the present research work. i) Select Forward Capacity Node. ii) Source / Destination / Edge Node Selection for each and every hop. iii) Link Stability of the Route, Direction of Motion Identification and Potential Score Calculate before transmit the data. iv) Select shortest path using Energy Saver Path Routing (ESPR) Algorithm to improve the Throughput, reduced End-to-End Delay, Reduce Overhead and increase Mobility of the node v) Transmission Power calculation mechanism for selected path.

## III. Optimized Link State Routing (OLSR) Protocol

The Optimized Link State Routing (OLSR) [4] [5] protocol could be a proactive routing protocol associate it's an improvement over the pure link state protocol. In OLSR each node maintains topology information by periodically exchanging link-state messages. OLSR minimizes the size of the management packet by beside solely a set of its current neighbours, and minimizes flooding by the utilization of a MultiPoint Relay (MPR) strategy. These two optimizations create OLSR applicable to be used in large and dense networks. Victimisation the MPR technique, each node selects variety of its current neighbours as its MPRs that unit allowed rerunning management packets. Once a node receives a bearing packet, it solely rebroadcasts the packet if it is a MPR of the inflicting node. Otherwise, it solely reads and processes it however does not rerun the management packet. To figure out the MPRs, each node periodically broadcasts a hello message containing a list of its one hop neighbours and their link standing (Symmetric or Asymmetric). Once a node receives a hello message, it selects a set of 1 hop neighbours that covers all of its 2 hop neighbours. One issue with OLSR is but its nodes decide whether or not a link is interchangeable. The solution is easy, if a node receives a hello message and sees its own address within the sender’s hello message; therefore it considers that the link is interchangeable.

Instead of using a simple flooding mechanism, OLSR uses MPR-flooding that aims to cut back the problems caused by duplicate reception of a message among a section. MPRs unit of measurement accustomed diffuse topology information through the network. Each node acting as a MPR creates and broadcasts Topology management (TC) messages to all or any or any its 1-hop neighbour node. Also, MPR transmit to their 1-hop neighbour the TC messages that unit of measurement received from nodes among its MPR Selector Set. A TC message contains a list of neighbour nodes that selected the TC’s sender node as a MPR and a MPR Selector Sequence Node (MSSN) that is incremented for every new TC message created.

OLSR maintains a neighbours table, where a node records the information relating to one hop neighbours, the standing of the link, and an inventory of two hop neighbours that these one hop neighbours can offer access to. Upon receiving salutation messages, a node can construct its MPR Selector table that contains the nodes who have elected it as MPR [6]. Each node within the network maintains another table noted as a topology table where it stores the topological information relating to the network. The topology table contains the address of the destination node (T_dest), the address of the last hop to the destination (T_last), the sequence type of the TC message (T_seq), and a holding time that indicates the time that this tuple expires (T_time). Finally, each node uses the information within the neighbour table and additionally the topology table to construct its routing table. Each entry within the routing table consists of the destination node (R_dest), consecutive hop to the destination node (R_next) and type of hops to the destination node (R_dist). Throughout route analysis, the shortest path rule is employed.

## IV. Proposed Concept

The main Objective of this research work is to increase Throughput above 90%, reduced End-to-End Delay below 60%, reduced Transmission power to find the path from source to destination, and reduced overhead below 60%. Our proposed concept is Energy Saver Path Routing (ESPR) algorithm. This ESPR algorithm is using OSLR protocol labelled as ESPR_OLSR. The ESPR Algorithm as follows

### *1) Assumption:*

All nodes are equipped with Global Positioning System (GPS) receivers, digital maps, optional sensors and On Board Units (OBU). Location information of all nodes can be identified with the help of GPS receiver. The only communication paths available are via the Mobile Ad-hoc Network and there are no other communication infrastructures. Node power is not the limiting factor for the designed. Because all communications are message oriented. The Maximum Transmission Range (MTR) of each node in the environment is 250m. Our proposed algorithm Energy Saver Path Routing (ESPR) algorithm is used to find the shortest path from source to destination. This ESPR algorithm is using OSLR protocol. The ESPR description as follows

### *2) Algorithm ESPR (S, D, dt)*

// The following steps are repeated to find the path from Source S to Destination D in time interval t. The same procedure followed in 1 hop, 2 hop and soon.

**start**
**select** hop1 (v) node from the source S
**then** store V
**select** FCN(v) from set V
**then** store $V_f$
find Edegenode (En(v)) from Set $V_f$
**if** (En(v) Motion towards Destination D)
**then**
calculate Motion Mv(v) in particular time interval t
calculate Tp(v)
calculate Dt(v) from S
calculate Tp(S)
  **if** (Tp(v) &Tp(S) is sufficient to forward **dt** data)
  **then if** (Dt(v) is within Range of S)
    accept (v)
    add (Path(S,v,Dt))
**else**
reject(v)
**end;**

*3) Notations:*

| | |
|---|---|
| S | - Source Node |
| D | - Destination Node |
| dt | - Data transfer (Mbps) |
| t | - time intervals |
| hop1(v) | - 1 hop nodes |
| V | - Collection of 1 hop vertices set |
| FCN(v) | - Forward Capacity Node v |
| $V_f$ | - Collection of FCN vertices set |
| En(v) | - Edge node |
| Mv(v) | - Motion of that node |
| Tp(v) | - Transmission power of that node |
| Dt(v) | - Distance form Source to that node |
| Accept(v) | - Node accepted |
| Reject(v) | - Node Rejected |
| Path(S,v,Dt) | - Add path from source, edge node and distance Dt. |

## V. METHODOLOGY FOR ESPR

In figure 1 is flow diagram for the Energy Saver Path Routing (ESPR) algorithm in MANET using OLSR. Select all the vertices from source within 1 hop and stored. Again select the entire forward Capacity Node (FCN) from the set of vertices within 1 hop and stored. To find the edge node En(v) from the set of forward capacity vertices with maximum distance node from source and also within one hop transmission range. Source node can maintain the edge node capacity towards the destination then calculate Mv(v) motion of that node in particular time interval t, Tp(v) Transmission power of that node, Dt(v) Distance from source to that node, and Tp(S) source have sufficient power to forward the data to that selected edge node. If the Tp(v) and Tp(S) is sufficient to forward dt (data transfer in mbps) data then if Dt(v) is within the range of source, accept the node and add path with (S, v, Dt), Otherwise the node will be rejected.

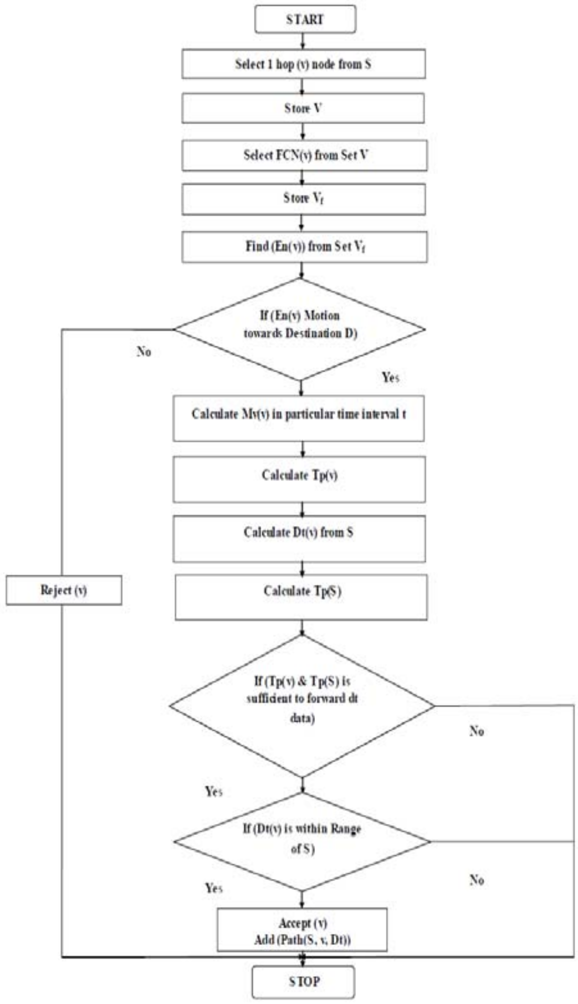


Fig.1. Flow Chart for the Proposed Concept

A. *Hop Node Selection (HNS):* Inform all nodes at intervals the transmissions vary of source/packet forwarding node to intimate its presence by causing a beacon message each μ second. When the reception of a beacon, every node can update its neighbor set table. If a node position is modified, then it will update its position to any or all neighbors by causing beacon signal. If a well-known neighbor, times out when ρ * μ seconds while not having received a beacon (ρ is that the range of beacons that a node is allowed to miss) and it will be faraway from the neighbor set table.

*B. Forward Capacity Node (FCN):* When a sender broadcasts a packet, then based on the greedy approach, it selects a subset of 1-hop neighbors as its forwarding nodes to forward the packets. Node N1 assigns a weight to each of its neighbor which represents the combination of neighbor's battery lifetime and its distance to N1. For a neighbor h1 of N1, the weight can be determined by the following equation:

$$FCN = BL_{h1} + D_{h1}$$

Where:
FCN = is Forward Capacity Node
$BL_{h1}$ = is the battery lifetime of h1
$D_{h1}$ = is the distance of h1 from N1.

*C. Distance Calculation (DC):* The distance between two nodes at time t by the following mathematical formula:

$$D = \sqrt{\{(x_2' - x_1') + t(v_2 cos\theta_2 - v_1 cos\theta_1)\}^2 + \{(y_2' - y_1') + t(v_2 sin\theta_2 - v_1 sin\theta_1)\}^2}$$

Where:
$x_1'$, $x_2'$ and $y_1'$, $y_2'$= Coordinate for node $n_1$ and $n_2$
$v_1$ and $v_2$ = velocity
$\theta_1$ and $\theta_2$ = direction
t = time interval
D = Distance between two nodes at time t.

$$DC = (1 - (D_i / D_c))$$

Where:
$D_i$ = Shortest distance from edge node i to distance D,
$D_c$ =Shortest distance from packet forwarding node c to destination D,
$D_i/D_c$ = closeness of nexthop
DC= Distance between next hop node from Source

*D. Direction of Motion Identification (DMI):* The appropriate neighbor node which is moving towards the direction of destination node is identified using the mathematical model

$$DMI = \cos(\vec{v}_i, \vec{l}_{i,d})$$

Where:
$\vec{v}_i$ = vector for velocity of edge node i
$\vec{l}_{i,d}$ = vector for the location of edge node i to the location of destination node D
$\cos(\vec{v}_i, \vec{l}_{i,d})$ = cosine value of angle made by these vectors

The cosine value of vector for velocity of edge node i and vector for location of edge node i to the location of destination node D is calculated. A large cosine value implies a node can still approach the destination closer and closer along its current direction.

*E. Link Stability (LS):* Link stability between two nodes at time t:

$$LS = R/D$$

Where:
LS= Link Stability of any two nodes over time period t,
R=Maximum transmission range
D=distance between two nodes at time t.

*F. Potential Calculation (PC):* The Potential Calculations (PC) of all nodes present within the different levels of transmission range of source/packet forwarding node is calculated. The Potential Calculation is calculated to identify the closeness of next hop to destinations, Direction of Motion of that node and reliability of neighbor node. The appropriate edge node with largest potential score will be considered as having higher potential to reach the destination node and that particular node can be chosen as next hop to forward the packet to the destination node. Potential calculation is calculated by combination of DC, DMI and LS and that mathematical model as follows

$$PC_i = ((\alpha \text{ x } DC) + (\beta \text{ x } DMI) + (\lambda \text{ x } LS))$$

$$PC_i = \alpha \text{ x } (1 - (D_i/D_c)) + \beta \text{ x } \cos(\vec{v}_i, \vec{l}_{i,d}) + \lambda \text{ x } LS_{c,i}$$

Where:
$PC_i$ = Potential Calculation of node i
$\alpha, \beta, \lambda$ = Potential factors
Let $\alpha + \beta + \lambda = 1$; $\lambda > \alpha$ and $\lambda > \beta$
$D_i$ =shortest distance from neighbor node i to distance D
$D_c$ =shortest distance from packet forwarding node c to distance D
$D_i/D_c$ = closeness of next hop
$\vec{v}_i$ = vector for velocity of edge node i
$\vec{l}_{i,d}$ = vector for the location of edge node i to the location of destination node D
$\cos(\vec{v}_i, \vec{l}_{i,d})$ = cosine value of angle made by these vectors
$LS_{c,i}$ = link stability between packet forwarding node c to neighbor node i

*G. Edge Node Calculation (ENC):* Edge Nodes are selected for packet forwarding events. An edge node is a node which has shortest distance to the destination D compared to all other nodes within the transmission range of source/packet forwarding node.

An edge node has the responsibility of saving received data packets in forwarding table and transfers it later when those nodes meet new neighbor. The overall objective of the algorithm is to forward the packet as soon as possible to increase Throughput, minimize the end to end delay and reduce transmission power. The Maximum Transmission Range of a node is 250m.

a. Notations:

MTR = Maximum Transmission Range
current node = the current packet carrier
$loc_c$ = the location of current node
$\vec{v}_c$ = speed vector for current node
dest = destination of the packet
$loc_d$ = the location of destination
nextHop = the node selected as next hop
$Nh_i$ = the $i^{th}$ neighbor
$loc_i$ = the location of the $i^{th}$ neighbor
$\vec{v}_i$ = the speed vector of the $i^{th}$ neighbor

b. Pseudo code for ENC:

$loc_c \leftarrow$ getLocation(currentnode)
$\vec{v}_c \leftarrow$ getSpeed(currentnode)
$loc_d \leftarrow$ getLocation(destination)
$D_c$ = distance ($loc_c$, $loc_d$)

$\vec{l}_{c,d} = loc_d - loc_c$
$PC = \beta \times \cos(\vec{v}_c, \vec{l}_{c,d})$
nextHop = current node
**for all** neighbor of currentnode **do**
$loc_i \leftarrow$ getLocation($Nh_i$)
$\vec{v}_i \leftarrow$ getSpeed($Nh_i$)
$D_i$ = distance ($loc_d$, $loc_i$)
$D_{ci}$ =distance ($loc_c$, $loc_i$)
**for** all neighbor of currentnode with $D_{ci}$ **do**
**if** ($D_{ci}$ < MTR)
$\vec{l}_{i,d} = loc_d - loc_i$
$PC_i = \alpha \times (1 - (D_i/D_c)) + \beta \times \cos(\vec{v}_i, \vec{l}_{i,d}) + \lambda \times LS_{c,i}$
**for** $Nh_i$ with greater $PC_i$ **do**
  $PC = PC_i$
  nextHop = $Nh_i$
**end for**
**else**
carry the packet with currentnode
**end if**
**end for**
**end for**

*H. Transmission Power Calculations (TP):* Transmission Power Calculation is the following equation,

$$TP = T_x / T_t$$

Where:
TP = is Transmission Power
$T_x$ = is transmission Energy
$T_t$= is time taken to transmit data packets.

## VI. Simulation Result and Analysis

In this section we evaluate the performance of routing protocol of Mobile Ad-hoc Networks in an open environments. The simulations were carried out using Network Simulator (NS-2) [16]. We are simulating the mobile ad hoc routing protocols using this simulator by varying the number of node. The IEEE 802.11 distributed coordination function (DCF) is used as the medium access control protocols. The packed size is 512 bytes. The traffic sources are UDP. Initially node were placed at certain specific locations and then the nodes move the speeds up to 25 meter/sec. for fairness, identical mobility and traffic scenario were used across the different simulation. The simulation parameters are specified in Table.1.

TABLE 1. Simulation Parameter

| Parameter | Value |
|---|---|
| Simulation Area | 1000m * 1000m |
| Number of Nodes | 20-100 |
| Average speed of nodes | 0 – 25 meter/second |
| Mobility model | Random Waypoint |
| Number of packet Senders | 40 |
| Transmission Range | 250m |
| Constant Bit Rate | 2 (Packets/Second) |
| Packet Size | 512 Bytes |
| Node beacon interval | 0.5 (Seconds ) |
| MAC Protocol | 802.11 DCF |
| Initial Energy/Node | 100 joules |
| Antenna Model | Omnidirectional |
| Simulation time | 500sec |

The following performance metrics to evaluate through simulation:

1) Throughput
2) End-to-End Delay
3) Transmission Power
4) Overhead

*1) Throughput:* Throughput is the number of bytes or bits arriving at the sink over time period. It's generally measured in Kilo bits per second or Mega bits per second.

In this part, we compare the performance of ESPR_OLSR and ordinary OLSR. In figure.2 Shows ESPR_OLSR is improved the Throughput with number of nodes is increased compare to ordinary OLSR protocol.

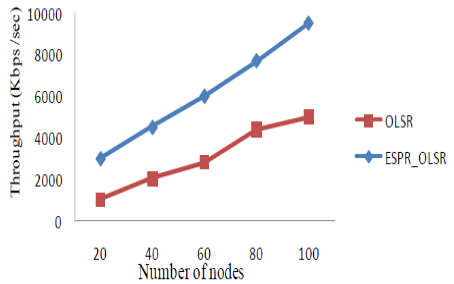


Fig.2. Throughput vs. Number of nodes

In figure.3 we compare the performance of ESPR_OLSR and ordinary OLSR. In figure.3 Shows ESPR_OLSR is improved the Throughput with Transmission Range is increased compare to ordinary OLSR protocol.

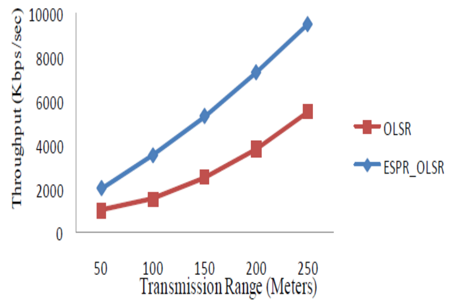


Fig.3. Throughput vs. Transmission Range

*2) End-to-End Delay:* in this part we compare the performance of ESPR_OLSR and OLSR. In figure.4 shows ESPR_OLSR is reduced more end-to-end delay with number of nodes is increased compare to ordinary OLSR protocol.
*3)*

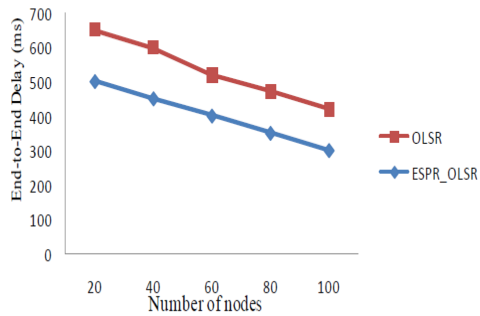


Fig.4. End-to-End Delay vs. Number of nodes

In figure.5 shows ESPR_OLSR is reduced more end-to-end delay with Transmission Range is increased compare to ordinary OLSR protocol.

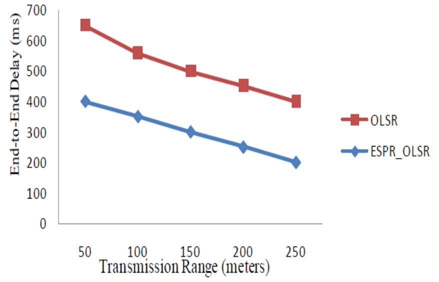


Fig.5. End-to-End Delay vs. Transmission Range

*4) Transmission Power:* The ESPR algorithm takes minimum energy to select the path from source to destination for each and every hop in dynamic environment. In figure.6 our proposed algorithm Energy Saver Path Routing using Optimized Link State Routing protocol (ESPR_OLSR) takes minimum energy consumed (Joules) than ordinary OLSR with transmission range is increased.

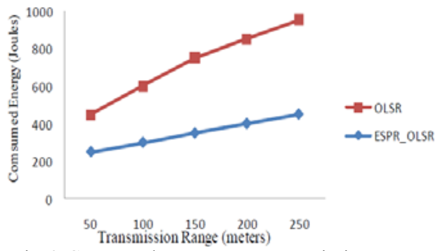


Fig.6. Consumed Energy vs. Transmission Range

*5) Overhead:* The number of generated and forwarded routing messages as separate metric to understand the routing overhead. In figure.7 shows ESPR_OLSR is reduced Overhead percentage with number of nodes is increased compare to ordinary OLSR protocol.

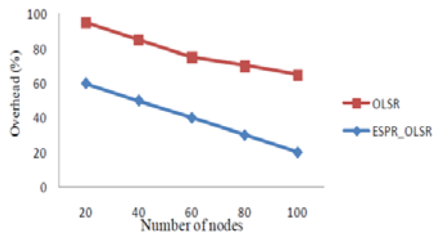


Fig.7. Overhead vs. Number of nodes

In figure.8 shows ESPR_OLSR is reduced Overhead percentage with Transmission Range is increased compare to ordinary OLSR protocol.

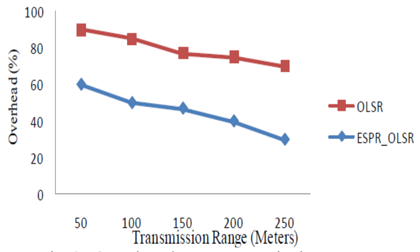


Fig.8. Overhead vs. Transmission Range

## VII. CONCLUSION

In the recent time there has been a lot of interest within the field of wireless networks. The fast paced world demands seamless communication facilities, therefore former types of connectivity like wired networks, radio waves are fast turning into obsolete. One in all the recent developments within the world of wireless technology is that the use of Mobile Ad-hoc Networks is an ideal technology that was at first developed for military application. The fast use of MANET has results within the identification of several issues. In all, though the widespread readying of MANET is still years away, the research in this field can continue being very active and imaginative. In this paper we proposed new routing algorithm named Energy Saver Path Routing using Optimized Link State Routing (ESPR_OLSR) protocol. This algorithm execute based on the edge node selection concept with height potential score. This potential calculation based on the distance calculation, motion calculation and stability of the link between the nodes. We compare the performance of our proposed routing protocol ESPR_OLSR algorithm and ordinary Optimized Link State Routing (OLSR) protocol through simulation. Our proposed routing protocol ESPR_OLSR is providing better performance than ordinary OLSR protocol. In figure.2 shows ESPR_OLSR is improved Throughput above 90% with number of nodes is increased compares to ordinary OLSR. In figure.3 shows ESPR_OLSR is improved throughput above 90% with transmission range is increased compare to ordinary OLSR. In figure.4 shows ESPR_OLSR is reduced below 60% end-to-end delay with number of nodes in increased compare to ordinary OLSR. In figure.5 shows ESPR_OLSR is reduced below 60% end-to-end delay with Transmission range is increased compare to ordinary OLSR. In figure.6 shows ESPR_OLSR is take minimum energy for finding the path from source to destination compare to ordinary OLSR proactive protocol in 1 hop, 2 hop and so on. In figure.7 shows ESPR_OLSR is reduced overhead below 60% with number of nodes is increased compare to ordinary OLSR. In figure.8 shows ESPR_OLSR is reduced below 60% with Transmission range is increased compare to ordinary OLSR.

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## AUTHOR PROFILES

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