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Energy Efficient Routing in Mobile Ad Hoc Network Through Edge Node Selection

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Abstract: In this research, researcher 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 hop 1, 2 and so on. Finally, adjust the parameter after using ESPR-OLSR algorithm, provide better performance compare to ordinary OLSR protocol and also improve Packet Delivery Ratio (PDF) above 90%, reduced end to end delay below 60% and also reduced transmission power to finding path between source to destination.

Key words: Routing algorithm, energy efficient, end to end, ESPR-OLSR, PDR

INTRODUCTION

Recently, network researcher's square measure for learning networks supported in new communication techniques, especially wireless communication by Perkins (2001). Mobile networks has been serious interest in the decade of year in which years attributable to their improved flexibility and reduced prices. Compared to wired networks, mobile networks have distinctive characteristics and dissent within the manner of communication. Wired networks transfer knowledge packets through physical cables whereas, in mobile networks, the communication between totally different devices may be either wireless or wired. In mobile networks, node mobility makes the network topology change often times which is rare in wired networks. Mobile networks have a high error rate, bandwidth limitations and power restrictions by Costagliola *et al.* (2012). Thanks to the impacts from transmission power, receiver sensitivity, noise, fading and interference, wireless link capacity frequently varies. Wireless networks may be deployed quickly and simply and users stay connected to the network while they are moving around. Also, they play a very important role in both civilian and military fields. Researchers have seen nice developments in wireless networks infrastructure, convenience of wireless applications and proliferation of wireless devices everyplace like laptops, PDAs and cell phones.

According to the preparation of network infrastructure, wireless networks are divided into 2 types. The primary sort is Infrastructure-based wireless networks and therefore the second square measure infrastructure-less mobile networks, normally referred to as mobile ad hoc networks. Infrastructure networks square measure those networks with fixed and wired gateways. The bridges for this sort of networks square measure referred to as base stations. A mobile node connects to the closest base station that is at intervals its communication radius as the mobile travels out of vary of 1 base station and into the vary of another, a "handoff" occurs from the previous base station to the new and therefore, the mobile is able to continue communication seamlessly throughout the network.

A Mobile Ad hoc Network (MANET) could be a group of wireless mobile nodes dynamically establishing a brief live network without any use of network infrastructure or centralized administration. Additionally,

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to the high degree of mobility, MANET nodes area unit distinguished by their limited resources like power, bandwidth, processing and memory. If 2 mobile nodes got to communicate with each other, they will communicate directly if they are within the transmission range of each other; otherwise intermediate nodes (nodes in between) ought to forward the packet from one in all them to the opposite. Thus, each node within the network acts each as a host and router and should so be willing to forward packets to other nodes. All nodes in mobile impromptu networks area unit absolve to move and the link between 2 nodes is broken once one in all them moves out of other's transmission range and hence the constellation could change often.

ROUTING PROTOCOLS FOR MANET

Routing is the exchange of information (in this case typical term 'packets') from one station of the network to the other by Prabu and Subramani (2012) and Toh (2002). The major goals of routing are to find and maintain routes between nodes in a dynamic topology with possibly uni-directional links using minimum resources. A protocol is a set of standard or rules to exchange data between two devices. These protocols find a route for packet delivery and deliver the packet to the correct destination. Routing protocols are classified into unicast, multicast and broadcast routing protocols. Unicast forwarding means a one-to-one communication, i.e., one source transmits data packets to a single destination. Multicast routing protocols come into play when a node needs to send the same message to multiple destinations. Broadcast is the basic mode of operation over a wireless channel, each message transmitted on a wireless channel is generally received by all neighbors located within 1 hop from the sender. The studies on various aspects of unicast routing protocols have been an active area of research for many years such as table driven or proactive, on-demand driven or reactive and hybrid routing protocols.

Table driven/proactive protocols: Keep track of routes for all destinations in the ad hoc network are called Proactive protocols or table-driven protocols as the routes can be assumed to exist in the form of tables. Each node maintains one or more tables containing routing information to every other node in the networks. All nodes keep on updating these tables to maintain latest view of the network. The main advantage is that communications with arbitrary destinations experience minimal initial delay from the point of view of the applications. The disadvantages of proactive protocols is that additional control traffic is needed to continually update stale route entries. In table driven routing protocols some of the existing table driven or proactive protocols are: DSDV (Destination Sequenced Distance Vector), CGSR (Cluster-head Gateway Switch Routing), WRP (Wireless Routing Protocol), STAR (Source Tree Adaptive Routing Protocol), OLSR (Optimized Link State Routing protocol), FSR (Fisheye State Routing protocol), HSR (Hierarchical State Routing protocol) and GSR (Global State Routing protocol).

On demand/reactive protocols: In this protocol, routes are created as and when required. When a transmissions occurs from source to destination, it invokes the route discovery procedures. The route remains valid till destination is achieved or until the route is no longer needed. The advantage is that due to the high uncertainty in the position of the nodes, however, the reactive protocols are much suited and perform better for MANET. The disadvantages of reactive protocols include high latency time in route finding and excessive flooding leading to network clogging. Some of the on demand or reactive routing protocols are: DSR (Dynamic Source Routing), AODV (Ad hoc on-demand Distance Vector), ABR (Associative Based Routing), SSA (Signal Stability based Adaptive routing), PLBR (Preferred Link Based Routing protocol), TORA (Temporally Ordered Routing) and FORB (ipv6 flow handoff in adhoc wireless network).

Hybrid routing protocols: This protocol is belonging to this category combine the best features of the above 2 categories. Nodes within a certain distance from the node concerned or within a particular geographical region are said to be within the routing zone of the given node. For routing within this zone you can use table-driven approach is used. For nodes that are located beyond this zone you can use on-demand approach is used. Disadvantages of hybrid protocols is that success depends on amount of nodes activated and reaction to traffic demand depends on gradient of traffic volume. Some of the hybrid routing protocols are: CEDAR (Core Extraction Distributed Ad hoc Routing), ZRP (Zone Routing Protocol) and ZHLS (Zone based Hierarchical Link State routing).

OLSR ROUTING PROTOCOL

The Optimized Link State Routing (OLSR) protocol is a proactive routing protocol by Clausen and Jacquet (2003) and it's an improvement over the pure link state protocol. In OLSR every node maintains topology data by sporadically exchanging link-state messages. OLSR minimizes the scale of the management packet by together with only a subset of its current neighbours and minimizes flooding by the employment of a MultiPoint Relay (MPR) strategy. These two optimizations make OLSR appropriate for use in giant and dense networks. Using the MPR technique, every node selects a number of its current neighbours as its MPRs which square measure allowed rerunning management packets. When a node receives an effect packet, it only rebroadcasts the packet if it's a MPR of the causing node. Otherwise, it only reads and processes it but doesn't rerun the management packet. to work out the MPRs, every node sporadically broadcasts a hullo message containing a listing of its one hop neighbours and their link status (Symmetric or Asymmetric). When a node receives a hullo message, it selects a subset of one hop neighbours which covers all of its two hop neighbours. One issue with OLSR is however its nodes decide whether a link is interchangeable. The answer is straightforward, if a node receives a hullo message and sees its own address in the sender's hullo message, so it considers that the link is interchangeable.

Instead of employing a straightforward flooding mechanism, OLSR uses MPR-flooding that aims to reduce the issues caused by duplicate reception of a message among a neighborhood. MPRs area unit accustomed diffuse topology info through the network. Every node acting as a MPR creates and broadcasts Topology Control (TC) messages to all or any its 1 hop neighbour nodes. Also, MPRs transmit to their 1 hop neighbours the TC messages that area unit received from nodes among its MPR selector set by De Rango and Fotino (2009) and Kunz (2008). A TC message contains a listing of neighbour nodes that designated the TC's sender node as a MPR and a MPR Selector Sequence range (MSSN) that is incremented for each new TC message created.

OLSR maintains a neighbours table, wherever a node records the knowledge regarding one hop neighbours, the status of the link and a list of 2 hop neighbours which these one hop neighbours will give access to. Upon receiving salutation messages, a node will construct its MPR selector table that contains the nodes who have elect it as MPR. Every node in the network maintains another table referred to as a topology table wherever it stores the topological info regarding 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 variety of the TC message (T_seq) and a holding time which indicates the time that this tuple expires (T_time). Finally, every node uses the knowledge in the neighbour table and also the topology table to construct its routing table. Every entry in the routing table consists of the destination node (R_dest), consecutive hop to the destination node (R_next) and variety of hops to the destination node (R_dist). During route evaluation, the shortest path rule is used.

PROPOSED CONCEPT

Energy saver Path Routing (ESPR) algorithm: The proposed concept is Energy Saver Path Routing (ESPR) algorithm by Guo *et al*. (2011). This ESPR algorithm is using OSLR protocol. The ESPR Algorithm as follows:

Assumption: The proposed concept is based on the following assumptions: 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 250 m. The 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:

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, 2 hop and so on.
start
select hop1 (v) node from the source S
then store V
select FCN(v) from set V
then store Vf
find Edegenode (En(v)) from set Vf
if (En(v) motion towards Destination D)
then
calculate Mv(v) in particular time interval t
calculate Tp(v)
calculate Dt(v) from S
calculate Tp(S)
        if (Tp(v) and 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;
```

Notations:

S:	Source Node
D:	Destination Node
dt:	Data transfer (Mbps)
t:	time intervals
hop 1(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 to selected vertex with distance Dt

METHODOLOGY FOR ESPR

Figure 1 is flow diagram for the energy saver path routing algorithm in MANET using OLSR by Kunz and Alhalimi (2010). 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.

Hop node selection: Inform all nodes within the transmission range of source/packet forwarding node to intimate its presence by sending a beacon message every μ second. After the reception of a beacon, each node will update its neighbor set table. If a node position is changed, then it will update its position to all neighbors by sending beacon signal. If a known neighbor, times out after $\alpha\times\mu$ seconds without having received a beacon (α is the number of beacons that a node is allowed to miss) and it will be removed from the neighbor set table by Prasanth *et al*. (2010).

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 by Kalpana and Punithavalli (2012) and Murugesan and Krishnan (2010):

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

Where:

Bl_{h1} = The battery lifetime of h1
D_{h1} = The distance of h1 from N1

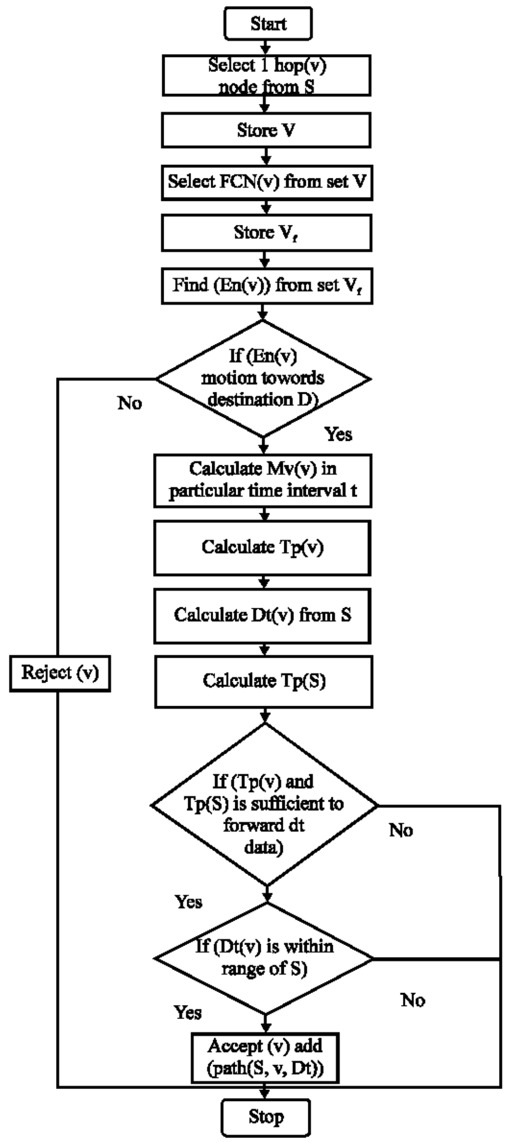

Fig. 1: Flow diagram for ESPR algorithm

Distance Calculations (DC): The distance between two nodes at time t by the mathematical:

$$D = \sqrt{\begin{array}{l}\left\{\left(x_1^{'}-x_2^{'}\right)+t\left(v_1\cos\theta_1 \_ v_2\cos\theta_2\right)\right\}^2 + \\ \left\{\left(x_1^{'}-x_2^{'}\right)+t\left(v_1\sin\theta_1 - v_2\sin\theta_2\right)\right\}^2\end{array}}$$

Where:

x_1', x_2' and y_1', y_2'	=	Coordinate for node n_1 and n_2
v_1 and v_2	=	Velocity
θ_1 and θ_2	=	Direction
t	=	Time interval
D	=	Distance between two nodes at time t

$$DC = \left(\frac{1-D_i}{D_c}\right)$$

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

Direction of Motion Identification (DMI): The appropriate neighbor node which is moving towards the direction of destination node is identified using the Mathematical Model:

$$DMI = \cos\left(\overrightarrow{v_i}, \overrightarrow{l_{i,d}}\right)$$

Where:

$\overrightarrow{v_i}$ = Vector for velocity of edge node i
$\overrightarrow{l_{i,d}}$ = Vector for the location of edge node i to the location of destination node D
$\cos\left(\overrightarrow{v_i}, \overrightarrow{l_{i,d}}\right)$ = 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 measured. A large cosine value implies a node can still approach the destination closer and closer along its current direction by Prasanth *et al.* (2010).

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

$$LS = \frac{R}{D}$$

Where:

LS = Link stability between any two nodes over time period t
R = Maximum transmission range
D = Distance between two nodes at time t

Potential Calculation (PC): The Potential Calculation (PC) of all nodes present within the different levels of transmission range of source/packet forwarding node is calculated. The Potential Calculation (PC) is calculated to identify the closeness of next hop to destination, direction of motion of nodes and reliability of neighbor nodes. 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 by Prasanth *et al.* (2010). Potential calculation is calculated by addition of DC, DMI and LS and that mathematical model as follows:

$$PC_i = (\alpha \times DC) + (\beta \times DMI) + (\lambda \times LS)$$

$$PC_i = \alpha \times \left(1 - \left(\frac{D_i}{D_c}\right)\right) + \beta \times \cos\left(\overrightarrow{v_i}, \overrightarrow{l_{i,d}}\right) + \lambda \times LS_{c,i}$$

Where:

PC_i = Potential calculation of node i
α, β, λ = 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
$\overrightarrow{v_i}$ = Vector for velocity of edge node i
$\overrightarrow{l_{i,d}}$ = Vector for the location of edge node i to the location of destination node D
$\cos\left(\overrightarrow{v_i}, \overrightarrow{l_{i,d}}\right)$ = Cosine value of angle made by these vectors
$LS_{c,i}$ = Link stability between packet forwarding node c to neighbor node i

Edge Node Calculation (ENC): In the edge node calculations by Prasanth *et al.* (2010), edge nodes are selected for packet forwarding event. 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 neighbors. The overall objective of the algorithm is to forward the packet as soon as possible to increase packet delivery ratio, minimize the end to end delay and avoid packet loss. The maximum transmission range of a node is 500 m.

Notations:

MTR = Maximum Transmission Range
Current node = The current packet carrier
loc_c = The location of current node
$\overrightarrow{v_c}$ = 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 ith neighbor
loc_i = The location of the ith neighbor
$\overrightarrow{v_i}$ = The speed vector of the ith neighbor

Pseudo code for ENC:

$loc_c \leftarrow$ getLocation(currentnode)
$\overrightarrow{v_c} \leftarrow$ getSpeed(currentnode)
$loc_d \leftarrow$ getLocation(destination)
D_c = distance (loc_c, loc_d)
$\overrightarrow{l_{i,d}} = loc_d - loc_c$

$PC = \beta \times \cos(\overrightarrow{v_c}, \overrightarrow{l_{c,d}})$
nextHop = current node
for all neighbor of currentnode do
$loc_i \leftarrow$ getLocation (Nh_i)
$\overrightarrow{v_i} \leftarrow$ 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)
$\overrightarrow{l_{i,d}} = loc_d - loc_i$
$PC_i = \alpha \times (1-(D_i/D_c)) + \beta \times \cos(\overrightarrow{v_i}, \overrightarrow{l_{i,d}}) + \lambda \times LS_{c,i}$
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

Transmission Power Calculations (TP): By Gajurel and Malakooti (2008):

$$TP = \frac{T_x}{T_t}$$

Where:
TP = Transmission Power
T_x = Transmission energy
T_t = Time taken to transmit data packet

SIMULATION RESULTS AND ANALYSIS

In this study researchers evaluate the performance of routing protocol of mobile ad-hoc networks in an open environment. The simulations were carried out using Network Simulator (NS-2)[15]. Researchers are simulating the mobile ad hoc routing protocols using this simulator by varying the number of nodes. The IEEE 802.11 Distributed Coordination Function (DCF) is used as the medium access control protocol. The packed size is 512 bytes. The traffic sources are UDP. Initially, nodes were placed at certain specific locations and then the nodes move the speeds up to 25 m sec^{-1} for fairness, identical mobility and traffic scenario were used across the different simulations. The simulation parameters are specified in Table 1.

Performance metrics to evaluate simulation
Packet Delivery Ratio (PDR): The ratio of the packets that successfully reach destination:

$$PDR = \frac{\text{Total No. of packets deliverd}}{\text{Total No. of packets transferred}} \times 100$$

In this part, researchers compare the performance of ESPR-OLSR and ordinary OLSR. Researchers will show how packet delivery is affected by the data transmission density and traffic density. Figure 2 shows ESPR-OLSR is improved the Packet Delivery Ratio (PDR) with number of nodes compare to ordinary OLSR.

Table 1: Simulation parameter

Parameters	Values
Simulation area	1000×1000 m
Number of nodes	50-500
Average speed of nodes	0-25 m sec^{-1}
Number of packet senders	40
Transmission range	500 m
Constant bit rate	2 packets sec^{-1}
Packet size	512 bytes
Node beacon interval	0.5 sec
MAC protocol	802.11 DCF

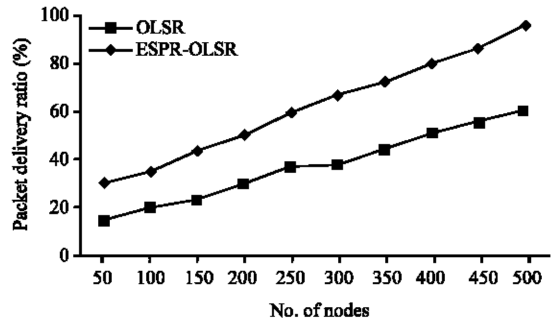

Fig. 2: Packet delivery ratio vs. No. of nodes

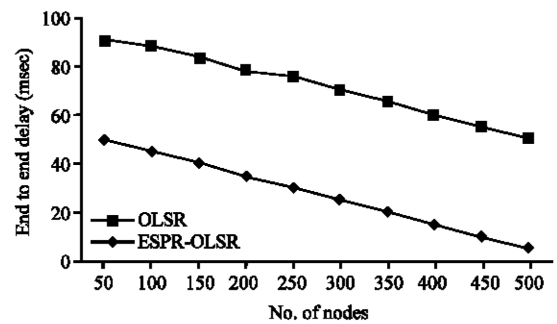

Fig. 3: End to end delay vs. No. of nodes

End to end delay: In this part, researchers compare the performance of ESPR-OLSR and OLSR. Figure 3 shows ESPR-OLSR is reduced more end to end delay with no of nodes compare to ordinary OLSR by Prabu and Subramani (2012).

Total transmission power: The ESPR algorithm takes minimum energy to select the path from source to destination for each and every hop in dynamic environment. Figure 4 proposed algorithm Energy Saver Path Routing using Optimized Link State Routing Protocol (ESPR-OLSR) takes minimum energy (J) than ordinary OLSR with transmission range is increased.

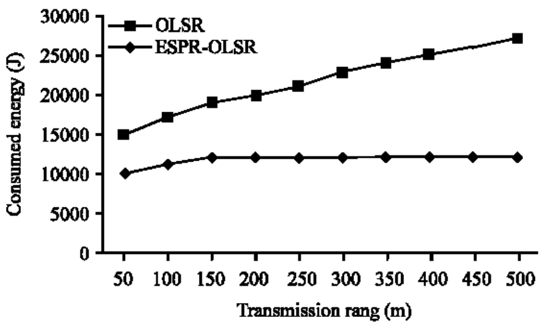

Fig. 4: Consumed energy (J) vs. transmission range (m)

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 applications. The fast use of MANET has resulted 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 study researchers 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. Researchers compare the performance of the proposed routing protocol ESPR-OLSR algorithm and ordinary Optimized Link State Routing (OLSR) protocol. The proposed routing protocol ESPR-OLOSR is providing better performance than ordinary OLSR protocol. Figure 2 shows ESPR-OLSR is improved the Packet Delivery Ratio (PDR) up to 80-95% with number of nodes compares to ordinary OLSR. Figure 3 shows ESPR-OLSR is reduced up to 70% end to end delay with number of nodes compare to ordinary OLSR. Figure 4 shows ESPR-OLSR is take minimum energy for finding the path from source to destination compare to ordinary OLSR proactive protocol in 1, 2 hop and so on.

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