Power Aware Routing Protocol in Mobile Ad-hoc Networks

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Abstract

Mobile Ad-hoc Network (MANET) are formed by a collection of mobile nodes, each equipped with wireless communication capabilities, without relying on any fixed infrastructure. In order to maintain network connectivity, each node may act as an ad hoc router, forwarding data packets for other mobile nodes that may not be within direct transmission range of each other. Energy efficiency is a most important design consideration in MANET due to the limited battery life of mobile terminals. The network lifetime will be improved by suitably reducing the requirement of power for connections. The objective of this paper is to develop a new routing protocol for MANET. I proposed the enhanced version of Power Aware Optimized Link State Routing (PA-OLSR) protocol using proactive OLSR protocol. This proposed PA-OLSR routing protocol uses a new metric to find the route with higher transmission rate, less latency and better stability. It checks bandwidth and delay constraint during route request and uses as well new mobility prediction mechanism to determine the stability of link during a path selection. We evaluate the performance of PA-OLSR using NS2 simulation tool and compare it with OLSR protocol. The simulation results show that the performance of new routing protocol significantly improves the network performance by discovering the required path with minimal power and delay

Keywords: *PA-OLSR, Energy Consumption, Network Life Time, Route Stability, OLSR*

1. Introduction

Ad-hoc network is one of the emerging trends in wireless communication. In conventional wireless communication there is need of base station for communication between two nodes. These base station leads to more infrastructure and more cost. An ad-hoc network facilitates communication between nodes without the pre-existing an established infrastructure. Nodes are connected randomly using ad-hoc networking and routing among the nodes is done by forwarding packets from one to another which is decided dynamically. In general, MANET [1] [2] is formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using any centralized administration. Mobile nodes that are within each other's radio range communicate directly via wireless links, while those that are far apart rely on other nodes to relay messages as routers. Node mobility in an ad-hoc network causes frequent changes of the network topology. The scopes of the ad-hoc network are also associated with dynamic topology changes, bandwidth-constrained, energy constrained operation, limited physical security, mobility-induced packet losses, limited wireless transmission range, broadcast nature of the wireless medium, hidden terminal problem, and packet losses due to transmission errors. In Energy constrained operations, it is important to save energy which results in improvement in network lifetime. For example, in battle fields soldiers are unable to charge node batteries so there is need for them to save battery power in such a way that communication can be possible for longer time. To improve network lifetime there are different methodologies used at different layers of OSI model. Network layer is used for routing of packets from source to destination.

2. Review of Routing Protocols In MANET

Routing protocols for MANET have been classified according to the strategies of discovering and maintaining routes into three classes: proactive, reactive, and hybrid [3]. Each routing protocol reacts differently to node mobility and density.

Proactive routing protocols: Proactive routing protocols acquire routing information periodically and store in one or more routing tables. The differences among the protocols in this class are routing structure, number of tables, frequency of updates, use of hello messages and the existence of a central node. Therefore, each protocol reacts differently to topology changes. Flooding of routing information is the mechanism that is often used to discover and update routes. However, it is common that proactive protocols generate more control traffic and overhead than other protocol classes because of periodic updating which increases as the number of nodes increases. Moreover, they extensively use memory for storing those tables. Examples of proactive routing protocols are: DSDV, CGSR, WRP, STAR, OLSR, FSR, HSR and GSR.

Reactive routing protocols: Reactive routing protocols discover or maintain a route as needed. This reduces overhead that is created by proactive protocols. Flooding strategy is used to discover a route. Reactive routing protocols can be classified into two groups: source routing and hop by hop routing. In source routing, data packet headers carry the path to destination. Hence, intermediate nodes do not care about maintaining the routing information. On the other hand, this kind of protocols may experience high level of overhead as the number of intermediate nodes increases. Also they have a higher chance of a route failure. Packets in the second group of reactive protocols have to carry only destination and next hop addresses which means that nodes have to maintain and store routing information for active routes. In general, reactive protocols suffer from delay because of the route discovery process. Some of the On Demand or Reactive Routing Protocols are: DSR, AODV, ABR, SSA, PLBR, TORA and FORB.

Hybrid routing protocols: 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, ZRP and ZHLS.

3. OLSR PROTOCOL

OLSR is proactive in nature, having routes immediately available in each node for all destinations in the network. OLSR [4] [5] [6] is an optimization of pure link state routing protocol like Open Shortest Path First (OSPF). This optimization is related to concept of multipoint relay (MPR). A multipoint relay reduces the size of control messages. The use of MPRs also minimizes flooding of control traffic. Multipoint relays forward control messages, providing advantage of reduction in number of retransmissions of broadcast control messages. OLSR contains two types of control messages: neighborhood and topology messages, known as Hello messages and Topology Control (TC) messages.

Neighbor Discovery: Each node periodically broadcasts Hello messages, containing list of neighbors known to node and link status. The link status can be either symmetric or asymmetric, multipoint relay, or lost link. The Hello messages are received by all one-hop neighbors and not forwarded. Hello messages are broadcast at regular interval (Hello_interval). The neighborhood and two hop neighborhood information has holding time (Neighbor_hold_time), after which it is not valid. With the help of this information node selects its own set of MPR among one-hop neighbors. MRP computed whenever there is change in 1hop and 2hop neighborhood.

Topology Dissemination: Each node of the network maintains topological information about the network obtained with help of TC messages. Each node selected as MPR, broadcasts TC message at regular interval (TC_interval). The TC message originated from node which declares MPR selectors of that node. If change occurs in MPR [7] [8] selector set, then TC message can be sent earlier than pre-specified interval. The TC messages are sent to all nodes in the network by taking advantage of MPR nodes to avoid number of retransmissions.

Route Calculation: The neighbor information and the topology information are refreshed periodically, and they enable each node to compute the routes to all known destinations. These routes are computed with Dijkstra's shortest path algorithm [9] [10]. Hence, they are optimal with respect to the number of hops. Moreover, for any route, any intermediate node on this route is a MPR of the next node.

4. MATHEMATICAL MODEL IN MANET

In MANET, a network can be represented by a weighted graph G = (V, E), where V is the set of nodes (Vertices) and E is the set of links (Edges) between two nodes. All the nodes of network are in mobile state. The position, rate and direction of motion of node V_i at time t can be represented as $(x_i(t), y_i(t))$, $s_i(t)$, $\theta_i(t))$ respectively. So the motion model is represented as follows:

$$x_i(t) = x_i(t-1) + s_i(t) \times \cos(\theta_i(t))$$
$$y_i(t) = y_i(t-1) + s_i(t) \times \sin(\theta_i(t))$$

The distance between two nodes in MANET is represented as follows:

$$d_{ij} = \sqrt{(x_j(t) - x_i(t))^2 + (y_j(t) - y_i(t))^2}$$

The nodes are deployed in free space to establish network connectivity. Two nodes are connected to each other if they are in transmission range of each other. The link between two nodes can be possible if the signals from the transmitter can be received correctly by other node. The distance R is the effective distance between two nodes when routing link between two nodes sets apart. So the relation between communication link and distance between two nodes are summarized below:

$$d_{ij}(t) \le R \Leftrightarrow (v_i, v_j) \in E$$

An edge (v_i, v_j) is bidirectional if both (v_i, v_j) and (v_j, v_i) are in E.

Link stability model: We consider two metrics to measure link and node stability such as LET and energy drain rate (EDR), respectively [11]. The LSR is the combination of LET and EDR, the stability of the entire path will be maintained by using this metric.

Link expiration time: It used to identify the duration of the link will be alive. The velocity and direction of the movement is constant [12]. The position of node i and node j is denoted as x_i and x_j, the velocity and direction of node i and node j is denoted as (v_i, v_j) and (θ_i, θ_j) ($0<=\theta_i$, $\theta_j < 2\pi$), respectively. The LET is denoted as

$$LET = \frac{\left(-(ab+cd)+\sqrt{(a^2+c^2)r^2-(ad-bc)^2}\right)}{(a^2+c^2)}$$

Where

$a = v_i \cos\theta_i - v_j \cos\theta_j$

$b = x_i - x_j$

$c = v_i \sin\theta_i - v_j \sin\theta_j$

$d = y_i - y_j$.

The motion parameters are exchanged among nodes at regular time intervals through global positioning system (GPS) clock. If the velocity and direction of node i and node j will be $v_i = v_j$ and $\theta_i = \theta_j$ then they LET of two nodes become ∞.

Energy drain rate: The energy-based routing algorithms send large amount of data with maximum energy levels that leads to depletion of battery power at very early stage in higher energy levels. The nodes lose some of it energy due to overhearing of the neighbouring nodes. In this situation, power is lost even if no data is being sent through it [13] [14]. This problem is solved by using DR and it is defined as a metric for energy dissipation rate in a given node. Total energy consumption is calculated in every T sec by every node and the DR is measured by exponentially averaging the values of previous and newly calculated values:

$$DR_i = \alpha DRold + (1-\alpha)DRnew$$

Where α is selected between 0 and 1 that gives higher priority to updated information. If the DR is higher, then the node is faster to deplete its energy. The LSR is measured from LET and DR and it is denoted as

LSR = Link expiration time / Drain rate

5. PROPOSED CONCEPT

In this section I proposed new routing protocol named Power Aware Optimized Link State Routing (PA-OLSR) Protocol for MANET. This proposed routing protocol using existing proactive (OLSR) protocol.

Algorithm PA-OLSR (S, v, D)

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

start
select hop1 (v) node from the source S
then store V
select R_REQ from set V
then store V_{R_REQ}
find B_{R_REQ} from Set V_{R_REQ}
set initial value as null
if ($B_{R\_REQ(i)}>=B_{R\_REQ}$ && $D_i<=D$)
if(intermediate node receive V_{R_REQ})
then
calculate LSR(v) value form LET and DR
Compare LSR with LSR_i
if($LSR_i>=LSR$ && $B_{R\_REQ(i)}>=B_{R\_REQ}$&&$D_i>=D$)
accept (v)
else
reject (v)
add (Path(S,v,D))
end;

In the above algorithm first select the hop1 node from source node S. then store the vertices set V. Again select Route Request (R_REQ) node from the vertices set V. then store the Route Request Vertices set V_{R_REQ} and set the all initial value is null. If check the condition Broadcast Route Request node i ($B_{R\_REQ(i)}$) is greater than are equal to initial Broadcast Route Request node (B_{R_REQ}) and Destination node i (D_i) is greater than are equal to Destination D. if intermediate node receive the all route request (V_{R_REQ}) then calculate Link Stability Route (LSR) value from Link Expiration Time (LET) and Drain Rate (DR). Compare the Link Stability Route i with another Route. if check the condition Link Stability Route i (LSR_i) is greater than are equal to Link Stability Route (LSR), Broadcast Route Request i ($B_{R\_REQ(i)}$) is greater than are equal to Broadcast Route Request (B_{R_REQ}) and Destination node i (D_i) is greater are equal to destination node (D) is true accept the node otherwise node will be reject. Finally add the path Source node S, selected intermediate with sufficient stability node v and Destination node D.

Route selection: When the RREQ receives at the neighbour node, it forwards a RREP packet back to the source. Otherwise, it rebroadcasts the RREQ. If they receive a processed RREQ, they discard the RREQ and do not forward it. If RREQ of multiple paths are received at source node, it is stored by the hop count value. In OLSR the route is selected on the basis of multipoint relay. But the PA-OLSR protocol selects the best path by sorting order of LSR and bandwidth.

Route maintenance: In case the energy value is less than the threshold value LSR then link is broken, a route error

(RERR) message is sent back to the previous node to indicate the route breakage. If node receives this RERR message, it informs to the source node then it starts route discovery procedure again.

6. SIMULATION RESULT AND ANALYSIS

In this section we evaluate the performance of routing protocol for MANET in an open environment. The simulations were carried out using Network Simulator (NS-2) [15]. We 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 simulation parameters are specified in Table.1.

Table1: Simulation Parameters

Parameter	Values
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

Mobility model: The mobility model for the simulation is random waypoint model in a rectangular field. The field configurations used is 1,000 m * 1,000 m field with 10 to 100 nodes.
Energy model: The energy model used the following transmission power is 1.4W, receiving power is 1.0W and idle power is 0 for simulation.
Traffic model: Random traffic connection of transmission control protocol (TCP) and continuous bit rate (CBR) can be setup between mobile nodes using a traffic scenario generator script.
The following performance metrics to evaluate through simulation and comparisons have been done by using route stability, network life time and energy consumption.

Route Stability: In figure 1 proposed protocol PA-OLSR is increased route stability with number of node is increased compare to existing OLSR protocol.

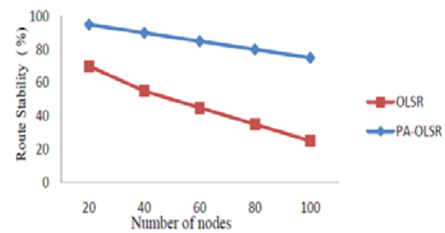

Figure 1: Route Stability vs Number of nodes

Network Life Time: In figure 2 proposed protocol PA-OLSR is increased network life time with data rate (kbps) is increased compare to existing OLSR protocol.

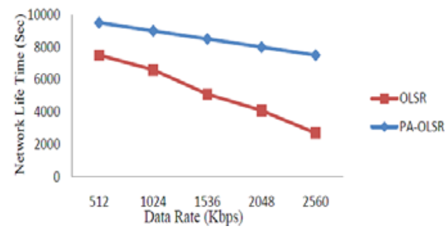

Figure 2: Network Life time vs Data Rate (kbps)

Energy consumption: In figure 3 proposed protocol PA-OLSR is reduced consumed energy with transmission range is increased compare to existing OLSR protocol.

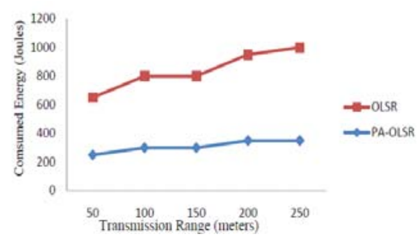

Figure 3: Consumed Energy vs Transmission Range

7 CONCLUSIONS

In this paper is an attempt to present a new power aware routing protocol PA-OLSR for MANET. PA-OLSR is providing better performance compare to existing Proactive Optimized Link State (OLSR) routing protocol. In fig.1 proposed protocol PA-OLSR is increased route stability with number of node is increased compare to existing OLSR protocol. In fig.2 proposed protocol PA-OLSR is increased network life time with data rate (kbps) is increased compare to existing OLSR protocol. In fig.3 proposed protocol PA-OLSR is reduced consumed energy with transmission range is increased compare to existing OLSR protocol. PA-OLSR outperforms than proactive OLSR in terms of route stability, network lifetime, and energy consumption.

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