MPC-EAR: Maximal Power Conserved and Energy Aware Routing in Ad hoc Networks

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Abstract— Power preservation in wireless ad hoc networks is a decisive factor as energy resources are inadequate at the electronic devices in use. Power-aware routing strategies are fundamentally route selection strategies built on accessible ad hoc routing protocols. This paper proposed a new Maximal Power Conserved And Energy Aware Routing (MPC-EAR) topology for mobile ad hoc networks that enhances the network life span. Simulation results prove that the projected protocol has a higher performance other minimal energy usage, energy level aware and energy conserving routing protocols such as MTPR, MMECR and CMMECR.

Key words: Mobile Ad Hoc Network, Power-aware, Overhearing, energy capacity aware, minimum total transmission power

I. INTRODUCTION

Networks are shaped in a dynamic manner of computer or communication nodes loosely connected to assist the forwarding of information between nodes by relaying packets through hop level nodes are re ferred as ad hoc networks. Each node under ad hoc networks connects to their hop level nodes and maintain connection to any other node by discovering multi hop level connectivity.

Building an ad hoc network is a base requirement in situations like military and rescue operations. Hence the ad hoc network augments in situations like, transmitting data/message between any two nodes of the network with no base station support. Due to constrained infrastructure, dynamic connectivity and multi hop level relay based communication, achieving quality of service an ad hoc network is a noteworthy practical confront, especially in ensuring the lifespan of the network, since the resources and energy levels of the nodes are constrained to finite level, wireless connectivity and mobility are other factors. These distinctiveness [1] oblige restrictions on connectivity and packet transmissions between nodes of the ad hoc network. Out of all these issues the limited lifetime of the energy that provides energy to nodes can be considered as a critical and significant issue since if energy with no energy levels downs the node that partitions the network.

Hence the energy conservation techniques are in need to enhance the energy lifetime. It is apparent that energy competent routing topologies should be implemented in place of the traditional routing strategies. All of these conventional routing strategies establish routing paths in the aim of shortest path and neglects the desired proportionality between energy levels required and available, consequently fallout in a quick exhaustion of the energy capacity of the nodes due to routes that are used extremely high in the network. In this regard, to preserve energy lifespan of the nodes, a variety of routing schemes labeled as power aware routing protocols have been designed to select substitute routes. This power aware routing strategies selects routes such that packet routes through paths that justify the proportionality between energy levels required to route and energy levels available at nodes. The underlying process of route discovery and optimal path selection in power-aware routing protocols can be the absorption of the emerging routing topologies such as DSR [2], TORA [3], and AODV [4].

II. RELATED WORK

The superior degree of power consumption at hop level nodes in a shortest path based routing is the severe topic that attracts current research. In this regard several power aware routing solutions proposed. The superior degree of power consumption is proportionate to distance between nodes. In this regard Shu-Lin Wu et al[5] anticipated a new mechanism to lessen power consumption while escalating channel use. The approach is considered the RTS/CTS packet transmissions to measure the energy lifespan used to forward data packets by a node to its target hop level neighbor node, considering this and attempted to generalize the proportionality between energy lifespan is used and relative distance to the target node.

S. Singh et al [6] projected the PAMAS protocol, a new channel admission topology for ad hoc networks that aims to avoid the wastage of the energy lifespan during idle time of the node. In this regard the PAMAS uses two distinct data and signaling channels. The signaling channel observes the idle time of the nodes and alerts them such that they shut down their RF devices. In addition, Wan et al., [7] proposed a routing solution for lowest energy usage broadcasting that committed to fixed MANETs.

Our proposed work concerned with power-aware route selection mechanisms for MANET routing protocols. Hence we analyze the power aware routing protocols that frequently cited in recent literature.

The MTPR (Minimum Total Transmission Power Routing) [9] was originally developed to reduce the total transmission power use of the nodes contributing in the attained route. According to Theodore S et al [10], the obligatory transmission power is proportional to d^{α} , where ‘ d ’ represents the distance between any two consecutive hop level nodes and ‘ α ’ value is in the range of 2 to 4. This concludes that the route discovery process of the MTPR opts more hop level nodes with low transmission distances compared to fewer hops with high transmission distances. But in contrast to the advantage of minimum total transmission power usage, increase in the hop level node count of selected routing paths can augment the end-to-end delay. Moreover MTPR is not considering the proportionality between the power available at the nodes and the power required, hence the selected routing path often experience the breakage due to nodes with no energy.

III. Maximal Power Conserved And Energy Aware Routing (MPC-EAR)

A. Motivation

The proposed MPC-EAR is a proactive approach. Each node of the network maintains a routing table to preserve the available energy capacity of its hop level neighbor nodes, status of route request and path level target nodes considered during route discovery. Here we introduce a novel conditional broadcasting to minimize packet overhead that selects optimal paths with shortest distance and minimal signal to noise ratio. In this regard we consider a novel periodical process that initiates the nodes to exchange their available energy capacity with their hop level neighbor nodes.

B. Route Discovery with Conditional Broadcasting

Under conditional broadcasting a node selects the hop level neighbor nodes to broadcast a route request by considering the proportionality between energy life required and energy life available at hop level neighbor nodes.

1) Route Request

Initially the source node 'n_s' measures the minimal amount of energy capacity 'mec' required to route the data/message by measuring the average energy dissipation per bit of data that transmits to its hop level nodes. Then the source node transmits that 'mec' along with route request. Further each node that receiving a route request in a broadcast manner verifies the status of the route request. If that route request already received earlier then discards. If not then it verifies, whether that node itself is destination node, if not then it initiates conditional broadcasting of that route request to its hop level neighbor nodes. In this regard it initially measures minimum energy capacity threshold 'τ_h' (see Eq1) and then selects hop level neighbor nodes that are having energy capacity more than 'τ_h'. Then it broadcasts that route request to selected hop level neighbors. This process continues till the route request arrives at the destination node. $\tau_h = mec + ec * \frac{tt}{tu}$ …….. (Eq1)

Here in this equation (Eq1):

'mbc' Is minimum energy capacity required, which measured at the source node n_s

'ec' Is average energy consumption per time unit tu during idle time of the nodes.

'tt' Is the time taken by route request to transmit from source node 'n_s' to the current node h.

The structure of the route request '$RREQ$' at the hop level neighbor node h_i is as follows:

$$RREQ = < id(n_s), id(n_d), mec, \{h_1, ...h_i\} >$$

2) Response to Route Request:

Upon receiving the route request $RREQ$, the destination node n_d verifies the status of the $RREQ$. If it is duplicate of the earlier received '$RREQ$' then discards. If not, the destination node n_d initiates transmission of the route response $RREP$. The $RREP$ that initiated, transmits towards source node n_s through the same path used by $RREQ$. Upon receiving the '$RREP$' a hop level node h_i updates the $RREP$ with the distance $d_{(h_i \to h_{i+1})}$ and signal to noise ration $snr_{(h_i \to h_{i+1})}$. The process of measuring signal to noise ratio is explained in following section (see section 3.2.3). This continues until '$RREP$' received by the source node n_s.

The structure of '$RREP$' at a hop level node h_i is as follows:

$$hl = \{h_1, h_2, ...h_{i-3}, h_{i-2}, h_{i-1}, h_i, h_{i+1}, h_{i+2} .....h_m, n_d\}$$

$$dl = \{d_{(h_m \to n_d)}, d_{(h_{m-1} \to h_m)}, ..., d_{(h_i \to h_{i+1})}\}$$

$$sl = \{snr_{(h_m \to n_d)}, snr_{(h_{m-1} \to h_m)}, ..., snr_{(h_i \to h_{i+1})}\}$$

$$RREP = < id(n_d), id(n_s), hl, dl, sl >$$

Here

'hl' Is a list of nodes used by $RREQ$ to reach the destination node n_d from the source node n_s.

'dl' Is a list of distances between each two consecutive hop level neighbor nodes that belongs to 'hl'.

'sl' Is a list of signal to noise ratios between each two consecutive hop level neighbor nodes that belongs to 'hl' and measured using the approach discussed in following section (see 3.1.3).

Once $RREP$ reaches the source node n_s, then the source node registers the path used by $RREP$ into the optimal paths list.

C. Route Selection:

During the optimal route selection, the protocol concentrates only on path optimality in terms of distance and signal to noise ratio. Like as CMMECR, MPC-EAR need not to check for the paths that engaged with nodes with less energy life, since such paths has been discarded by proposed novel conditional broadcasting approach during the route discovery phase. The optimal path selection process is as follows:

The route selection phase of the MPC-EAR initially checks the average distance $d_\alpha(p_i)$ (see Eq5) and average signal to noise ratio $snr_\alpha(p_i)$ (see Eq6) between hop level nodes for each path p_i of the discovered paths list Pl.

$$d_\alpha(p_i) = \frac{\sum_{k=|dl|}^{2} \{d_{(h_k \to h_{k-1})} | d_{(h_k \to h_{k-1})} \in dl\}}{|dl|} \text{ …….. (Eq5)}$$

Here in Eq5 dl is the list of distances that is available at root response packet $RREP$ of the path p_i.

$$snr_{\alpha}(p_i) = \frac{\sum_{k=|sl|}^{2} \{snr(h_k \to h_{k-1}) | snr(h_k \to h_{k-1}) \in sl\}}{|sl|} \quad \ldots\ldots \text{(Eq6)}$$

Here in Eq6 sl is the list of signal-to-noise ratios that is available at root response packet $RREP$ of the path p_i. Afterwards, root selection phase of the MPC-EAR measures SNR per unit of distance snr_{δ} (see Eq7) and distance per unit SNR d_{τ} (see Eq8) to assess the path optimality of each path and rank them.

$$d_{\upsilon}(p_i) = \frac{\sum_{k=|dl|}^{2} \{d(h_k \to h_{k-1}) | d(h_k \to h_{k-1}) \in dl\}}{d_{\alpha}(p_i)}$$

$$hd_{\upsilon}(p_i) = \frac{d_{\upsilon}(p_i)}{|hl|}$$

$$snr_{\delta}(p_i) = \frac{\sum_{k=|sl|}^{2} \{snr(h_k \to h_{k-1}) | snr(h_k \to h_{k-1}) \in sl\}}{hd_{\upsilon}(p_i)} \quad \ldots\ldots \text{(Eq7)}$$

Here in Eq7:

- $d_{\upsilon}(p_i)$ Is the number of distance units(Average distance $d_{\alpha}(p_i)$ is one unit)
- $hd_{\upsilon}(p_i)$ Is the number of distance units per hop level node in the path p_i

$$snr_{\upsilon}(p_i) = \frac{\sum_{k=|sl|}^{2} \{snr(h_k \to h_{k-1}) | snr(h_k \to h_{k-1}) \in sl\}}{snr_{\alpha}(p_i)}$$

$$hsnr_{\upsilon}(p_i) = \frac{snr_{\upsilon}(p_i)}{|hl|}$$

$$d_{\tau}(p_i) = \frac{\sum_{k=|dl|}^{2} \{d(h_k \to h_{k-1}) | d(h_k \to h_{k-1}) \in dl\}}{hsnr_{\upsilon}(p_i)} \quad \ldots\ldots \text{(Eq8)}$$

Here in Eq8:

- $snr_{\upsilon}(p_i)$ Is the number of snr units (Average distance $d_{\alpha}(p_i)$ is one unit)
- $hsnr_{\upsilon}(p_i)$ Is the number of snr units per hop level node in the path p_i

Then the each path p_i will be ranked based on $snr_{\delta}(p_i)$ such that the path with lowest $snr_{\delta}(p_i)$ value will be ranked as high. If more than one path is conflicting on same rank then those paths will be ranked based on $d_{\tau}(p_i)$ such that the path with lowest $d_{\tau}(p_i)$ value will be ranked as high.

IV. SIMULATIONS AND RESULTS DISCUSSION

A. *Experimental setup*

The experiments were conducted using mxml. We build a simulation network with hops under mobility and count of 50 to 200. The simulation parameters described in table 1. The simulation model aimed to compare CMMECR [12] and MPC-EAR. The performance check of these two protocols carried out against to the QOS metrics describe in following section (see section 4.2) .

Node count	Range of 50 to 200
Network Area	1500 m × 300 m dimensions
Radio Frequency	Range of 250 m
Number of source and destination node sets	20
Data pattern for each source node per second	4 packets
Payload of the data per packet	512 bytes
Data-load used	In the range of 128 to 512 kbps
Bandwidth used at physical link	2 Mbps
Timeout set for the primary route request in seconds	2
Utmost timeout set for the route request in seconds	40
Maximum number of routes can be cached	32
Caching policy	First-In-First-Out

Table 1: Simulation parameters that we considered for experiments

B. *The Qos metrics to verify the performance of the routing protocol*

- Data packet delivery ratio: It indicates the proportionality between the number of packets sourced and number of packets delivered.
- PACKET DELIVERY FRACTION: It exploits the frames delivered to the destination nodes as a percentage of the frames generated at source nodes. The higher the value of PDF scales the performance of that protocol as best.
- AVERAGE END TO END DELAY: This metric specifies the average delay time in packet delivery at destination node that sourced from the source node. The end to end delay can be observed due to the issues such as buffering in regard to route discovery latency, queuing at hop level nodes of the routing path, delays due to retransmission at the MAC layer and during transfer of packets at hop level nodes. Once the time at sourced packets and delivered packets observed as divergent, dividing the total time at disproportion over the count of CBR packets received claims the average end-to-end delay for the packets delivered. The minimal end to end delay indicates the high performance of the protocol.
- Packet Loss: The divergence among the number of packets sent by the source and received by the sink. The packet loss and performance of the protocol is inversely proportional.

– ROUTING OVERHEAD: Routing overhead is the percentage of total number of routing packets to data packets, which is measured at the MAC layer.

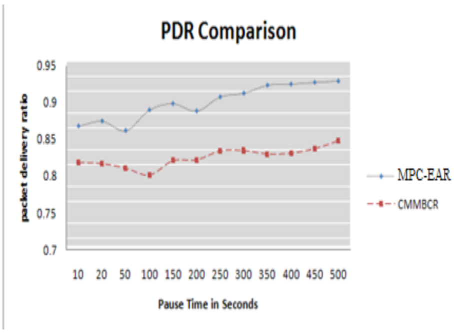
C. Results Discussion

Figure 1(a) shows the Packet Delivery Ratio (PDR) for CMMECR and MPC-EAR . Here in this case we can notice that MPC-EAR is scalable over CMMECR. The percentage of PDR advantage observed in MPC-EAR over CMMECR observed is around 1.5%, which is an average of all pauses. The minimum percentage of PDR advantage of MPC-EAR over CMMECR observed is 0.14% and maximum observed is 3.3%. Figure 1(b) indicates a CMMECR advantage over MPC-EAR in Path optimality. The average 0.016 hops longer path has been used by MPC-EAR than CMMECR, it has happened since MPC-EAR is considering the distance to be travelled, average signal-to-noise ratio required and minimum energy capacity of the hop level nodes between the source and destination nodes as metrics during route discovery, but in the case of CMMECR, it considers only distance between source and destination nodes as route discovery metric. Hence the CMMECR route discovery phase determines much number of paths than the route discovery phase of MPC-EAR. Here slight advantage of CMMECR over MPC-EAR can be observed, which in contrast effects the performance of CMMECR during optimal path selection phase.

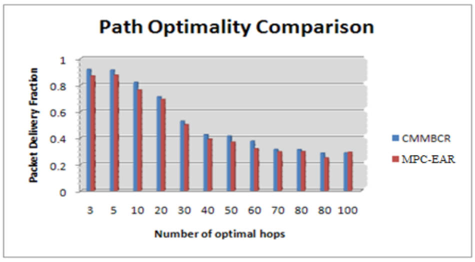
MPC-EAR is scalable to minimize the packet overhead during route discovery and data transmission that compared to CMMECR (see fig 1(c)). This is due to conditional broadcasting introduced in route discovery phase of MPC-EAR and the process of path selection that selects the path with fewer signal-to-noise ratio. The average of 5.29% of additional packet overhead observed in CMMECR over that observed in MPC-EAR The minimum and maximum percentage of additional packet overhead observed in CMMECR over MPC-EAR is 4.73% and 9.12% respectively.

The proposed MPC-EAR protocol is indicating the slightly high MAC load overhead that compared with CMMECR (see figure 1(d)), which is due to the process of MPC-EAR that determines the signal-to-noise ratio required between any two consecutive hop level nodes. The average additional MAC load overhead that observed in MPC-EAR over CMMECR is 1.64%. The minimum and maximum MAC load overhead observed is 0.51 and 2.94% respectively.

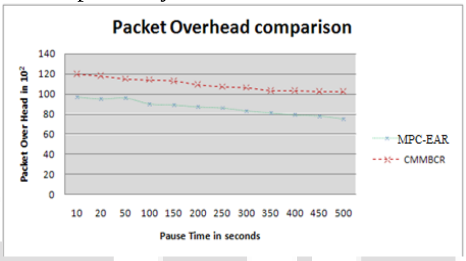
The average end-to-end delay that observed in MPC-EAR is significantly lower that compared to the average end-to-end delay observed in CMMECR (see figure 1(e). This is due to the consideration of hop count during optimal path selection in MPC-EAR. The minimal hop count is not playing any role in optimal path selection process of the CMMECR. Hence the increases in number of hops proportionately increase the average end-to-end delay. Where as in the case of MPC-EAR the hop count is playing a key role to define the signal to noise ratio per distance unit (snr_δ). The high hop count leads to the higher value of snr_δ that indicates the low optimality of the path. Hence the optimal path that selected in MPC-EAR is possible with less number of hops.



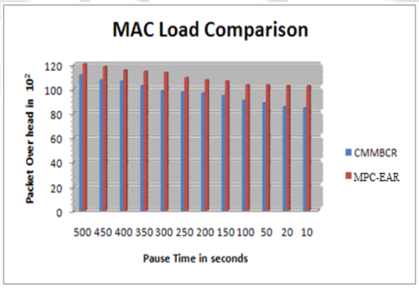
(a) Comparison report of PDR observed at CMMECR and MPC-EAR



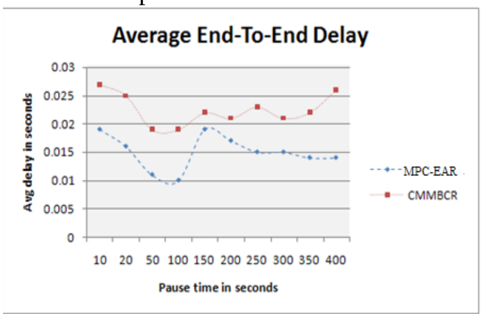
(b) Path optimality of CMMECR and MPC-EAR



(c) Packet overhead comparison report of MPC-EAR and CMMECR



(d) Mac load comparison of MPC-EAR and CMMECR



(e) Average end-to-end delay observed at multiple pause times

Fig. 1: Evaluation report on MPC-EAR performance over CMMECR

V. CONCLUSION

This paper was presented an evaluation of power aware routing protocols [5], [6], [7], [8], [9], [11], [12], [13] and [14], and described their limits that can be subtle and difficult to discover by informal reasoning about the properties of the protocols. The proposed MPC-EAR protocol applies conditional broadcasting to avoid the verification of energy capacity while choosing the optimal path from the paths selected by route discovery phase. Unlike CMMECR [12], the proposed MPC-EAR is interlinking the the energy life aware and minimum usage total transmission power routing together. Due to the conditional broadcasting in route discovery phase and optimal path selection process introduced in MPC-EAR, this protocol is scalable over any other power aware routing protocols such as MTPR [9], MMECR [11] and CMMECR12]. The hop count of the routing path is a crucial metric that influences the average end to end delay. Here in this protocol hop count of the path is playing a significant role to define the snr required per unit of distance and distance covered by a unit of 'snr'. As described in the Eq7 and Eq8, the SNR per unit of distance snr_{δ} is proportionate to hop count, hence minimal hop count leads get minimal value to snr_{δ}, which leads to rank that path as higher optimal.

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