Improvement of Battery Lifetime of Mobility Devices using Efficient Routing Algorithm

Rajendra Prasad P[1] and Shivashankar[2]

[1,2]Department of Electronics and Communication Engineering, Sri Venkateshwara College of Engineering, VTU, Bengaluru, India; rajisvec@gmail.com, chanduss123@gmail.com

Abstract

Ad-Hoc Network being one of the types of mobility devices that form a temporary mesh network. Routing is one of the techniques in Mobile Ad Hoc Network (MANET) which is mostly adopted due to its dynamic topology nature. In MANETs, the major issues that need to be handled are battery power, bandwidth which are the limited resource. The main issues with mobile ad hoc devices are power consumption. The rate of energy consumption of each mobility device must be equally assigned and transmission power of each path should be minimized for increasing the network life time of each path in the network selection. In the proposed work, the Minimum Power Consumption Routing (MPCR) protocol is been studied and analysed followed by comparison with the existing power routing protocols such as Minimum Total Transmission Power Routing(MTPR) protocol and Minimum Battery Cost Routing (MBCR) based on Constant Bit Rate (CBR) traffic patterns.

Keywords: Battery Power, Network Lifetime, End to End Delay, CBR

1. Introduction to Mobile Ad-Hoc Networks

Today, wireless communication with Mobile Ad-Hoc Networks (MANETs) and sensor networks are very important issues in the research work for self-configuration and pre-established infrastructure. Ad-Hoc networks are the spontaneous networks that provide communication everywhere for the mobile users and access the information regardless of location. The routing in MANETs creates the problem because of node mobility. The upcoming research field is more keen on design of protocols for the efficient and prolong battery life by reducing sleep and idle power consumption[1-4]. All the mobility wireless devices are mainly operated on the limited battery power.

Each mobile node spends some amount of battery power to execute control and network algorithms for specific task in MANET. Effective and accurate power aware routing techniques find the significance for routing protocols in MANET design, where each node in the network is powered by battery. Each mobile node in defined wireless communication network is mainly operated on battery power. When battery power of any mobile node is fail in any situation. It is not only affecting itself also effects on the whole network communication. This prompts general system lifetime disappointment. Thus, to resolve these issues, research exertion on to enhance the increase in battery capacity at the networks different level aspects of MANET. These aspects include the power consumption with respect to communication and non-communication purpose. Each node mainly consists of processor, memory and uses some significant amount of power in non-communication system. It is necessary to implement power management strategies for these components to reduce power consumption in communication system. During forwarding a packet, power is consumed in either idle or sleep mode or active mode communication states. In high traffic environment, power consumed by active mode communication is significant than others.

The remaining structure of the proposed work is described as below. The Existing work wherein it reviews literature survey on several power aware routing protocols and various factors influencing the routing performance are discussed in Section 2. The detailed description of our proposed Minimum Power Consumption Routing (MPCR) protocol is presented in Section 3. The simulation

** Author for correspondence*

experiments and their results to compare MPCR, MTPR and MBCR presented in Section 4. Finally, we conclude the result of the proposed work.

2. Existing Work

The major related issues in wireless ad-hoc network are the route calculation. That deals to find the best and accurate route to sink node during the mobility and network topological changes and uniformly distributed. These are the main challenges issues in wireless communication. All these problems including reliable peak power consumption and gaining accurate spectrum are considered in the earlier research work[5-6]. Researchers argue with a simple algorithm[7] implementation that describes, and which promises connectivity, strong communication and stated node limitation to radio range wireless communication. There are many protocols are existing based on shortest-path protocol mechanism and flooding algorithm is used in the proposed system. A dynamic routing algorithm is developed for possible elimination of the ideal links at the time of backbone network setup will not yield minimum energy solution for route calculation to establish and maintain the network for connection related sessions which make use of the knowledge of re-routing configuration to cope with the nondeterministic topology changes[8]. The shortest path routing algorithms are used in MANETs in order to know the number of hops is the path length of the routing protocols[3].

For a wireless radio spectrum to communicate in a mobile network, MANETs differ significantly from other existing networks and co-operative network. The mobile nodes are dynamic in nature and also act as administration in the network topology[9]. These nodes are self-configuring and intended to be de-centralized control in the network topology. In such networks, it is not desirable to assume all the nodes will have single hop communication with each other. So, such type of networks need specialized efficient routing protocols which provide self-starting behaviour of mobility. In such situations, existing wired network routing protocols would degrades in performance. In wireless correspondence framework, there is dependably interest for new routing protocols have been on interest in MANETs. Invention of any new wireless routing protocol is classified based on the mobility and character in which route tables are created, maintained and updated[10].

Network performance based on battery power has been major focusing area for research on routing protocols in MANETs. The designed conservative routing algorithms in[4] which are performance based and optimization fairly power efficiency. For multi-hop communication various routing protocols have been proposed[6]. These protocols, traditionally evaluated in terms of data rate loss, packet overhead and route length. A growing emphasis on long-lived networks has added energy consumption as an important metric. A number of research studies have been done on power-aware routing protocols of MANETs.

3. Analysis of Re-Active Routing Protocol and Design of Proposed Algorithm

Minimum Power Consumption Routing (MPCR] is proposed based on modified DSR algorithm. The factor of battery power is considered as a criterion for choosing a shortest path. Diminish in the nodes remaining battery force expands the expense of a node. The goal is amplifying the lifetime of an ad hoc network. Basically to keep up the network topology information the nodes are not required for an on-demand routing protocol. Using a connection establishment process, the necessary path will be obtained by the nodes, as and when required. The stack wherein the diverse layer of the network protocol are focused in order to have better efficiency and different regressive practices have begun in the area of power conservation. On the other hand, the MAC layer and the network layer have been focused for the examination.

3.1 Minimum Total Transmission Power Routing

The power of the minimum transmission depends on the desired bit error rate and distance. The base aggregate power route can be gotten by utilizing the hosts n_i and n_{i+1}. By using the P(n_i, n_{i+1}) transmission power as a metric, the total amount of transmission power can be obtained of the route (P_t) by the equation(1).

$$P_t = \sum_{i=0}^{D-1} P(n_i, n_{i+1}) \quad (1)$$

Where '*i*' indicates the path for all nodes participated in the network, where n_i is source and n_D are destination nodes respectively. Therefore, from the following result the desired route 'k' can be derived as

$$P_k = \min_{l \in k} P_t \quad (2)$$

Where, 'k' is set of every possible route in the characterized network and l is the total number of paths. Vast number of hop routes is chosen by considering the transmission power (P_k)which is subject to the separation corresponding $\frac{1}{d^n}$. More end to end delay will be observed if in the routing protocols the large number of nodes is considered. This condition is due to large number of nodes that are high unstable of the routing packets, with greater possibility the intermediate nodes shift away. By considering this the route that has been obtained from above algorithm is non-attractive.

3.2 Minimum Battery Cost Routing (MBCR)

In MANET by considering mobile nodes total transmission power, the life span of the mobile host is determined. On the other hand, in the lifetime of nodes it is a serious issue. The overall reduction in the power consumption and the life span of each host is not reflected directly by this metric. The battery of the specific host will die soon if it is used for the minimum total transmission power routes. This is due to the battery of the host getting exhausted at faster rate. The remaining battery in each host describes the life span of every host.

Let the battery capacity be c_i^t, of a host at time t and let battery cost function be $f_i(c_i^t)$ of a host n_i. It will be more reluctant if it has less capacity. This can be shown as below.

$$f_i\left(c_i^t\right) = \frac{1}{c_i^t} \quad (3)$$

For D nodes and route i; the cost of the battery R_l is given as below:

$$R_l = \sum_{i=0}^{D-1} f_i\left(c_i^t\right) \quad (4)$$

Therefore, the energy of the route i with minimum cost (R_l), should be selected in order to find the route that is having the battery capacity that is high.

$$R_l = Min\{R_j | j \varepsilon k \quad (5)$$

There will be increase in the life span of the hosts by using the battery capacity directly. This metric avoids the excess host utilization in the routing protocol and when the life time of the battery used by all other nodes are similar then the selection made by the metric will be of smaller hope route. However, the battery capacity that has been taken into account is addition of battery capacity values. The limited remaining life time of the battery that the route contains decides the selection of the route.

3.3 Design of proposed MPCR protocol

We present several power-aware metrics that do result in power efficient transmission. The following are some methodologies to implement MPCR protocol.

Consider a network as shown in Figure 1. Wherein the protocol has to identify the shortest path along with it has to maintain the lifetime of each node till it reaches the destination. The network life time or battery power of each node is mentioned at their respective mobile nodes shown in the figure 1. The protocol identifies the three possible path to transmit data from Source (Sr) node to Destination (Dt) node i.e.,

Path 1: Sr → H → I → Dt
Path 2: Sr → E → F → G → Dt
Path 3: Sr → A → B → C → Dt

From the above three paths the networks identifies that the path 1 has the shortest path along with the maximum network lifetime of each node in the path.Figure 1. MPCR working model.

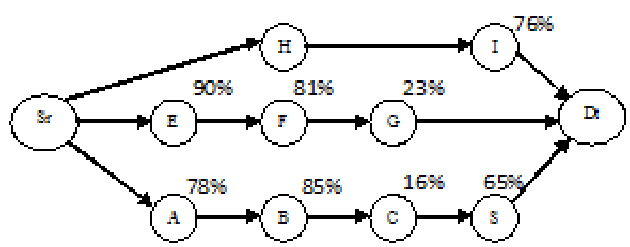

Figure 1. MPCR working model.

3.3.1 Minimize Energy consumed per broadcast

It's one of a most indisputable metrics which throw back our immediate insight roughly safeguarding energy. Define l as few packets to broadcast in the networks in which to pass or move over number of nodes n_1, n_2, n_3,..., n_k where n_1 is considered as the source n_2, n_3,..., n_k and are neighbour/intermediate nodes that retransmit this packet. $T(n_i)$ refers to the power consumption by a nodefor transmitting total number of data packet. As this is a show, every node must get this parcel yet we will not guide the energy to consume bundle in this metric.Then the energy consumed for packet l by all the transmitters is given as

$$E_l = \sum_{i=1}^{k} T(n_i) \quad (6)$$

Thus, the desire about metric is to reduce E_l, for all broadcast packets *l*. It is not difficult to manage the metric that will cut the respectable energy consumed per broadcast packet. It is also not difficult to manage the metric that also will cut the respectable energy consumed per broadcast packet. However, it is not inconsequential to get ahead this metric as it is esoteric to engage the proficient broadcast trees to get ahead this goal. One major drawback the metric have is that the nodes will toil to have frequently divergent energy consumption profiles which could authorize in promptly demise for sprinkling nodes.

3.3.2 Minimize Cost per Packet

For maximizing the all career node functions of networks, previously metrics distinctive than desire consumed by each packet require to be used. The paths engaged when by the agency of these metrics should be a well-known that nodes with depleted energy reserves do not become intermediate nodes on multiple broadcast trees. Let the node cost is denoted by $f_i(x_i)$ which denotes the weight of node *i*, x_i, represents the total energy by means of this far. The charge per cost of transmitting a packet *l* from source n_1 to all nodes going through inter-mediate nodes $n_2,\ldots, n_k$ is given by,

$$C_l = \sum_{i=1}^{k} f_i(x_i) \quad (7)$$

The desire about metric is to minimize C_l and abode of packets *l*. subliminally f_i, denotes a node's reluctance to earlier packets and we boot see that by all of a suitably chosen f_i, we can accomplish a different goals. In this way, if f_i is a monotone collective work, nodes that lie on many trees will not be completely used herewith accumulative their life. Conversely, the delay and the energy consumed per packet make out are in a superior way for several packets. Here, f_i can further be tailored to strongly reveal a battery's exclusive lifetime. Many batteries bring to light a discharge curve which lessens faster than linearly by all of increased use. So, we can behave two f_i's, linear and quadratic, in crucial the cost to ahead a packet over a node.

We can summarize small number of the benefits of this metric as:

- It is accessible to relate the battery characteristics soon into the broadcast protocol,
- As a side-effect, we take turn for better time to network partition and decrease variation in node costs (though we do not optimize these metrics) and battery power.
- Effects of network congestion are undivided into this metric (as an increase in node cost right to contention).

3.4 Mathematical Model for Proposed Protocol

Let us had the appearance of that several packet *l* traverses nodes $n_1, n_2, n_3,\ldots, n_k$ where n_l is the source and n_k is the destination. The vitality expended is demonstrated by $T(a,b)$ for accepting and transmitting a parcel around a hop from to. At that point the energy used for packet *l* is

$$E_l = \sum_{i=1}^{k-1} T(n_i, n_{i+1}) \quad (8)$$

Thus, the idea about metric is to, reduce E_j for all packets *l*. Under light loads, the routes chosen by this metric will be equivalent to routes occupied by shortest-hop routing. If we adopt that $T(a,b) = T(constant)$, $\forall(a, b) \in E$, by the time mentioned the power consumed is $T(k_i)$.

To minimize the above, we simply need to decrease the valve *k* which is related as shortest hop routing. The ways chose by this metric are not evermore same as that of briefest hop routing. The measure of energy exhausted in transmitting one bundle totally over one hop will not be a constant considering consume of variable amounts of battery power on contention. Thus, in this situation the metric will inclined to route packets everywhere in congested areas. One profession weakness of this metric is that hubs will slope to have generally shifting energy utilization profiles bringing about straightforwardly death for some nodes. It prompts bigger utilization of power in the system. Some difficult situation in implementing this metric are

- Since nodes in dissimilar partitions independently capture routing decisions we cannot accomplish the worldwide equalization required to expand the network partition time interim minimizing the normal postponement.

- Because the power utilization is relying upon the length of the bundle, we cannot represent optimal routes without the development of future packet arrivals.

3.5 Study of Power Consumption Model in MPCR Protocol

In the proposed article, the consumption of node power in MANET is been divided into 3 categories: (i) power utilized for transmitting data packets, (ii) power utilized for receiving packets and (iii) power utilized in idle state. The energy optimization cannot be achieved if there is MANET overhearing. The power expended for the gathering and transmission of parcels is the fundamental centre of this paper and the idle state energy loss.

During the simulations of mobile nodes in the network, the transmission power is fixed to 1.4W. The transmission power per hop is tuned by formula *1.118 + 7.2*10-11*(d) 4*, where the distance between the source and destination nodes is *d* and the power *1.1182W* is required to drive the circuit. The gathering force per hop for all conditions is settled and it is around *0.967 W*. The above qualities for transmission and gathering power per hop are usually utilized as a part of simulation studies.

3.5.1 Power saving Mechanisms

Without a fixed infrastructure, ad hoc networks have to rely on portable with limited battery power. In communication, the energy consumption at the node energy is dominant when compared to the energy consumption in processing. Thus the communication system must have efficient energy to optimize the different states consumption communication. The following sections briefly discuss energy models and some important techniques that used to design energy efficient routing protocols related with transmission power control and load balancing.

- Power aware routing: here the transmission power decides the routing, that is again depended on the distance between the source to destination.
- Cost aware routing: here the lifetime remained is utilized as a metric for decision making.
- Combining power and cost aware metrics: here both the power of transmission along with node lifetime are combined in a link for cost computation and then use this as a metric to process.

3.6 Route Discovery Mechanism in Proposed Algorithm

The source hub sends RREQ parcel when it does not have one accessible and cravings a route to a destination. Every one of the hubs other than destination hub ascertains the expense of the connection and afterward they include it in the RREQ's header. In the event that the hub is middle of the hubs rejects the RREQ or on the off chance that it is the destination hub, then it gets all the RREQ with the identical telecast ID and source IP Address. The clock starts at the paramount RREQ to the destination hub and is the same clock for all the RREQs with the same source address and telecast ID. This is the point out as the destination hub may get RREQs from different sources or other telecast ID in the meantime. Subsequently, destination has differing clocks for each one of a kind RREQ. RREQ is received at the destination, checks if it's already heard it earlier, if it is not heard earlier, then it initiates timer, which records the cost link of the route with minimum cost in the list.

If additional RREQs arrival is present with the similar Broadcast ID and source address, then the minimum cost is compared to the new RREQ cost packet.

- The cost is modified to the new minimum one, if new packet arrives that has less cost, then the information related to the route will be stored in the RREQ
- But if the new RREQ cost is higher, then it is retained with previous information, i.e., nothing will be changed.

At that point when the time terminates, the destination hub sends REPLY subsequent and to put away the RREQ with lower connection cost. When the first RREQ is received, in the existing reactive protocol the destination generates RREP. So the briefest course is picked and the various RREQs are disposed. MPCR can have the privilege of choosing the route that in light metric of energy-aware.

4. Simulation Results And Discussion

With the implementation of MPCR, MTPR and DSR routing protocols. At the beginning of the simulation, defined area 2000m X 2000m consist of 100 mobile nodes in random nature and two way communication.

4.1 Simulation setup

For the simulation of MPCR, MTPR and MBCR routing protocols, we have used NS-3.0 simulator, and the routing trace are collected with mobility history. The required simulation model is summarized in table 1.

Table 1. Practical Set up Values

Simulator	NS-3.0 Version
Network Area	2000m X 2000m
Total Number of Mobile Nodes used	100
Communication Model	Two – way Communication
Transmission Range	500m
MAC layer	IEEE-802.11g
Link bandwidth	1.8 Mbps
Routing Protocols used for comparison	MPCR,MTPR,MBCR
Mobility Model	Random way
Node Speed Ranges	1,5,10 and 15m/s
Traffic Model used	CBR,UDP
Data Packet size	512 bytes

4.1.1 Packet conveyance proportion

It is the proportion ratio of quantity of bundles received by destination hub to quantity of parcels sent by the source hub. It is an important metric since it depicts the loss rate and thus reflects the throughput. For every one of the simulations, the quantity of information bundles conveyed is kept steady. The quantity of bundles got at the destinations will give correlation about the effective underlying routing algorithm throughout for similar traffic load. Packets may fail to reach the destination because any of the following factors like network partitions, routing loop and interface queue drop. Packet conveyance proportion is characterized as the quantity of packet got by CBR sink at destination by number of bundles sent by CBR. It describes the percentage of packets, which reach the destination. Simulation results in this paper show characteristic differences in performance between considered routing protocols mechanism used. As shown in Figures 2 and 3, MPCR and MTPR, achieve high values of Packet Delivery Ratio (PDR), which means they are efficient protocols from the point of delivering packets to their destination.

$$PDR = \frac{\sum \text{Total Number of CBR Packets received}}{\sum \text{Total Number of CBR Packets sent}} \quad (9)$$

For MPCR and MTPR protocols, PDR is independent of mobility and number of sources, while MBCR has approximately the same PDR under low mobility. As shown in table 2, MPCR and MTPR protocols deliver over 60% of packets for all considered values of pause time and maximum movement speed. There is no adaptive to the route changes that occur under high mobility as MPCR and MTPR protocols since MBCR protocol uses a minimum cost approach of maintaining routing information. That is why; it delivers less data packets which are also shown in Tables 2 and 3.

In the following simulations, the data rate is varying from 100 to 1000Kbps. The maximum node moving speed is increased to see the behaviours of the MPCR, MTPR and MBCR protocols with high mobility. The results are shown in terms of average end to end delay and packet delivery ratio with maximum node moving speed range from10 to 100 m/s.

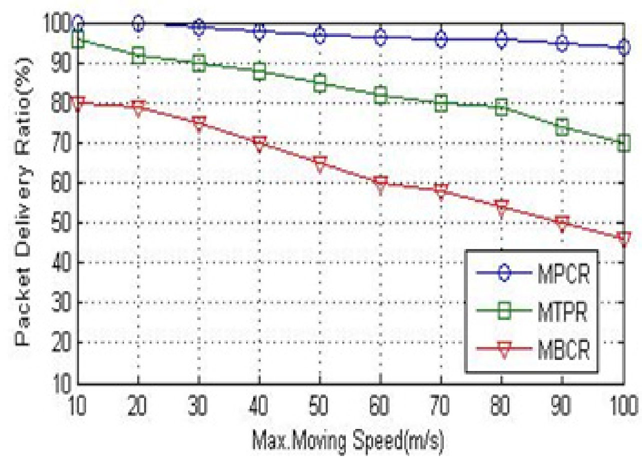

Figure 2. Comparison of protocols with PDR v/s Maximum Moving Speed.

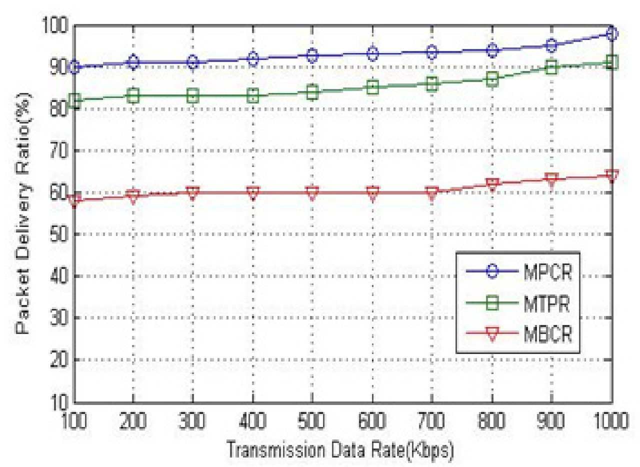

Figure 3. PDR v/s Transmission Data Rate.

4.1.2 End-to-end Delay

The Figures 4 and 5 show measure of end-to-end delay for the power aware routing requirement 100 m/s at different node mobility. As the hub pace builds, end-to-end postponement is likewise increments. Higher mobility causes more links broken and frequent re-routing and thus causes larger end-to-end delay. The end-to-end delay in MPCR protocol is within the limit (100m/s) and reduces up to 40% improvement compare to MTPR and MBCR protocols. The MTPR and MBCR protocols have a longer delay because their route discovery takes more time as every intermediate node tries to extract information before forwarding the reply. Tables 2 and 3, show the comparison of end to end delay with respect to three protocols.

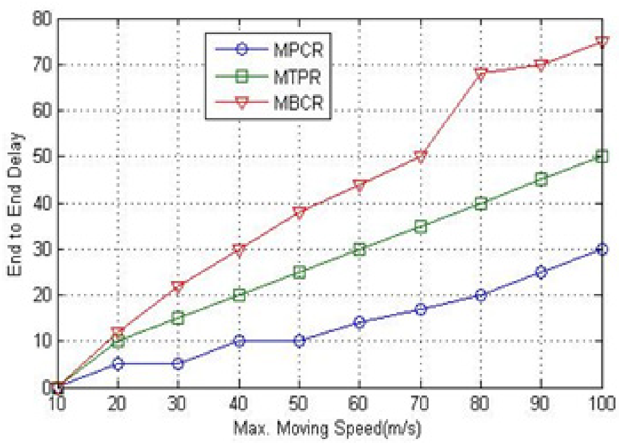

Figure 4. End to End Delay v/s Maximum Moving Speed.

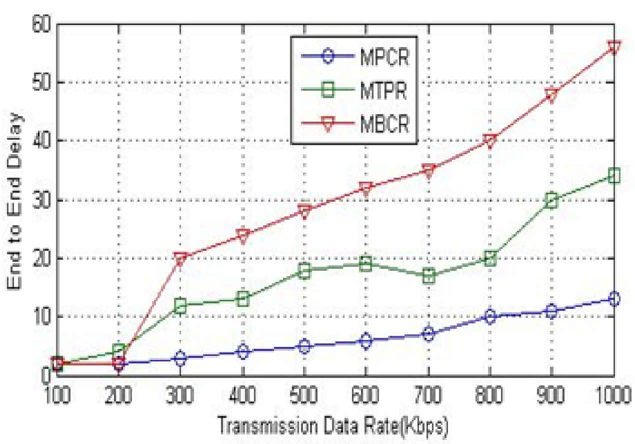

Figure 5. End to End Delay v/s Transmission Data Rate.

5. Conclusion

This paper presents a brief description of several routing protocols which are proposed for MANETs and also provides a classification of these protocols according to the routing strategy. Therefore, battery is critical resource in the mobile nodes, so more efficient way of utilizing the energy is directly proportional to maximum network life time of nodes. The end-to end-delay and packet delivery ratio are also considered as major critical issues. Hence, it is difficult to design and develop a well-tailored ad hoc routing protocol by considering these parameters. Metrics such as minimum battery cost and min-max battery cost schemes can enlarge the time till the first node goes down and hence the network partitioning time increases. The performance of these protocols analyzed with NS-3 simulator with scenario of 100 nodes. The observations are made with variation in node speed in the network. After analysis in different situations of network, it can be practical that MPCR perform glowing than MTPR and MBCR in terms of end to end delay, while MPCR is provided to be best in case of packet delivery ratio.

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