Power Efficient Routing Protocol for Mobile Ad Hoc Networks

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ABSTRACT:

Mobile Ad hoc Networks (MANETs) routing is challenged by power and bandwidth constraints as well as frequent topology changes due to which it must adapt to and converse quickly. The absence of any central coordinator and infrastructure less network make routing a complex one for MANETs. Routing protocols consider the path with the minimum number of hop counts as the efficient path for transmission of data packets to any given destination. However, it does not provide efficient power consumption and may create node failure resulting loss of data packets. If the battery of a node is drained out, then it cannot communicate with other nodes and the number of dead nodes makes the network partition. A routing protocol called Power Efficient Routing (PER) is proposed which enhances the quality of services' issues such as Packet Delivery Ratio, End to End delay, Energy Consumption and Network Lifetime. This paper presents a scheme for efficient power routing based on residual battery capacity, transmission power, and hop count to route the data packets. A simulation study demonstrates the effectiveness of proposed scheme to provide reliable transmission than the existing AODV.

KEYWORDS:

MANETs, power, routing, hop counts, data packets, dead nodes, quality of service

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INTRODUCTION:

A Mobile Ad hoc Network (MANET) consists of a set of wireless mobile nodes communicating to each other without any centralized control or fixed network infrastructure (Palanisamy and Renuka Devi 2012). MANETs have been evolving to serve a growing number of applications that rely on multi-hop wireless infrastructures that can be deployed quickly. The potential applications include emergency disaster relief, battlefield situations, mine site operations and wireless classrooms in which participants wish to share information or acquire data. One of the challenging problems in this type of network is the utilization of an inefficient routing process. Efficient routing operations require collective cooperation of all nodes (Baxla and Nema 2013). In these networks, routing protocols should be more dynamic so that they quickly respond to topological changes (Perkins et al. 2003).

A critical issue in MANETs is that the mobile nodes are power constrained. Various power aware routing protocols have been proposed. However, most of the existing protocols have not focused on the life time of a node. Even in sleep awake scheduling algorithm, node will consume power although it is in sleeping mode (Rajeswari and Venkataramani 2012). A constant amount of power is consumed by nodes even in sleep mode because the signals will check all the nodes over the network before broadcasting to a particular path. The power consumption in sleeping, idle and transmitting modes are approximately 150mW, 160mW and 300mW respectively (Mishra and Pattanayak 2013).

There are no dedicated routers, servers, access points, base stations and cables. Two mobile nodes within the transmission range communicate directly with each other. If they are far apart, intermediate nodes forward the packets from source to destination. Thus, every mobile nodes function as a router to forward the packets. All the mobile nodes communicate with each other through the Base Station (BS) and BS sets the path for transmitting data packets among two nodes. BS provides various services such as path identification, packets routing and route maintenance. But in MANETs all these services provided by BS has to be provided by node itself which increases the power consumption rate and decreases the life time of the network. Thus the nodes battery will get drained soon and node dies which ultimately causes network partition and loss of information. The power is optimized by avoiding the nodes having less battery capacity to forward data packets (Mishra and Pattanayak 2013). But if there are more than one consecutive nodes having less battery power then the longest path has to be selected which increases link cost and delay. The proposed protocol overcomes such issues.

This paper presents efficient power routing protocol in MANETs considering the Packet Delivery Ratio, End to End delay, Energy Consumption and Network Lifetime. The proposed PER protocol provides multiple routes to a destination so that a single route with least hop count is chosen and routes with the higher hop counts are discarded so that minimum power is required for transmission which enhances the battery capacity of nodes, increases packet delivery ratio and end to end delay. Thus, PER routing protocol selects efficient path with minimum path load.

RELATED WORK:

There are two transmission models; one-to-all model and one-to-one model for Broadcasting at physical layer. In one-to-all model, transmission by each node reaches all the nodes that are within transmission radius, while in one-to-one model, each transmission is directed only towards neighbor. Broadcasting at the network layer has many important uses and several MANET protocols assume the availability of an underlying broadcast service. Network routing protocols should be more dynamic to respond to the topological changes. Lee and Gerla (2001) have proposed an approach to constrain Route Request (RREQ) packets based on node caching.

Several power routing protocols for MANETs have been proposed till date which focuses on various parameters like energy consumption, time delay, packet delivery ratio, accuracy etc. Most of the approaches are on-demand based protocols; that is, they combine load balancing strategies with path discovery. A path with the least load among multiple possible paths from source to destination is usually chosen (Toh et al. 2009). A great challenge in the design of ad hoc network is the development of efficient routing protocols that can provide high quality communication between two mobile nodes.

The Minimum Total Transmission Power Routing (MTPR) protocol uses minimum total power consumption among all the possible paths (Scoot et al. 2001). The power consumption depends on the separation between two nodes. This protocol reduces the power consumption among nodes but does not increase the life time of nodes in the network and also has higher end to end delay due to more number of hop counts between source and destination. Power consumption of each node should be a uniform distribution function and nodes with maximum remaining battery capacity must be selected to increase life time of nodes. The disadvantage of these existing protocols is that there is more delay in transmitting packets from source to destination. But the proposed protocol overcomes delay through efficient path with low power consumption.

Vidhyapriya and Vanathi (2007) have proposed an energy constraint routing protocol in which routing packets are transmitted based on energy. Hieng et al. (2010) proposed an algorithm which is an improvement of energy efficient routing by selecting high energy paths, taking into account of energy conservation and other performance metrics. Ramrekha et al. (2010) suggested an approach to improve the performance of routing protocols with respect to traffic balance and balance energy consumption. Tan et.al (2007) suggested an Error - aware and energy efficient routing approach in MANET. They proposed two novel protocols one is Multi Threshold Routing Protocol (MTRP) and the other is Enhanced Multi Threshold Routing Protocol (EMTRP). Nodes having more transmission power than threshold are usually chosen to forward data packets to the destination. It is not sure that all the nodes within that path satisfy this criterion and ultimately packets need to find alternate path which increases delay.

The proposed protocol overcomes all the issues in the existing protocols and provides power efficient routing increasing the network life time. On increasing the life time of nodes meaningful information can be obtained with any error so that quality of services is enhanced.

PROPOSED PROTOCOL:

The proposed Power Efficient Routing (PER) protocol is meant for computing multiple stable paths and path having minimum power consumption is selected. The proposed protocol considers residual battery capacity of nodes, total transmission power of all the possible paths and number of hops to route the data packets form source to destination. The packets are forwarded through the nodes having maximum residual battery capacity, minimum transmission power and hop count so that the life time of network is increased. The proposed PER protocol is carried out in route request procedure. When source wants to communicate with destination and has no available routing information about the destination, it will flood a route request to find a route by broadcasting a route request message (RREQ) but not every intermediate node that receives the message will respond to the route request. Before broadcasting the RREQ, the intermediate node itself first makes a decision whether it is qualified or not. If its residual battery capacity (*RBC*) is above the threshold value (*Thr*), then the node is qualified and able to broadcast.

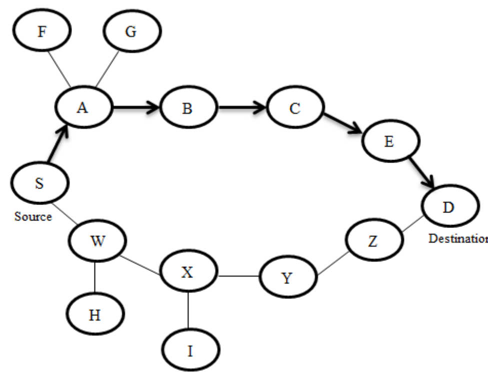

Figure 1: Route request with adaptive threshold

Figure 1 illustrates that the threshold value plays the key role in selecting nodes whether or not to forward the RREQ. Every time an intermediate node receives a RREQ, it will recalculate the threshold according to the node's residual battery capacity around the backward path. Therefore the threshold is variable and changing adaptively with load status of the network.

Figure 1 depicts the path established from source to destination by broadcasting RREQ message that compares the current '*RBC'* with its threshold (*Thr*). If '*RBC'*< '*Thr'* , RREQ will be dropped in nodes such as F, G, H, I, X, Y and Z. Otherwise nodes will deal with RREQ normally, such as nodes S, A, B, C,E and D.

PROPOSED PROTOCOL ANALYSIS:

Source node considers three parameters viz. residual battery capacity, total transmission power and hop-count for broadcasting RREQ packet. The cost of any route can be obtained as,

$$RC_i = \frac{1}{RBC_i} \qquad (1)$$

Where, RC_i =Route cost of i^{th} node

RBC_i= Residual Battery Capacity of i^{th} node

Equation 1 suggests that nodes having maximum residual battery capacity has minimum route cost.

Efficient route is the route having minimum route cost which is the lowest value of all possible links.

$$ERC = \min_{\forall i}(RC_i) \quad (2)$$

Where, *ERC*= Efficient route cost

A node with minimum transmission power is chosen to forward packets if all the available nodes have same residual battery capacity. The total transmission power to route the packets among 'n' nodes form source to destination is obtained as,

$$P_T = \sum_{i=0}^{n-1} P(n_i) \quad (3)$$

Where P_T= Total transmission power for 'n' nodes

$P(n_i)$= Power consumption of i^{th} node

Minimum transmission power is the least value of the total transmission power among all possible paths (P).

$$P_m = \min_{\forall p} P_T \quad (4)$$

Path with minimum number of hop counts is chosen if all the nodes have same residual battery capacity and transmission power. The total number of hops for all the possible paths can be obtained as,

$$H_T = n - 1 \quad (5)$$

Where 'n' is the total number of nodes associated with that route. Thus, the minimum number of hops to route data packets is obtained as,

$$H_m = \min_{\forall p} H_T \quad (6)$$

SIMULATION RESULTS:

The proposed protocol PER is compared with the existing AODV protocol, hence evaluated the performance of AODV and PER in terms of Packet Delivery Ratio, End to End delay, Energy consumption per packet and Network Lifetime with different mobility of nodes through simulation. NS-2 is used to perform the simulation for 100 mobile hosts with transmission range of 250 m. Each node moves randomly with the mobility of 0-30 m/s. The parameters that are involved in simulations are tabulated below:

Table 1: Simulation Parameters

Parameters	**Values**
Number of nodes	100
Transmission range	250m
Topology size	100mx100m
Number of destination	1
Traffic size	Constant Bit Rate(CBR)
Packet size	512 bytes
Packet rate	5packetsper second
MAC layer	802.11
Bandwidth	2Mbps
Node placement	Uniform
Initial Energy for all nodes	0.5J
Transmit power	0.660W
Receive power	0.395
Nodes Mobility	0-30 m/s
Mobility	Random waypoint model

PACKET DELIVERY RATIO:

Packet delivery ratio (PDR) is the number of data packets received at the destination to the number of data packets transmitted by the source. The higher delivery ratio specifies maximum packets received at the destination. Mobility is inversely proportional to delivery ratio. The mobility of 100 nodes is varied from 0 m/s to 30 m/s for existing AODV and the proposed PER protocol. The tabulation of PDR versus mobility is given below in Table 2.

Table 2: PDR Vs Mobility

Mobility(m/s)	AODV	PER
0	1.00	1.00
5	0.90	0.95
10	0.86	0.93
15	0.80	0.90
20	0.70	0.83
25	0.52	0.71
30	0.00	0.50

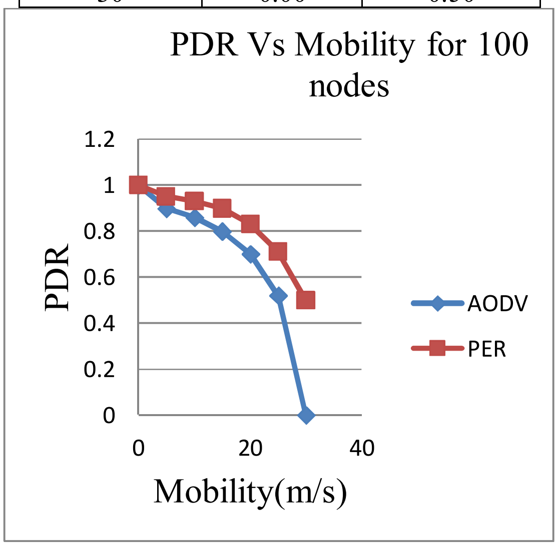

Figure 2: PDR Vs Mobility for 100 nodes

From figure 2, PER has higher delivery ratio than AODV. PER has an average of 21% higher delivery ratio than AODV while transmitting packets to the destination. Both protocols have same delivery ratio when nodes are stationary and has 50% higher than AODV when nodes are at highest mobility. The reason is that central node traffic gets concentrated in AODV resulting loss of packets due to less available buffer space and collision of heavy packets.

END TO END DELAY:

End to end delay is the time (second) taken by packets to reach the destination. It is calculated by subtracting time at which first packet was transmitted by source node from time at which the first data packet reached to destination. The least value of delay specifies the better performance. The tabulation of end to end delay versus mobility for 100 nodes is given below in Table 3.

Table 3: End to End delay Vs Mobility

Mobility(m/s)	AODV	PER
0	0.0000	0.0000
5	0.0032	0.0026
10	0.0037	0.0012
15	0.0604	0.0145
20	0.1129	0.0753
25	0.1137	0.0846
30	0.1154	0.0978

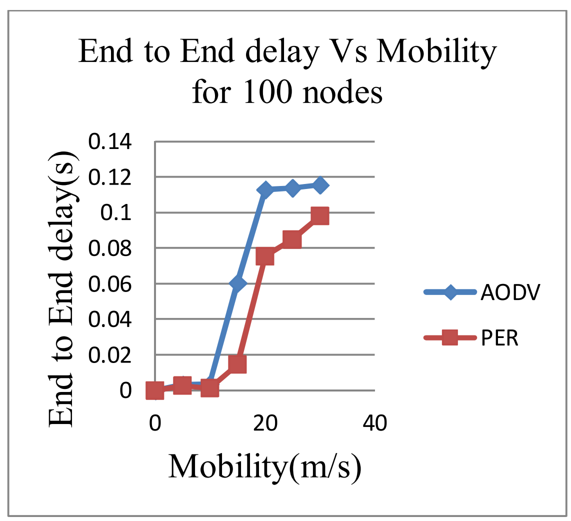

Figure 3: End to End delay Vs Mobility for 100 nodes

Figure 3 illustrates better End to End Delay performance for PER than AODV. The average value of End to End Delay is 0.0584s for AODV and 0.0394s for PER. This depicts that PER has about 0.02s less delay than AODV. At the extreme values of mobility the delay difference is nominal. The reason is that there is heavy traffic in AODV resulting high congestion so that data packets have to wait for a longer time in the queue. This is eliminated in PER by selecting path having least Load function.

ENERGY CONSUMPTION:

Energy consumption is obtained by the ratio of the total energy consumed to the total number of nodes present in the deployed network. The Energy per Packet is calculated in Joules (J). The least value of Energy consumption per packet specifies better performance. The mobility of 100 nodes is varied from 0 m/s to 30 m/s for existing AODV protocol and the proposed PER protocol. The tabulation of Energy/Packet Versus Mobility is given below in Table 4.

Table 4: Energy Vs Mobility

Mobility(m/s)	AODV	PER
0	0.0000	0.0000
5	0.2252	0.0373
10	0.2391	0.1847
15	0.2658	0.2064
20	0.2743	0.2016
25	0.2917	0.2709
30	0.2854	0.2638

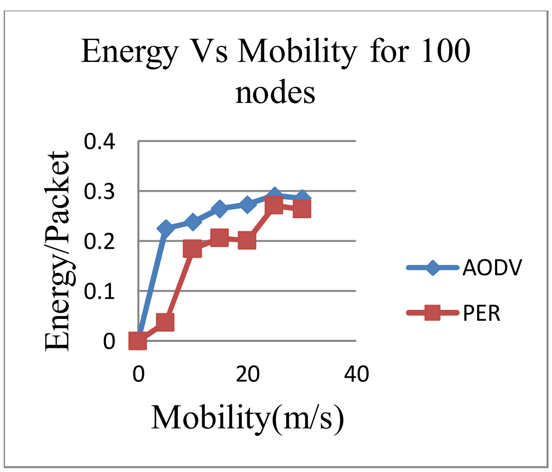

Figure 4: Energy Vs Mobility for 100 nodes

Figure 4 shows lower Energy Consumption for PER than AODV. The average Energy Consumption per Packet for AODV is 0.2259J while it is 0.1664J for PER. This depicts that energy consumption of PER is about 0.0595J less than that of AODV. At the highest level of mobility the energy difference is marginal. The reason is that there is an alternate path creation in AODV by flooding technique and has high energy consumption. This is eliminated in PER by selecting path having least Load function.

NETWORK LIFETIME:

The network lifetime is defined as the time taken for any node to die due to energy exhaust. The network life time of AODV and PER is compared with discrete span of time. Each node in the network is moving randomly with the mobility of 0 to 30 m/s. Due to energy drainage, node dies and changes network topology. The tabulation of number of live nodes versus time span is given Table 5.

Table 5: Number of alive nodes Vs Time

Time (s)	AODV	PER
0	100	100
100	100	100
200	100	100
300	96	100
400	90	94
500	83	91
600	61	80
700	20	59
800	00	37

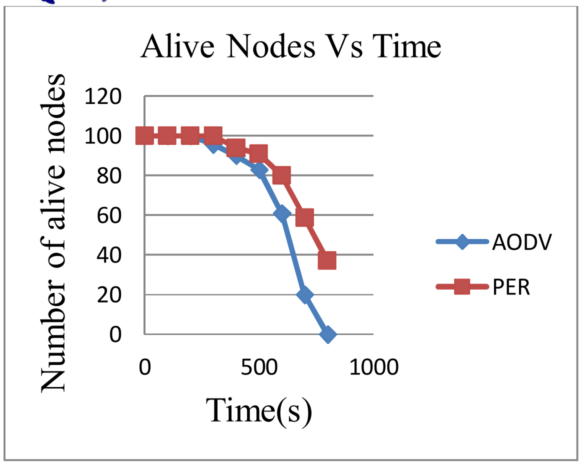

Figure 5: Number of alive nodes Vs Time

From figure 5, PER has higher number of alive nodes than AODV. After 800s of simulation, all nodes die in AODV protocol whereas there are still 37 nodes alive in PER protocol. Thus the life time of network is enhanced in PER protocol due to residual battery power.

CONCLUSION:

This paper presents power efficient routing of packets in ad hoc wireless networks. The proposed routing protocol PER gives an ideal way of forwarding data packets due to which reliable transmission is achieved in terms of Packet Delivery Ratio, End to End delay, Energy consumption and Network Life Time. The packets cover minimum hops to reach the destination node preserving the battery of nodes. Thus, PER provides the shortest power efficient path routing than the existing AODV protocol. The future work can be extended by comparing with other existing routing protocols and to provide secure reliable transmission in MANETs.

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