Power Aware with the Survivable Routing Algorithm for Mobile Ad Hoc Networks

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Abstract. The mobile ad hoc networks are gaining importance because of their versatility, mobility and ability to work with a limited infrastructure. In the mobile ad hoc network, each node works as a router as well as host. It is generally decentralized network, where all network activities include route discovery and message delivery must be executed by the nodes themselves. In this paper, we present a power-aware with survivable routing algorithm for the mobile ad hoc networks to route the data packets from the source to destination. It works based on the transmission-power and relay-capacity of the node. Both source and destination pair uses the route-selection-window mechanism to route the data packets. The model has simulated using C++ language. The proposed model has tested under various conditions and compared with the minimum total transmission power routing model and min-max battery cost routing model. The simulation results show that the proposed model has increased the route survivability and throughput. It decreases the number of path reconstructions over the network.

Keywords: MANET, route survival, throughput, relay-capacity node, power.

1 Introduction

A Mobile Ad Hoc Network(MANET) is an autonomous collection of mobile nodes, that communicate over the wireless links. Due to the node mobility, the topology will be changed rapidly and unpredictably over the period of time. The MANET does not require any fixed infrastructure and central administration for communications. In the MANET, each mobile node acts as a router and host. It means that all the mobile nodes participating in the network have to send and receive the data packets. Depending on transmission range and current location of the node, the mobile nodes can get in and out, forming a network in an arbitrary fashion. The network partition is an event in MANET environments and inconsistency can prove to be very costly in mobile computation scenarios. The mobile nodes interact with others over wide spaces, inconsistency can be propagated indefinitely. It can cause the unrecoverable damages in all the critical applications. High mobility of nodes has more link failures. It refers to communication failures/ disconnections caused by the nodes moving out of coverage[1].

Y. Cai et al. (Eds.): Mobilware 2010, LNICST 48, pp. 265–275, 2010.

The MANET can be applied anywhere, where there is a little communication or no communication infrastructure or infrastructure is expensive to use. The MANET allows mobile nodes to maintain the multiple connections over the network. It is easily adding and removing the nodes into the network. The set of MANET applications are ranging from the large-scale, mobile, highly dynamic networks to small, static networks that are constrained by the power sources. Due to quick and economically less demanding deployment, we can use this in several areas such as military applications, collaborative and distributed computations, emergency operations, wireless mesh networks, wireless sensor networks and hybrid wireless network architectures.

There are two types of routing models in the MANET such as proactive and reactive used to route the data packets. The proactive routing models are Destination Sequenced Distance Vector Routing Protocol(DSDV) and Wireless Routing Protocol(WRP). The proactive routing models are good at low mobility. The reactive routing algorithms are Dynamic Source Routing(DSR) and Ad Hoc On-Demand Distance Vector(AODV). The reactive routing algorithms are good at low load. Both the proactive routing and reactive routing models do not reduce the power consumption of the node and do not increase the network lifetime[2].

The main challenge in the MANET is to increase the efficiency of the data transfer while handling harsh conditions such as power constraints and highly mobile devices. The advances in the wireless communication are required to overcome the limitations of the broadcast radio networks. In addition to the routing protocols and transport protocols, it must work an intelligent system while routing the data packets from one location to another[3].

In this paper, we present a power-aware with survivable routing algorithm for the mobile ad hoc networks to route the data packets. The proposed work is based on the transmission-power and relay-capacity of the node to increase the route survivability and throughput. Rest of the paper is organized as follows. In section 2, it describes some of the existing projects and their limitations. The proposed model is presented in section 3. Section 4 presents the simulation results. Conclusions are discussed in section 5.

2 Some of the Related Work

This section discusses about some of the existing research algorithms on power-aware routing in the MANET. In the MANET, mobile nodes are operated with a limited battery capacity and frequently recharging/replacement of the batteries may be undesirable or even impossible. The power failure of the node will affect the node-itself and also its ability to forward the data packets to others. For this reason, many researchers have been devoted to design an energy-aware routing protocol for the MANETs. Several recent studies have tried to increase the node lifetime and network lifetime by using the power-aware metrics at different layers[4].

2.1 Power Aware Multi Access Protocol with Signaling (PAMAS)

The PAMAS model is an energy efficient media-access-control protocol for the MANETs. Here, it uses the separate-signaling- channel protocol apart from the channel to transmit the data. The request-to-send message and clear-to-send message packers are used while transmitting the data packets. PAMAS model achieves the goal by making the nodes with power-off. PAMAS protocol is tested in a random network, a line topology and a fully connected network. It provides best results in dense networks, but in small network the power saving is low. The PAMAS protocol exhibits the best performance under light load[5].

2.2 Minimum Total Transmission Power Routing (MTPR)

The MTPR model tries to minimize the total transmission-power consumption for all the nodes participating in a route[6]. The total transmission-power for all the routes is calculated as follows:

$$P(L_d)=\sum_{i=0}^{D-1} T(n_i, n_{i+1}) \tag{1}$$

The optimal route L_o is one of the routes, which verifies the following conditions:

$$P(L_o)=\underset{L_k \in L_*}{Min}\, P(L_k) \tag{2}$$

Drawback of this model is that it selects a path with more number of hops. It accepts the possibility that the participation of more nodes in forwarding the data packets. It also increases the end-to-end delay. The MTPR model fails to consider the remaining-battery capacity of the nodes so that it may not succeed in extending the lifetime of each node in the network.

2.3 Min-Max Battery Cost Routing (MMBCR)

Here, it treats the nodes more fairly from the standpoints of their remaining-battery capacities. The smaller remaining-battery capacities of the nodes are avoided and the nodes with more residual-battery capacities are chosen in a route.

Let us assume that $B_i(t)$ is the battery capacity of the node i and battery cost of the node i calculates as follow:

$$C_i(t)=1/B_i(t) \tag{3}$$

The path cost is defined as follows:

$$R(L_e)=\underset{n_i \in Le}{Max}\, C_i(t) \tag{4}$$

$$R(L_o)=\underset{L_e \in L_*}{Min}\, R(L_e) \tag{5}$$

In equation(5), it selects a route with the minimum cost among all. However, there is no guarantee that the total transmission-power is minimized[7-9].

2.4 Conditional Max-Min Battery Capacity Routing (CMMBCR)

The CMMBCR model takes into account of the residual-battery capacity of the node and total transmission-power consumed by the route while selecting a path. When all the nodes in some possible routes have sufficient battery capacities, a route with the minimum total transmission-power among all is chosen. In order to maximize the lifetime of the network, the power-consumption rate of each node must be evenly distributed. However, if all the nodes in a given path have higher remaining-battery capacity (thr- eshold value(θ)), then chooses a path using MTPR model, otherwise selects a path L_o with the maximum remaining-battery capacity by using MMBCR model[10-13].

$$R(L_e) \geq \theta, \text{ for any route } L_e \in L_* \quad (6)$$

$$R(L_o) = \min_{L_e \in L_*} R(L_e) \quad (7)$$

The drawback of this model is that it does not consider the network coverage and network partition.

2.5 Minimum Drain Rate (MDR)

The MDR model was proposed by *Kim et al.*[14]. It incorporates the drain rate metric in routing process. The MDR model behaves like a power-aware routing. It can be applied into one of the MANET routing protocols while finding a path from the source to destination. MDR model does not guarantee that the total transmission-power is minimized over a chosen route as in MTPR model.

3 Proposed Model

In order to route the data packets from the source to destination, it uses two metrics namely, minimum total transmission-power and relay-capacity of the node. Here, the source-destination pair chooses an efficient route by using the route-selection window mechanism.

3.1 Route Discovery

In this work, it uses the DSR protocol to route the data packets from the source to destination. The route-discovery process is initiated by the source node. The source node specifies the entire path in a packet header itself to the destination. The route-discovery process allows the mobile nodes to discover a path to the destination using Route Request(RREQ) packet. In the RREQ packet, the type field indicates the type of packet is sent over the network and the flag field is used to make synchronization. The reserved field with ‘0’ value is used to ignore the packet on the reception. The hop-count field is measured the number of hops from the source to destination. In order to identify a route, it uses the RREQ_ID field. The originator IP field indicates the IP address of the source, which originates the RREQ packet. The destination IP field indicates the address of the destination for which a route is desired. The originator-sequence number field provides the current sequence number for the route entries to the source. The destination sequence number field is used for the route entries pointing to the destination. The P_{XT} field indicates the transmission-power of the node. The P_{XR} field indicates the received power of the node and RN_i field represents the relay- capacity of the node as shown in table 1.

Table 1. RREQ packet

Type					Reserved	Hop-count
RREQ-ID						
Originator IP						
Originator-Sequence Number						
Destination IP						
Destination-Sequence Number						
P_{XT}						
P_{XR}						
RN_i						

3.2 Route Selection

Let us assume that S is the source and D is the destination. The nodes 2 and 3 are intermediate nodes with the transmit powers P_{XL2}, P_{XL3} and relay capacities with RN_1 and RN_2 respectively. Here, the node S uses the route-selection window for 3 ms to find a route. In the route-discovery phase, the S broadcasts the RREQ packet. The intermediate nodes 2 and 3 forward the RREQ packets over the network. The node D accepts the RREQ packets, reverses the route and sends Route Reply(RR) packet within the route-selection window for 2 ms. The intermediate nodes 2 and 3 receive the RR packets and calculate their transmission powers and relay-capacities of the nodes. The node S receives the RR packets from the nodes 2 and 3, then it selects a path with the minimum transmission-power and maximum relay-capacity of the nodes. In this work, each node maintains the power table as shown in the Table 2 with the entries of neighboring nodes such as estimated transmission-power and received power of the node and last-packet received time. The power table is result of all the RR packets received by the node. If a node S wants to forward a data packet, then it uses the power table. Once the route formation is completed, the node S sends the data packet to the node D. Every node records its P_{XT} in the data packet and sends it to the next hop. If the next-hop receives the data packet at P_{XR}, then it reads the P_{XT} and calculates *Total power* for previous node as follows:

$$Total\ Power = P_{XT} - P_{XR} \tag{8}$$

Table 2. Power table of the node *i*

SN	Link	P_{XL}	P_{XR}	Last-packet-received time

The intermediate nodes 2 and 3 check the *Total Power* value in the RR packet. If the RR packet contains less value of *Total Power,* then the value is stored in its database. The data packets are transmitted through the node with less energy consumption over the network.

$$RN_i=NT_i * LT_i \tag{9}$$

In equation(9), NT_i is the current data rate of the node *i* and LT_i is the lifetime of the node *i*.

$$LT_i = \frac{RE_i}{E_i(t)} \tag{10}$$

In equation(10), RE_i is the residual-energy and $E_i(t)$ indicates how much energy is needed per second at the node *i*.

The proposed model allows the node *D* to select a path among the multiple-RRE packets based on the minimum total transmission-power and relay-capacity of the node within the route-selection-window time(2 ms). If a node *D* receives the REQ packet from the *S*, then it starts a timer(route-selection time window(3 ms)). The node *D* selects a route among all the viable routes according to the computation of a decision function. If any two nodes have equal transmission-power, then chooses a node with more relay-capacity.

4 Simulation

In this section, first we explain some of the parameters used in the simulation. Then, we present the simulation results. We compare the performance of all the three models.

4.1 Simulation Environment

The simulation environment has shown in the Table 3. The proposed model simulated in a 1000m×1000m area with 50 mobile nodes using random waypoint model. Here, we designed and implemented our test-bed using C++ language to test the performance of all the three routing algorithms. The mobile speed of each node was from 0-20 m/s and the transmission range was 250 m. Here, it used Constant Bit Rate(CBR) and the data packet size was 512 bytes. The data transmission rate was set to 2 Mbps. Total simulation time was conducted for 7 hours, the source and destination nodes were randomly chosen. Each node was randomly assigned an initial energy (9,000 Joules).

Table 3. Simulation parameters

Simulation parameters	**Value**
Traffic type	CBR
CBR packet size	512 bytes
Routing protocol	DSR
Hello_packet_interval	1 s
Node mobility	0-20 m/s
Frequency	2.4 Ghz
Channel capacity	2 Mbps
Transmission range	250 m
Transmit power	1.32 W
Receiver power	0.96 W
Idle power	0.82 W
Mobility model	Random waypoint
Voltage	5 V
Initial node energy	9000 J
Route-selection window time at source	3 ms
Route-selection window time at destination	2 ms

5 Results

In order to evaluate the network performance of all the three protocols, it uses following metrics such as route survivability, throughput, transmission-power and number of path reconstructions.

5.1 Route Survivability

Here, we deployed 100 mobile nodes within the defined area and the node mobility varied from 0-20 m/s. The experimental setup has executed for 25 runs with the different mobility speeds in a given topology and 5 mobile nodes transmit the data at the rate of 5 packets/s. From the results, we conclude that the route survivability is more in the proposed model as compared to other models. After 4 hours and 75 mints, the proposed model has dropped piercingly due to energy exhaustion of the nodes. Whereas MTPR and MMBCR models drop at 4 hours and 12 mints, 4 hours and 25 mints respectively as shown in the figure 1. It is also noticed that the proposed model has transmitted the data packets without having new route-discovery packets due to robustness of the network connectivity.

5.2 Throughput

In this scenario, it considered 100 mobile nodes spreading within the defined area and the node mobility differed from 0-20 m/s. The simulation has executed for 25 runs

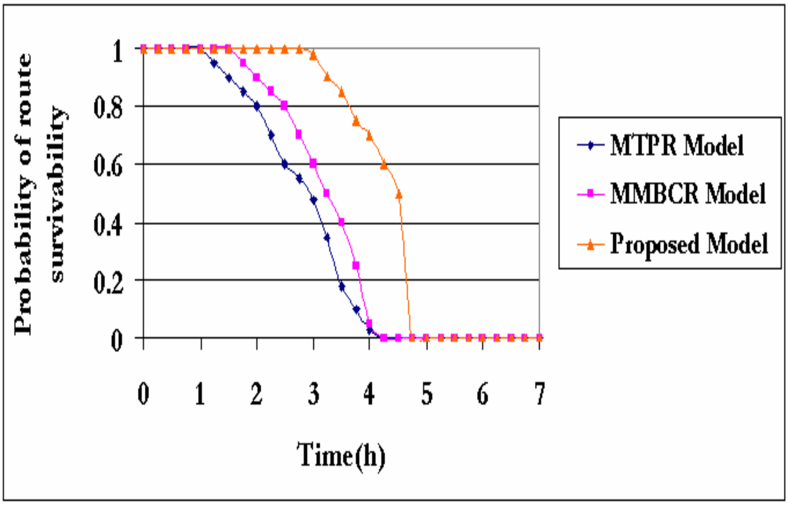

Fig. 1. Probability of route survivability

with the different mobility speeds in a given topology. Here, 5 nodes transmit the data at the rate of 5 packets/s. Figure 2 depicts the packet delivery ratio of all the three protocols under different motilities. The packet delivery ratio has decreased as the node mobility increases due to more number of the link breaks. The proposed model has delivered 95% of the data packets at 10 m/s due to relay-capacity of the nodes, whereas MMBCR and MTPR models have transmitted the data packets at 93% and 91.5% of the data packets respectively.

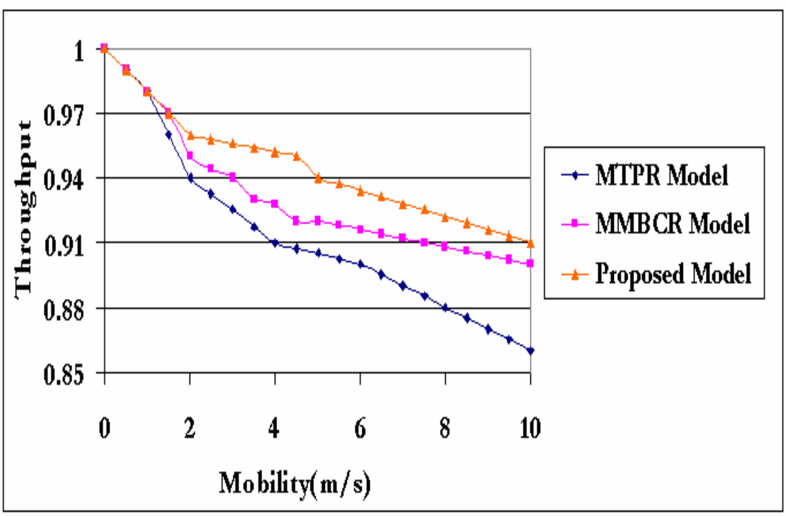

Fig. 2. Mobility versus throughput

5.3 Power Consumption

Here, it deployed 25 mobile nodes and the number of data packets sent between 0-80 packets/s and each node traveled constantly at 2 m/s. The experimental setup has executed for 20 times with the different arrival rate of the data packets. For investigation, the energy consumptions of all the nodes have their initial energy values, which are randomly selected. In the figure 3, it is clearly shown that MTPR model is designed to minimize the power consumption by selecting the routes, which are the most power efficient. In MTPR model, 15% to 20% of the paths are consumed with less power than the paths in MMBCR model. There is no much difference between the proposed model and MTPR model with respect to the power consumption from 1-3%.

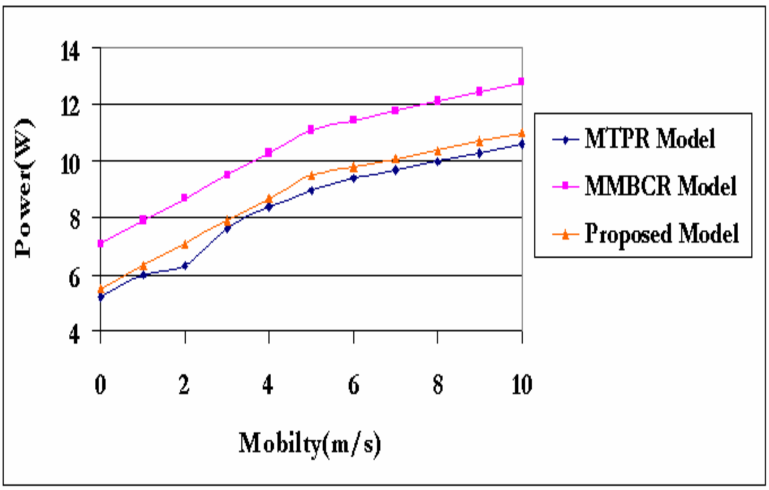

Fig. 3. Mobility against power

5.4 Number of Path Reconstructions

In the experimental setup, we deployed 50 mobile nodes within the defined area. The number of data packets sent between 5-20 packets/s and each node moved constantly with 0-25 m/s. As the number of nodes decreases, the number of path reconstructions has increased due to the node mobility. The path reconstruction is consistently low in the proposed model as compared to MMBCR and MTPR models as shown in the figure 4. The proposed model works well if the network has an adequate number of strong nodes in terms of relay-capacity. In fact, it has reduced the number of route reconstructions by 45% as compared to MMBCR model and 65% against to MTPR model at mobility 10 m/s. Since, the proposed model has routed the data packets through the route with strong relay-capacity nodes. The strong relay-capacity nodes are less vulnerable than the weak relay-capacity nodes.

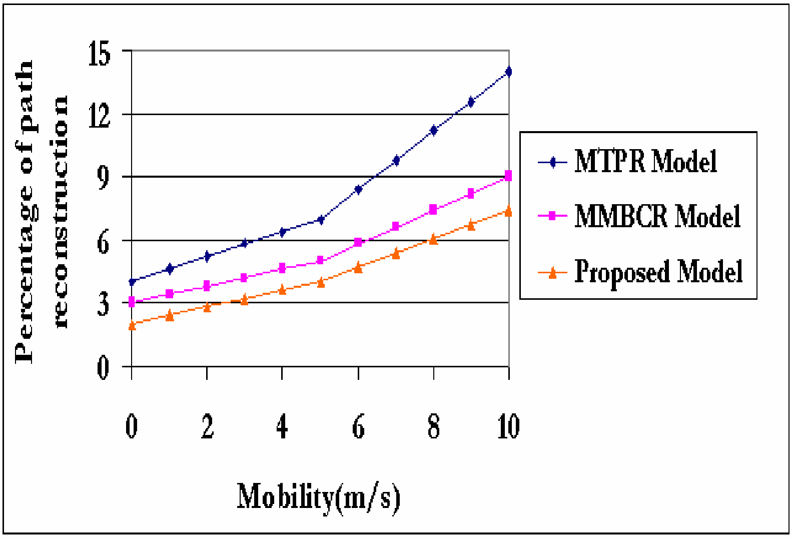

Fig. 4. Mobility versus percentage of path reconstructions

6 Conclusions

This paper presents a power-aware with survivable routing algorithm for the MANETs. It used the minimum transmission-power and high relay-capacity node to route the data packets from the source to destination. In this work, we used nearly 50 mobile nodes with area of 1,500 m X 1,500 m. Here, it is likely to have the unpredictable links, nodes, and variable mobility patterns. The proposed model forwarded the data packets based on more relay-capacity nodes and minimum transmission-power at physical layer. It is also helped us to switch new route before failure occurs and the proposed work makes QoS for end-users over the network. The simulation results are proved that the proposed model has reached at top position in terms of the route survivability, throughput, number of path reconstructions as compared to MMBCR and MTPR models. The drawback of this model is that it takes more number of hops to reach the destination because the data packets are routed with the more relay-capacity nodes.

References

1. de Moraes, R.M., Sadjadpour, H.R., Garcia-Luna-Aceves, J.J.: Mobility-Capacity-Delay Trade-Off In Wireless Ad Hoc Networks. Ad Hoc Networks 4(5), 607–620 (2006)
2. Chao, C.M., Sheu, J.P., Chou, I.C.: An Adaptive Quorum-Based Energy Conserving Protocol for IEEE 802.11 Ad hoc Networks. IEEE Transactions on Mobile Computing 5(5), 166–170 (2006)

3. Ma, C., Yang, Y.: A Prioritized Battery-Aware Routing Protocol for Wireless Ad Hoc Networks. In: Proceedings of The ACM International symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems, pp. 45–52 (2005)
4. Sánchez, J.A., Ruiz, P.M.: Improving Delivery Ratio and Power Efficiency in Unicast Geographic Routing with a Realistic Physical Layer for Wireless Sensor Networks. In: Proceedings of The DSD, pp. 591–597 (2006)
5. Raghavendra, C.S., Singh, S.: PAMAS-Power Aware Multi-access Protocol with Signaling for Ad Hoc Networks. ACM Communications Review 28, 5–26 (1998)
6. Singh, S., Woo, M., Raghavendra, C.S.: Power-Aware with Routing in Mobile Ad Hoc Networks. In: Proceedings of The ACM MOBICOM, pp. 181–190 (1998)
7. Toh, C.-K.: Maximum Battery Life Routing to Support Ubiquitous Mobile Computing in Wireless Ad Hoc Networks. IEEE Communications 39(6), 2–11 (2001)
8. Ahmad, S., Awan, I., Waqqas, A., Ahmad, B.: Performance Analysis of DSR and Extended DSR Protocols. In: Proceedings of The International Conference on Modeling and Simulation, pp. 191–196 (2008)
9. Balaswamy, C., Soundararajan, K.: An Efficient Route Discovery Mechanism for Mobile Ad Hoc Networks. International Journal of Computer Science and Network Security 8(10), 25–51 (2008)
10. Roux, N., Pegon, J.-S., Subbarao, M.W.: Cost Adaptive Mechanism to Provide Network Diversity for MANET Reactive Routing Protocols (2007), `http://w3.antd.nist.gov/pubs/roux_m2000.pdf`
11. Gobriel, S., Mosse, D., Melhem, R.: Mitigating the Flooding Waves Problem in Energy-Efficient Routing for MANETs. In: Proceedings of The IEEE Conference on Distributed Computing Systems, pp. 47–47 (2006)
12. Jaikaeo, C., Sridhara, V., Shen, C.C.: Energy Conserving Multicast for MANET with Swarm Intelligence. In: Proceeding of The International Symposium on a World of Wireless, Mobile and Multimedia networks, pp. 7–11 (2006)
13. Hanashi, A.M., Siddique, A., Awan, I., Michael, E.: Woodward: Dynamic Probabilistic Flooding Performance Evaluation of On-Demand Routing Protocols in MANETs. In: Proceedings of The CISIS, pp. 200–204 (2008)
14. Kim, D., Garcia-Luna-Aceves, J.J., Obraczka, K., Cano, J.-C., Manzoni, P.: Routing Mechanisms for Mobile Ad Hoc Networks Based on the Energy Drain Rate. IEEE Transactions on Mobile Computing 2(2), 161–173 (2003)