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Power-Efficient Reliable Routing Protocol to Increase Throughput in Ad hoc Networks

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Abstract- In mobile ad hoc networks, each node acts as both host and router and performs all the routing and state maintenance.

Due to the unpredictable movement of mobile nodes, the network topology of a mobile ad hoc network changes frequently. It will directly cause the more power-efficient and reliable routing protocols are needed. In this paper we propose a novel routing protocol, PEAODV (Power Efficient Ad-hoc On-demand Distance Vector for mobile Ad-hoc networks), that providing power-efficient and reliable packet transmission. PEAODV uses a new cost function to select the optimum path based on considering the minimum residual energy of the nodes on a path, and the path's stability in accordance with the rate mobility of node and the available bandwidth and the radio frequency.

Our study also compares the performance of the PEAODV protocol with the well-known Ad hoc On-Demand Distance Vector (AODV) protocol, Results obtained by a simulation campaign show that PEAODV increases the throughput and decreases the delay, route discovery time, data dropped and number of hops per route.

Keywords- PEAODV, AODV.

I. INTRODUCTION

A mobile ad hoc network (MANET) consists of a collection of wireless mobile nodes that are capable of communicating with each other without the use of any centralized administration or network infrastructure. The routing protocols in an ad hoc network should be able to cope well with dynamically changing topology, and nodes should exchange information on the topology of the network in order to establish routes.

Although the original research on MANETs was for military purposes, MANETs are now proving useful in disaster recovery, emergencies, home networks, sensor networks, and various forms of personal area networks [1].

In a MANET, the network links are wireless and thus have many constraints, including a variable capacity and bandwidth, dynamic network topology, and unpredictable node connectivity. Routing protocols in ad-hoc networks are generally categorized into two groups: pro-active and on-demand protocols. In the case of on demand protocols, route discovery and maintenance are provided on an "as needed" basis, which reduces the routing overheads, whereas pro-active protocols make routing paths before a node actually needs the path. Essentially, a MANET needs a routing protocol that considers the battery-power of each node, is power-efficient, and includes route maintenance mechanisms [2].

Accordingly, this paper proposes a new ad-hoc routing protocol PEAODV, that providing power efficiency and reliable packet transmission. PEAODV uses a new routing cost metric that selects the optimum path based on considering the minimum residual energy of the nodes on a path, and the path's stability in accordance with the rate mobility of node and the available bandwidth and the radio frequency. In addition, the proposed route-maintenance mechanisms allow the currently used data transmission path to be changed to an alternative route in accordance with a residual energy and mobility monitoring algorithm. The remainder of this paper is organized as follows:

In section II, we review the AODV Routing Protocol. Section III describes the newly introduced protocol, PEAODV. Section IV presents the simulation results based on a mobile network example, and conclusions are presented in Section V.

II. AODV ROUTING PROTOCOL OVERVIEW

The starting point for our protocol was to modify an existing on demand routing protocol for best effort Ad hoc networking. We took the well-known Ad hoc On-Demand Distance Vector protocol (AODV). AODV uses a broadcast route discovery mechanism, and it relies on dynamically established routing table entries at intermediate nodes. The functions performed by AODV protocol include local connectivity management, route discovery, route table management and path maintenance. Local connectivity management may be summarized as follows. Nodes learn about their neighbors by either receiving or sending broadcast packets from or to their neighbors. Receiving the broadcast or HELLO from a new neighbor or failing to receive HELLO packets from a node that was previously in the neighborhood, indicates that the local connectivity has changed.

The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbors. When a node receives an RREQ, in case it has routing information, it sends the reply packet (RREP) back to the destination. Otherwise, it rebroadcasts the RREQ packet further to its neighbors. As the RREQ packet travels from the source to the destination it automatically sets up the reverse path for all nodes back to the source. As the RREP travels back to the source, each node along the path sets up a forward pointer to the node from which the RREP came and updates its timeout information for route entries to the source and destination.

For each destination of interest a node maintains a single route table entry that contains the address of the destination, the next hop along the path to that destination, the number of hops to the destination, and other route related parameters. If a node is present with two different routes to the destination it chooses the fresher route. If both routes were discovered simultaneously, the route with fewer hops is preferred.

Path maintenance is performed in several ways. When any node along an established path moves, so that some of the nodes become unreachable, a special RREP packet is sent to

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affected source nodes. Upon receiving notification indicating a broken link, the source node restarts the path discovery process, if it still needs that route [3].

III. PROPOSED ROUTING PROTOCOL

Conventional on-demand routing protocols, such as AODV and DSR, offer efficient route discovery and route maintenance, yet they are not fundamentally designed in a power efficient way [2]. As such, these methods can encounter power and transmission problems, plus they do not modify a route until a link-break occurs due to the power exhaustion of an intermediate node. The lifetime of a network is defined as the time from which the network starts operating until the time when the first node runs out of battery charge. To increase the lifetime of network and at the same time to support reliable service with few service interruptions and packet losses, we need a new ad-hoc routing protocol that can select a optimum path with a consideration of energy consumption, residual energy of nodes, and path stability at the same time.

Therefore, this paper proposes a new ad-hoc routing protocol PEAODV that uses an on-demand mechanism, while also providing new features that can achieve power-efficient and reliable data transmission. The new features of PEAODV are as follows:

(i) PEAODV only composes routing paths using nodes that meet the source's energy requirement before transmitting data packets.

(ii) A data packet is transmitted through the optimum path, decided based on the minimum residual energy, path stability, and total estimated energy to transmit and process a data packet.

This idea desire for choosing a stable path for: decreasing overhead for path finding, decreasing number of packages for presenting in path finding and optimized use of powerful and energetic paths. Before representing the suggested method, introduce some important parameters:

Frequency: This parameter show, RADIO FREQUENCY (in hertz) necessary for sending a file.

Power of battery: With using the parameter, account necessary energy for complete sending a file or data before transforming data packages with considering the size of packages.

Hop count (HC): This parameter as the distance (in hops) between the routers otherwise the HC is the number of hops for a feasible path. The smaller the HC is, the more reliable the routing path. Their route selection algorithm prefers the route that reaches the destination node first. The reason for selecting this route is that this route is less congested than the others.

Speed: This parameter show the rate of mobility for mobiles.

Bandwidth available (BW): Generally, the method to define the bandwidth metric is to calculate the available bandwidth between two adjacent nodes with the same speed which are separated by a direct and symmetric link. A simple method in [4] gives the available bandwidth based on the transmission speed which can be used to measure the bandwidth for a *(i,j)* link. This link has an available bandwidth of:

*Bandwidth available (i,j) = (1-u)*Bandwidth(i, j)* (1)

Where u is the link utilization (i.e. $u = A(t)/t$, $A(t)$ is the total amount of time where the link is used by nodes during an interval of time t) and the bandwidth seen by one packet of S bits can be calculated as:

$$BW = \frac{s}{(t_s + t_{overhead} + t_C) * R + \sum_{i=1}^{R} T_{B_i}} \quad (2)$$

Where t_s is the packet transmission time, $t_{overhead}$ the Control Overhead time, t_C the collision detection time, we use this method to detect collisions.

When a packet is sent, the acknowledgement must be received in a time duration $t_C = 2t_p + t_{sf} + t_{ACK}$ seconds, where t_p is the propagation time between the node and its next hop, t_{sf} the inter frame space time and t_{ACK} the time to transmit the acknowledgement. In consequence, nodes detect collision if the time to receive the acknowledgement exceeds t_c, R the number of necessary transmissions, T_{B_i} the Back off time for retransmission.

Also it is assumed that all nodes in PEAODV are equipped with a residual power detection device and know their physical node position. The packet transmitting energy for a

$$P_{TE} = (Power\_Level - ((Packetsize) * P_{tp})) / BW_A \quad (3)$$

Where p_{TE} is packet transmitting energy and p_{tp} is the packet transmitting power, and BW_A is the wireless link available bandwidth.

At each node, the total required energy is given by:

$$REQE = n * p_{TE} \quad (4)$$

Where n is the number of packets.

When a node receives a RREQ request, it keeps in the reverse route entry the address pair, the source sequence number and the frequency, number of hop count and power level of battery and the speed of each node.

A RREP request which is transmitted by node x contains the following parameters: *source-address, destination-address, source-sequence-number, hop count, bandwidth of x* hop count and power level of battery of x and the speed of x .

When another node receives a RREP request which is transmitted by x, it updates the required energy *REQE* in its routing table with the formula 4. So the packets where the next hop is x, are transmitted with the speed S. We can summarize our algorithm as follows:

1. When the source s receives a packet from the transport layer in direction of destination d, it checks if a route exists to the destination. If it already has a route, it transmits the packet to the next hop node. Else, it first calculates the required energy *REQE* for the packets to be sent until the next route discovery using formula (4), if the node have enough energy for sending data, and enough frequency for transmits, and have minimum rate of mobility for node then it transmits a RREQ request.
2. When a node x receives a RREQ request with a source s, a destination d and a source-sequence-number *ssn1*: x checks if a route exists to the destination. If it already has a route, it sends the RREP packet to the source node else node x calculates the required energy *REQE* for the packets to be sent, with the formula (4), if the node have enough energy for sending data, and enough frequency for transmits and have minimum speed for node other size the link that the package has received through this

route is suitable or not? Also if the link is suitable then the table of neighbor connections in middle node (node *x*) to be updates and it transmits a RREQ request. Also If node x is node d then x sends a RREP request to source *s*.

3. When the route requesting package reach to the destination, get the its parameters such as hop count and *REQE,…* from route requesting package like the middle nodes and determine the suitability of link and if the link is suitable save that.
4. Destination node create a RREP request and get the address fields of source and destination directly from route requesting package and copy it in the route answering package. Also add its parameters to the RREP request and send this to the source.
5. When a node *x* receives a RREP request from node *y* with a source *s*, a destination *d*, a required energy *REQE* 1, a source-sequence-number *ssn*1 and a bandwidth *BW1* and hop count HC*1* and rate of mobility or speed S*1:* x calculates the required energy *REQE* with the formula (4), if the pair $< s, d >$ exists in the routing table with a required energy *REQE* 2 and a source-sequence-number denoted *ssn*2 if node x not equal with node s then if (*REQE* 1 < *REQE* 2 and *ssn*1=*ssn*2) or (*ssn*1 > *ssn*2), x updates routing table with the next hop *y* Also add its parameters to the route answering package and send this to the source.
6. Source node with using the detected route, send the data to the destination.

IV. EXPERIMENTAL RESULTS

In this section, we show the network model that we use and compare our algorithm with the AODV protocol.

A. Simulation Model

To simulate our algorithm, we use the OPNET modeler 10.5 [5]. The initial positions of the nodes were uniformly distributed throughout the network. Node mobility was simulated according to the random waypoint mobility model, in which each node travels to a randomly selected location at a configured speed and then pauses for a configured pause time, before choosing another random location and repeating the same steps. Node transmission range was 250m. We ran simulations for constant node speeds from 0 to 10 m/s, with pause time fixed at 200 seconds. We simulated 20 CBR sessions in each run, with random source and destination pairs. Each CBR session generates 10 packets per second with data packets of 512 bytes. In the simulation, the network coverage area is a 2117m x 2117m square with 25 mobile nodes. We will use a simple topology, and Process model, as shown in figure 1 and figure 2. Simulation time is 600 seconds.

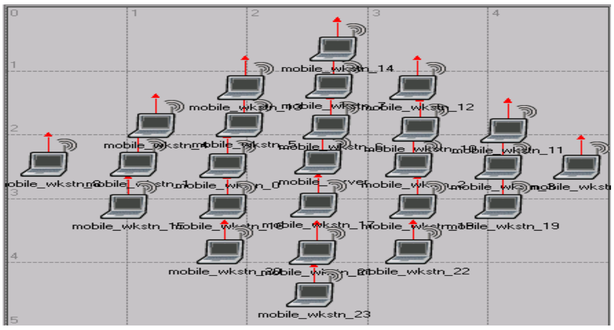

Fig.1. A sample topology for mobile ad hoc network (MANET)

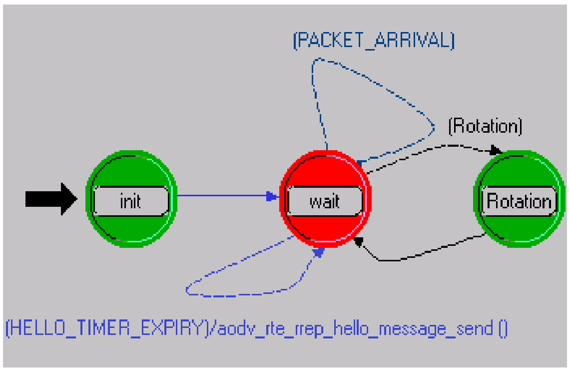

Fig.2. Process model for sample topology

For the experimental evaluation, we have assumed the performance metrics in order to analyze the performance of the proposed PEAODV protocol for ad hoc routing:

throughput: Also called packet delivery ratio in [6] and throughput in [7], this is the ratio of the number of packets received by the CBR sink to the number of packets sent by the CBR source, both at the application layer. Packets that are sent but not received are lost in the network due to malicious drops, route failures, congestion, and wireless channel losses.

Average delay: This is the average delay of all the packets that are correctly received. Lost packets are obviously not included in this measurement since their packet delay is infinity.

Hop Count: we determined the destination (hop count) for all possible next hops.

Route discovery time: a necessary time for route discovery.

Data Dropped: total data is dropped in during Route discovery time.

B. Results

In figure 3 we show the average performance in terms of throughput, according to the Simulation Time in a network of 25 nodes. X-axis represents the Simulation time and Y-axis represents the Throughput. The simulations of figure 3 show that PEAODV performs better from the AODV. Most of the ad hoc routing protocols presuppose the presence of bidirectional links between the nodes in the network. In reality, the ad hoc network may consist of heterogeneous nodes with different power capabilities and different transmission ranges. When this is the case, a given node might be able to receive the transmission of another given node but might not be able to successfully transmit data to the latter [8]. In PEAODV protocol with using the formula 4 determine the suitability of link and if the link is suitable, a given node is able to successfully transmit data to the latter. Thus, throughput of our algorithm is higher than the AODV algorithm. The average improvement is near 18%.

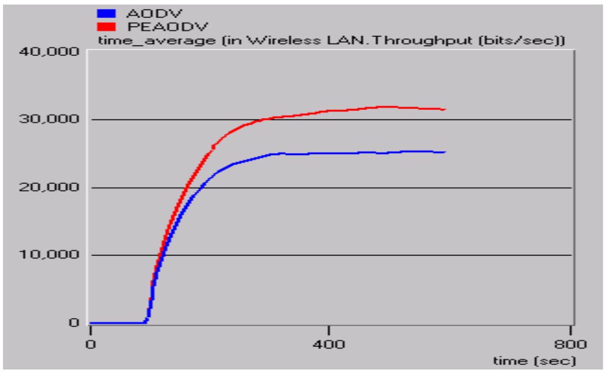

Fig.3. Throughput vs. Simulation time for 25 mobile nodes

Figure 4 shows the average delay of PEAODV and AODV for different simulation Time. X-axis represents the Simulation time and Y-axis represents the Delay.

By AODV in figure 4 can be explained by the fact that in AODV the number of dropped packets is larger than in the PEAODV protocols, and that such dropped packets are not taken into account in the average delay calculation. Then, when a packet is not dropped and is delivered with a large delay, the total average delay is increased. However, by the same fact, PEAODV increases the network reliability and average delay is reduced. The average improvement is near 63%.

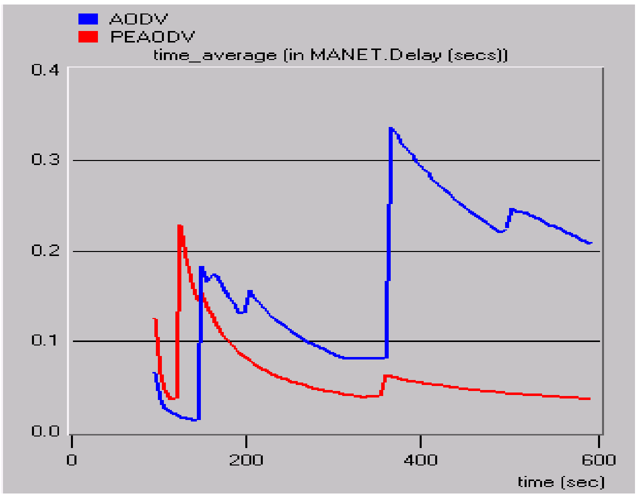

Fig.4. Delay vs. Simulation Time for 25 mobile nodes.

Figure 5 shows the number of RREQ (route requests sent) by both algorithms. X-axis represents the Simulation time and Y-axis number of RREQ. Our algorithm for Simulation Time 170, generates more requests because when a node receives a request and the sequence number is lower than the sequence number the reverse route entry table, it forwards the request up to date. Also the simulations of figure 6 show that finally, RREQ of PEAODV less than AODV. The average improvement is near 9%.

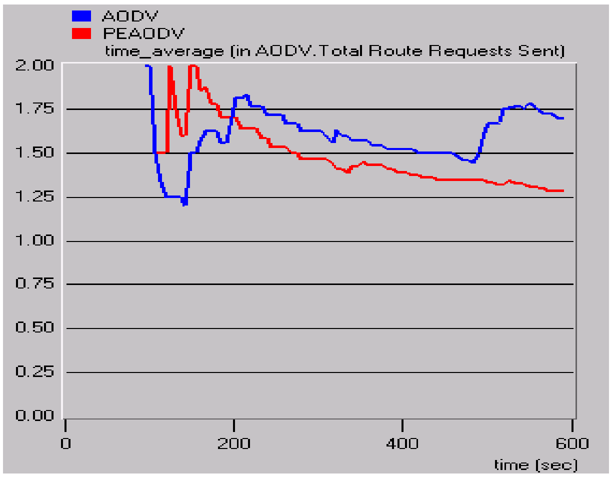

Fig.5. Packets control overhead

Figure 6 shows the hop count of PEAODV, and AODV for different Simulation Time. X-axis represents the Simulation time and Y-axis number of hop count. The simulations of figure 6 show that finally, hop count of PEAODV less than AODV because the hop count is one of certainty factor between each neighboring mobile node that we defined. The average improvement is near 10%.

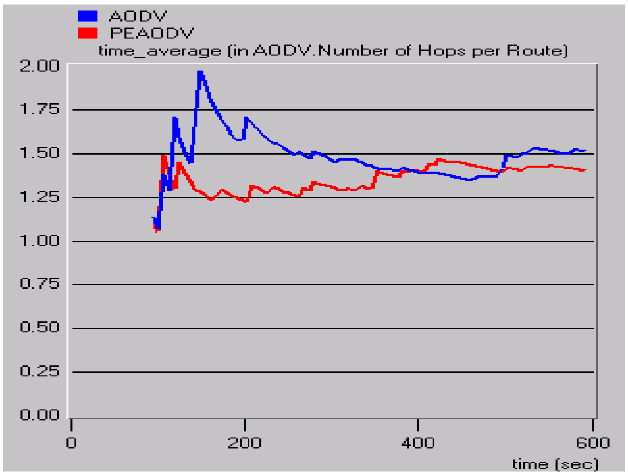

Fig.6. Hop count vs. Simulation Time for 25 mobile nodes

Figure 7 shows the numbers of data dropped by both algorithms. X-axis represents the Simulation time and Y-axis number of data dropped. From figure 7, we can conclude that PEAODV algorithm can greatly decrease the numbers of data dropped. It shows that the improvements become more significant with the increase of Simulation time. The average improvement is near 56%.

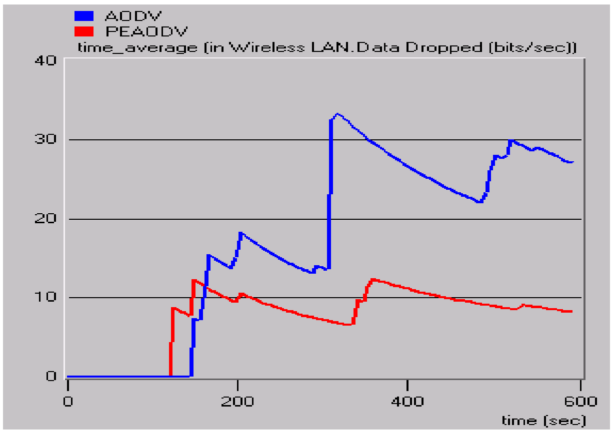

Fig.7. numbers of data dropped vs. Simulation Time for 25 mobile nodes

Figure 8 shows the route discovery time by both algorithms. X-axis represents the Simulation time and Y-axis route discovery time. From figure 8, we can conclude that PEAODV algorithm can greatly decrease the route discovery time. It shows that the improvements become more significant with the increase of Simulation time. The average improvement is near 58%.

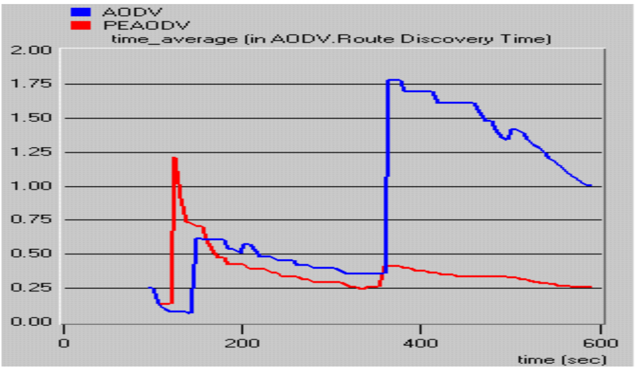

Fig.8. route discovery time vs. Simulation Time for 25 mobile nodes

V. CONCLOSION

In this paper, we provided a centralized algorithm for routing in Ad hoc networks. Simulation results show that the PEAODV algorithm improves the throughput and delay significantly, and Packets control overhead, and data dropped, and route discovery time and also improves the network performance. We show simulation results of our algorithm under random variation of the network. From a performance point of view, our heuristic gives a path with a higher throughput than the original AODV protocol. Moreover, it decreases the average delay and the hop count and route discovery time and numbers of data dropped.

REFERENCES

[1] G. Forman and J. Zahorjan, "The challenges of mobile computing," Computer, vol.27, no.4, pp.38–47, April 1994.

[2] Kyoung-Jin KIM, *Nonmember and* Sang-Jo YOO, "Power-E.cient Reliable Routing Protocol for Mobile Ad-Hoc Networks", IEICE TRANS. COMMUN., VOL.E88–B, NO.12 DECEMBER 2005.

[3] Hamed EL_afandi . An Intellig ent Wireless Ad hoc Routing Protocol. In University of Wisconsin_Milwaukee, 2006.

[4] H. Badis, et al., "QoS for Ad hoc Networking Based on Multiple Metrics: Bandwidth and Delay", MWCN'03, October 2003.

[5] OPNET Modeler, Available from: http://www.opnet.com

[6] J. Broch, D. A.Maltz, D. B. Johnson, Y. Hu, and J. Jetcheva. A performance comparison of multi-hop wireless ad hoc network routing protocols. In *MobiCom '98: Proceedings of the 4th annual ACM/IEEE international conference on Mobile computing and networking*, pages 85–97, New York, NY, USA, 1998. ACM Press.

[7] P. Michiardi and R. Molva. Simulation-based analysis of security exposures in mobile ad hoc networks. In *Proceedings of European Wireless Conference*, 2002.

[8] Nen-Chung Wang and Yung-Fa Huang and Jhu-Chan Chen. A stable weight-based on-demand routing protocol for mobile ad hoc networks. In Elsevier Inc., 2007.