International Journal of Future Generation Communication and Networking
Vol. 8, No. 1 (2015), pp. 207-214
http://dx.doi.org/10.14257/ijfgcn.2015.8.1.21

Multi-path Routing Improved Protocol in AODV Based on Nodes Energy

Xiaoxia Qi[1,2], Qijin Wang[1] and Fan Jiang [2]

[1]*College of Information Engineering, Anhui Xinhua University, Hefei 230088, China;*

[2] *College of computer science and technology, University of Science and Technology of China, Hefei 230026,China)*

Lushitou710@163.com

Abstract

Aiming at energy-constrained of Ad Hoc network, this paper proposes a multi-path routing protocol (EM-AODV)I n AODV that based on nodes energy. EM-AODV designs methods of obtaining nodes energy by upgrading the route discovery and route maintenance process of AODV, calculates the path of comprehensive energy derived path priority by routes total hops and nodes energy to format the multi-path routing mechanism. The energy as the metric prerequisite during the routing process, by setting nodes energy bound and balancing nodes data forwarding to postpone network lifetime. Simulation results show that EM-AODV has lower average end-to-end delay, well improve the energy consumption.

Keywords: *improved protocol, nodes energy, Multi-path routing*

1. Introduction

Ad hoc network is a kind of self-creation, self-organized, self-management, no other infrastructure support and centerless wireless network [1]. Combined with the characteristics of mobile communication and computer network, it is widely used in military and civil fields. Because of wireless communication, dynamic topology, limited energy, this makes its routing protocol more complex than the traditional network [2-3]. Therefore, MANET network routing strategy focuses on how to balance the energy consumption of nodes, prolong the network lifetime, establish a backup routing and shorten the network delay.

In the reference [4], a high energy nodes driven strategy for routing discovery has been proposed, through high energy node to transmit data to balance the network energy consumption. Reference [5] presented a routing protocol to avoid low energy nodes, to increase nodes lifetime by setting the node energy threshold, reducing the low energy nodes over involved in data forwarding. Paper [6] put forward a fast link algorithm for fault routing link on the thoughts of fast repairing.

The above documents made corresponding improvement and optimization on the energy and route repair of the route discovery process, because of without considering the multi-routing, the route discovery process still need to be carry on to repair the broken link, it will prolong the delay. Based on document [5], this paper improved a multi-path routing improved protocol in AODV based on nodes energy, establish multiple paths from the source node to the destination node by setting node energy threshold, When communication breaks, using alternate routing in a timely manner, so as to shorten the network delay. If there is breakage somewhere, the backup routing will be used timely to reduce the network delay.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ 2015 SERSC

2. The Improvement Ideological

AODV is an on-demand routing protocol, which combines characteristics of the DSR and the DSDV protocol, including the mechanism of DSR route discovery and route maintenance, DSDV hop by hop routing and sequence number [7]. AODV uses the routing hops, end to end delay as the routing metric, continue data transmission after routing establishment until the link occurs, it will cause some nodes to be used excessively and the energy to be consumed fast, bring the network to be segmented and the network lifetime to be shorten [8]. The AODV multi-path routing improved on two thoughts:

(1) Joining in the node energy as the routing metric. By getting the energy of nodes, balancing the network consumption, to avoid the low energy nodes frequently participate in forwarding data, so as to prolong the node life, delay the network to be segmented.

(2) Calculating the multi-path. When broke occurred, using multi-path routing mechanism to reduce the network burden that was caused by routing rediscovery. During the route discovery, saved many paths from the source node to the destination node, by calculating the path synthesis energy to determine routing priority, choosing the highest priority path as the main route and the rest as alternate routes.

3. EM-AODV

Traditional AODV routing protocol routing discovery and routing maintenance process have not considered the node energy, which makes the node survival time decreased, that increased the possible [9] of network rapidly segmenting. The EM-AODV (Energy saving& Multi-path AODV) protocol considered the total-path hop count and total energy as the routing metric. By setting the node energy threshold, the high energy path as the main routing is preferred, and the reconnecting delay shortens through backup paths.

3.1. Method for Obtaining Node eEnergy

AODV protocol recorded only neighbor nodes ID during routing discovery. EM-AODV improves the neighbor table structure to consider the next hop node energy during the routing discovery, records the neighbor nodes ID and nodes residual energy. EM-AODV also modified the Hello message, add T_S field to record nodes residual energy. When nodes broadcast Hello message periodically, its neighbor nodes within the range of one hop can get its residual energy by receiving the Hello message. Due to the periodic sending of Hello message, network nodes can dynamically update neighbor nodes residual energy, so as to adapt the topology changes.

3.2. Generation Mechanism of Multi-path

The EM-AODV protocol improves the routing response mechanism, and makes changes to the routing request packet RREQ and routing response packet RREP, adds the fields of E_{MIN} and E_{SUM}, E_{MIN} field records the node's minimum energy of a path, the E_{SUM} field stores all nodes sum energy of a path. When an intermediate node receives the RREQ request, if the node contains the path to the target node, it doesn't make RREP reply, but continues to broadcast the RREQ to its neighbor nodes till reached the target node. EM-AODV protocol adds a RREQ buffer queue in the target node, and sets a timer. Within the specified time, nodes receive the RREQ from all broadcast ID and the same

 Copyright ⓒ 2015 SERSC

source node, calculate priority P_{ri} of all paths and sort. When the timer is over, the target node will send the RREP that attached priority to the source node. Since then, the source node will choose the higher priority routing for data transmission.

$$P_{ri} = \sqrt{\left(\frac{0.6E_{\min} + 0.4\frac{E_{sum}}{S_{sum}}}{E_{initial}}\right)^2 + \left(\frac{1}{L}\right)^2} \tag{1}$$

Where P_{ri} is the path priority; S_{sum} is nodes total hops of a path; $E_{initial}$ is the node initial energy; L is the node current load. The greater the value of P_{ri}, the higher the priority of a path. It will choose the path of highest priority as main routing, the rest as backup routing.

3.3. Optimization of Routing Updates

Routing update optimization mainly has two aspects: the setting of node energy threshold and the selecting of the next hop.

Because of the difference of nodes energy consumption, nodes energy threshold T_1 and T_2 were set. T_1 is the minimum critical value of nodes, T_2 is the middle between T_1 and $E_{initial}$.

$$T_2 = \frac{T_1 + E_{initial}}{2} \tag{2}$$

(1)Add a buffer queue in the source node to receive several forward routing. The source node first checks whether there has the routing to the target node during the route discovery, if not, then broadcasts an RREQ request, according to the formula (3) ,nodes will choose the higher energy fitness node as the next hop.

$$f(i, j) = \mu E_{ij} \tag{3}$$

Where $f(i, j)$ expresses the energy fitness between node i and j, Fitness which are proportional to energy μE_{ij}. The greater the value of μE_{ij}, the higher the fitness.

(2) When the intermediate node received the RREQ packet, the node will compare T_S with T_1 and T_2, the routing process is carried out according to the following steps:

① $T_S < T_1$, the intermediate node will send routing update message to the source node, according to the value of P_{ri} ,the source node will choose backup route for data transmission.

② $T_1 < T_S < T_2$, the intermediate node only serve the path that is from itself to source node or to the destination node .

③ $T_S > T_2$, intermediate nodes receive and transmit information from its neighbor nodes normally.

4. Simulation and Performance Comparison

4.1. Simulation Environment

Compiler environment uses the cygwin, simulation platform uses the NS2 to analyze the routing protocol AODV and EM-AODV. Using the setdest to generate the simulation scenarios randomly, the scene contains 100 nodes, node movement model uses the Random Waypoint, node moving area is 1000 × 1000m and the simulation time is 500s. The source uses the CBR mode, data flow produced 4 512bytes UDP packages per second, MAC layer uses the DCF of IEEE02.11, the data transmission rate is 2Mbps, and the transmission coverage area is 250m.

The moving speed, residence time and energy of nodes are varied during the simulation. Energy consumption of each node is presented according to the Working Characteristics of Wave LAN PC/Card, node transmitting power is 850mw and the received power is 630mw. Node moving speed is equally distributed in [0, Vmax], Vmax is 30m/ s. Node residence time is set to 0s (without stop), 50s, 100s, 150s, 200s, 250s, and 300s.Specific parameters are shown in Table 1.

Table 1. EM-AODV Protocol Simulation Parameter Values

Parameters name	value
node number	100
scene size/m^2	1000×1000
Vmax /(m • s^{-1})	0~30
Type of service	CBR
data flow (packet • s^{-1})	4
transmitting power	850mw
received power	630mw
Simulation time/s	500

4.2. Performance Evaluation

Evaluation of qualitative and quantitative indicators can be used to judge and measure the routing protocol in a performance; the simulation makes the comparison between the average end-to-end delay and energy consumption. The average end to end delay reflects all the possible delay during transmission, including the interface queue time, routing discovery delay, *etc*.[10]. Energy consumption is related with working characteristics, packets size and the link bandwidth of wireless network card when node is transmitting or receiving data, node transmitting energy E_s and node received energy E_r are described respectively below:

$$E_s = \frac{p_s \times P}{B} \tag{4}$$

 Copyright ⓒ 2015 SERSC

$$E_r = \frac{p_r \times P}{B} \tag{5}$$

Where p_s is the node transmitting power, p_r is the node received power, P is the packet size, B is the bandwidth.

Forwarding a packet equal to receive the packet and then forward it on the network layer, so for energy consumption of forwarding a packet can be:

$$E_t = E_s + E_r \tag{6}$$

4.3. Simulation Results and Analysis

EM-AODV improved in the end-to-end delay and energy consumption compared with the AODV. Due to the multi-path of improved protocol, the source node does not need to restart the route discovery process but select the backup route for data transmission directly when the link is not up to the requirements or the transmission link is broken, so the stability and reliability are highly improved, transmission delay is shorten (It is depicted in Figure 1and Figure 2). When the node average moving speed is greater than 15m/s and the average residence time in the 0-150ms, the advantage of EM-AODV is more obvious in the average end-to-end delay.

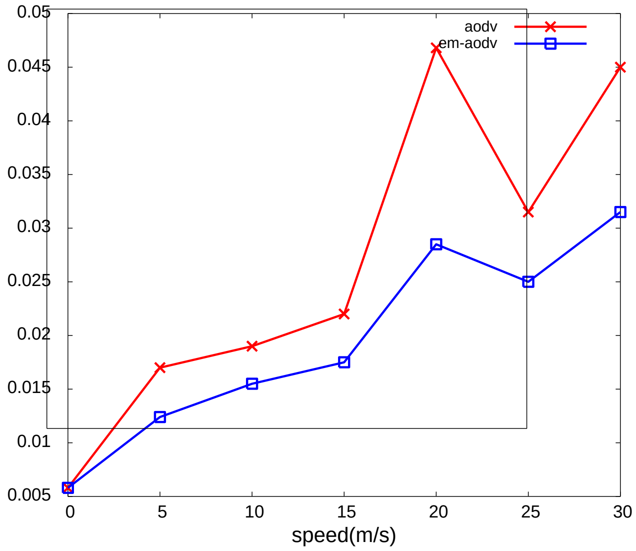

Figure 1. The Influence of Nodes Moving Speed to Average End-to-end Delay

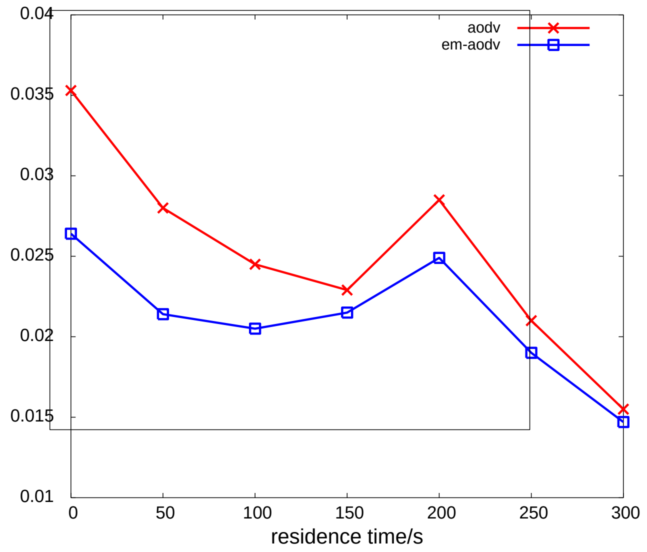

Figure 2. The Influence of Nodes Residence Time to Average End-to-end Delay

As shown in Figure 3, energy consumption of AODV and EM-AODV increased along with nodes moving speed up. When the average node moving speed is lower than 10m/s, the link is not easy to be damaged usally, the advantage of EM-AODV is not obvious. However, compared with AODV, EM-AODV protocol is obviously reduced in energy consumption with the increase of node average moving speed.

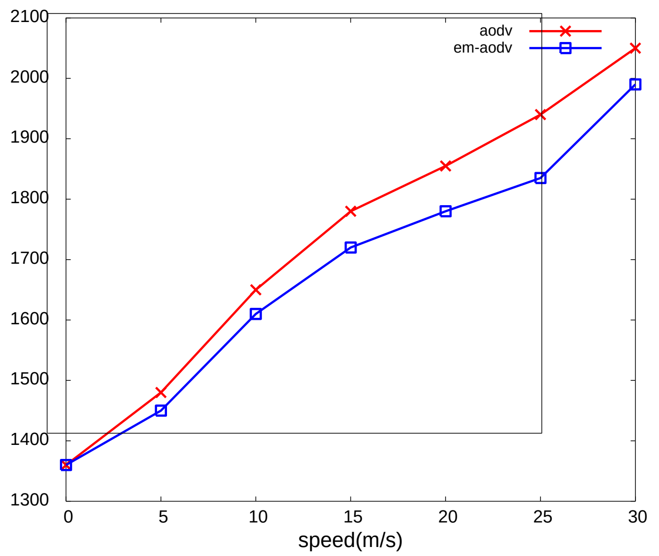

Figure 3. The Influence of Nodes Moving Speed to Energy Consumption

As shown in Figure 4, energy consumption of AODV and EM-AODV reduced along with the increased of nodes residence time. The energy consumption of EM-AODV is reduced by an average of about 6% than AODV. When nodes residence time is less than 150ms, the energy consumption of EM-AODV decreased significantly.

 Copyright ⓒ 2015 SERSC

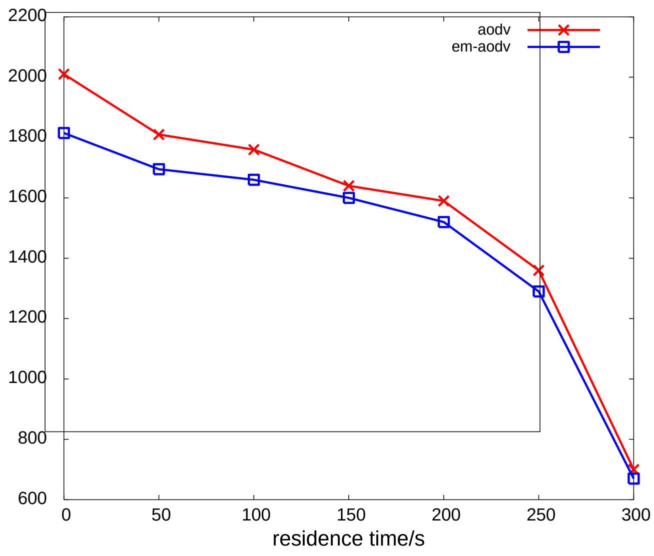

Figure 4. The Influence of Nodes Residence Time to Average Energy Consumption

5. Conclusions

The changes of network topology caused by the node mobility and energy limited is one of the important characteristics of Ad Hoc network, so routing and delay is a key problem of Ad Hoc network. EM-AODV proposed in this paper is a kind of multi-path routing protocol that uses the node and network comprehensive energy as the main basis. The simulation results show that, EM-AODV protocol balances the energy consumption of network nodes, allocates rationally the data forwarding, prolongs the network life cycle, and improves the average end-to-end delay and network energy consumption.

References

[1] Perkins, and E. cahrles, "Ad hoc networking", Addison-Wesley Professional, **(2008)**.
[2] M. Abelhasan , T. Wysoeki and E. Dutkiewicz, "A review of multing protocols for mobile ad hoc network", Ad hoc Network, vol. 25, **(2004)**, pp.1-22.
[3] A. Sankar and Z. Lium, "Maximum lifetime routing in wireless ad-hoc networks. IEEE INFOCOM", The Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies, Hong Kong, China, **(2004)**, pp. 1089-1097.
[4] Z. -Z. Jiao, K. Tian and X. -B. Zhang, "High Energy Node Driven On - demand Distance Vector Routing Protocol", Computer Science, vol. 38, **(2001)**, pp. 91-93.
[5] Q. –J. Wang, and Z. –F. Hou, "An improved protocol of nodes low energy avoiding based on AODV", Journal of Hefei university technology, vol. 36, **(2013)**, pp. 431-434.
[6] Q. –J. Wang, X. -X. Qi and Z. -F. Hou, "Improvement of AODV protocol based on link state", Journal of Beihua university (Natural science), vol. 14, **(2013)**, pp. 107-111.
[7] C. Perkins, E. B. Royer and S. Das, "Ad hoc on-Demand Distance Vector（AODV）Routing", IETF, vol. 3561, **(2003)**.
[8] X.-W. Wang, and X.-H. Zhao, "Design of low energy consumption routing protocol based on AODV in Zigbee network", Computer measurement & control, vol. 21, **(2013)**, pp. 461-463.
[9] Q. Sun, L. -Y. Li and N.-S. Chen, "A power control algorithm based on game theory in Ad hoc networks", Chinese journal of computers, vol. 32, **(2009)**, pp. 169-175.
[10] C. Zhu, P.-L. Hpmg and H.-C. Lu *et al.*, "Multi-path routing algorithm in space network", Communications technology, vol. 46, **(2013)**, pp. 42-46.

Copyright ⓒ 2015 SERSC

Authors

Xiaoxia Qi (1980), female，Zongyang, Master, lecturer, the main research directions: Computer network, information security.

Qijin Wang (1980), male，Huainan, Master, associate professor, the main research directions: wireless network, pattern recognition.

Fan Jiang (1956), male，Jiangsu, professor, the main research directions: computer network, Protocol and software testing, information security

 Copyright ⓒ 2015 SERSC