A Improved AOMDV Routing Protocol Based on Load Balancing with Energy Constraining for Ad Hoc Network

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Abstract. With the development of mobile technology and the increasing demand for free communication, Ad Hoc network has developed rapidly in the field of wireless communication. Due to the dynamic change of the system network topology, there are some shortcomings in the accuracy of routing selection. Therefore, this paper designs a routing protocol based on load balancing with energy constraining, which selects nodes with lower queue capacity of MAC layer and higher residual energy to forward packets. The simulation results show that the improved protocol has been effectively improved in terms of the number of energy exhausted nodes, end-to-end delay and routing discovery frequency.

Keywords: Ad hoc network · Queue capacity · Residual energy · Load balancing

1 Introduction

In recent years, Ad Hoc network has developed rapidly in the field of wireless communication due to its characteristics of no center and self-organization [1–3]. It is considered as an important complementary form of 5G [4]. However, due to the randomness of the moving speed and mode of each node in the network [5], the network topology may change at any time, which makes some nodes over-loaded, while others are under-loaded, and failing to make full use of resources [6]. Therefore, finding a reliable data transmission path is the key to the research.

Literature [7] proposes an MSR protocol, which takes delay as the measure of path specification, and achieves load balancing, but the overhead of sending packets increases significantly. The SMR protocol proposed in literature [8] improves the load balancing capability of the whole network by using the shunting method, but causes the problems of packet sorting. The AOMDV protocol proposed in [9, 10] selects the transmission path with the RREP arrival time, which reduces the delay but makes the packet delivery rate worse. The LBMMRE-AOMDV protocol proposed in [11] has greatly improved in terms of packet delivery rate, average energy consumption and routing overhead, but increased the delay.

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In order to overcome the above problems, this paper designs a routing protocol based on load balancing with energy constraining.

2 The Improved Routing Protocol

Since the classical routing protocol does not consider the residual energy and load of the nodes, the improved routing protocol selects nodes with lower queue capacity of MAC layer and higher residual energy to forward packets.

2.1 The Queue Capacity of MAC Layer

Queue capacity refers to the number of packets waiting to be forwarded in the interface queue. Nodes compare their current queue capacity qoc with threshold thr. If the threshold thr is greater than qoc, the node will respond to RREQ packets. Otherwise, RREQ packets are discarded directly.

The average queue capacity of nodes is calculated as shown in Eq. (1),

$$avg = \frac{qoc + \sum_{i=1}^{n} nb\_qoc_i}{n+1} \tag{1}$$

The threshold value of nodes is calculated as shown in Eqs. (2) and (3),

$$\overline{d} = \frac{|qoc - avg| + \sum_{i=1}^{n} |nb\_qoc_i - avg|}{n+1} \tag{2}$$

$$thr = \overline{d} + avg \tag{3}$$

Where, qoc represent the queue capacity of the node, nb_qoc_i represents the queue capacity of the neighbor node, and n represents the number of the neighbor node.

2.2 The Residual Energy of Nodes

The improved protocol uses the path with lower load to transfer packets, which effectively avoids the situation that some nodes are over-loaded while others are under-loaded. However, the residual energy of nodes is not taken into account, so the average residual energy of the nodes is introduced.

The average residual energy of nodes is calculated as shown in Eq. (4),

$$E_{avg} = \frac{E_r^i + \sum_{k=1}^{n} E_r^k}{n+1} \tag{4}$$

Where, E_{avg} is the average residual energy of the neighbor node, E_r^i is the residual energy of the node n_i, n is the number of neighbor nodes of the node n_i, E_r^k is the k-th $(k = 1,2,\ldots,n)$ residual energy of adjacent nodes.

In order to determine the relationship between average queue capacity of MAC layer and the residual energy of nodes, the path selection function T is introduced,

$$T = avg_{\max} \times (1/E_{\min}) = avg_{\max} \times \left[\frac{1}{\left(E_r^i + E_{avg}\right)/(n+1)}\right] \tag{5}$$

Where, $E_{\min}$ represents the minimum residual energy of all nodes, and $avg_{\max}$ represents the maximum queue capacity of all nodes on a path.

3 Simulation Results

In order to further test the network performance of the improved routing protocol, simulation is carried out using NS2 network simulation platform. In the simulation, a rectangular scene with a network range of 1000 m × 1000 m is used. A total of 100 mobile nodes are move randomly in the scene at a maximum speed of 20 m/s, and the simulation time is 300 s, the performance simulation analysis at different simulation times are as follows.

From Fig. 1, we can see that with the increase of simulation time, the energy consumption of nodes also increases, so the number of energy-exhausted nodes increases gradually. Since the improved protocol chooses the nodes with higher average residual energy to forward packets, which avoids exit the network when the energy of the intermediate nodes are exhausted, so the number of nodes exhausted in the improved protocol is relatively reduced.

Figure 2 shows that the improved protocol uses nodes with lighter load to forward packets, which reduces packet forwarding time, and then the delay is reduced. In addition, the improved protocol chooses nodes with large residual energy to forward packets. In addition, the improved protocol chooses nodes with large residual energy to forward packets, which reduces the disconnection of nodes due to energy exhausted, and the multi-path routing reduces the number of route discoveries compared with single-path routing, thus reduces the end-to-end delay.

From Fig. 3 we can see that multiple independent routes can be found in a route discovery process, the number of routing messages used for route discovery and maintenance is reduced, thus greatly reducing the number of route discovery. In addition, the improved routing protocol uses the path with lighter load to transmit the packets, and the residual energy of nodes is high, which improves the stability of the link and reduces the number of packets for routing maintenance. Therefore, the discovery frequency of the improved routing protocol is lower.

Figure 4 shows that multi-path routing protocol can find multiple independent paths of links in the process of route discovery, which greatly reduces the number of route discovery and the number of control packets are greatly reduced, so the routing overhead is lower than that of single path routing. The improved routing protocol is similar to AOMDV multipath routing protocol in routing overhead.

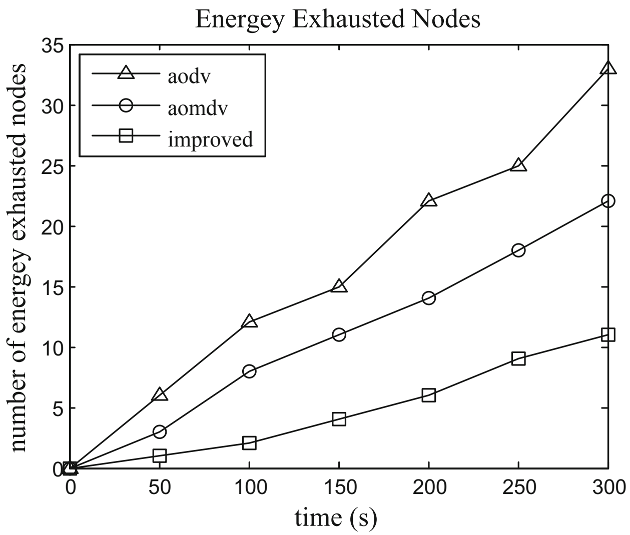

Fig. 1. The number of energy exhausted nodes

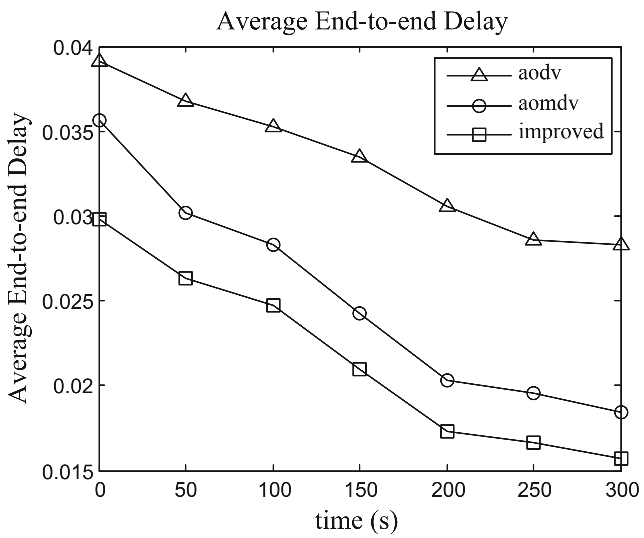

Fig. 2. Average end-to-end delay

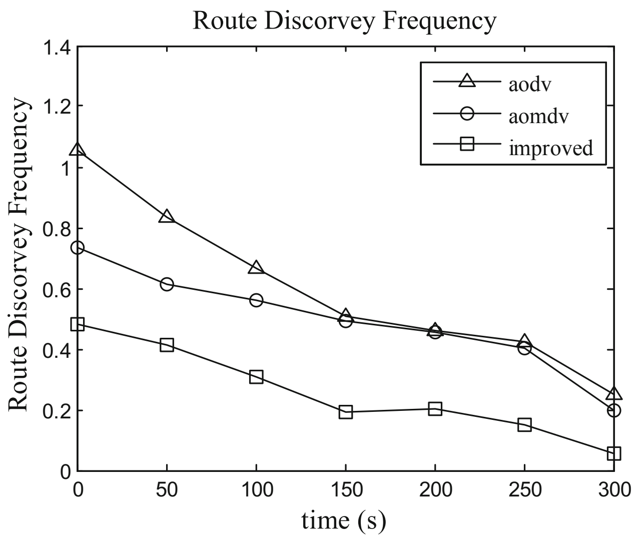

Fig. 3. Routing discovery frequency

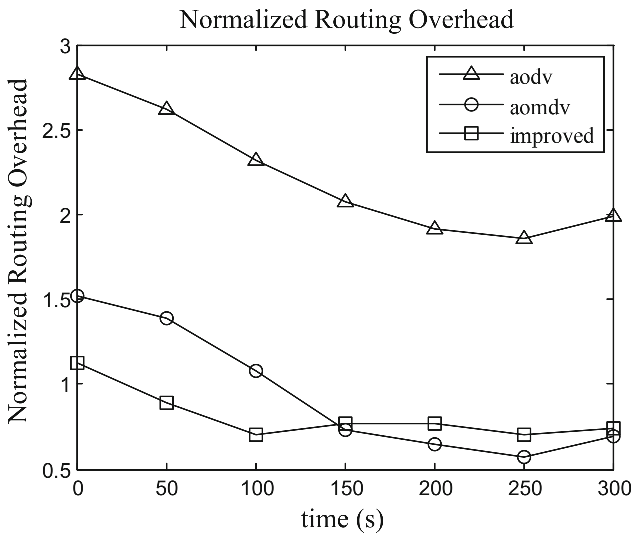

Fig. 4. The routing overhead

4 Conclusion

Aiming at the shortcomings of classical routing protocols, this paper comprehensively considers the queue capacity of MAC layer and the residual energy of the nodes. The simulation results show that to a certain extent, the improved routing protocol improves the network performance in terms of the number of energy exhausted nodes, end-to-end delay and routing discovery frequency.

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