A Modified AODV Protocol Based on Nodes Velocity

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Abstract. MANET has been widely used in many fields with the development of wireless communication technology. The AODV routing protocol which is known as a well-designed protocol of MANET has received widespread attention. However, high node velocity and frequent changes of network topology pose a challenge to the classic AODV protocol. Considering the stability of link, this paper proposes an algorithm to quantify the change frequency of network topology at first. Then a modified AODV protocol based on node velocity which is named RAODV is introduced in detail for high dynamic network topology. RAODV can build a more stable link according to the node velocity and reduce the normalized overhead of routing and average end-to-end delay by prolonging routing's survival time.

Keywords: Ad hoc network · High dynamic network topology
Node velocity · AODV · NS2

1 Introduction

When the network topology changes frequently, it is very important to establish a stable routing to guarantee the QoS of communication. Because that a stable route can effectively reduce the number of rerouting, thus the overall network latency and normalized routing overhead decrease. In the mobile ad hoc network, however, the traditional routing protocol lacks an effective mechanism to ensure the stability of the route.

In recent years, there are four methods for establishing the stable routing, they are the stable routing protocol based on the survival time of routing, the stable routing protocol on the speed of the node, the stable routing protocol on the strength of the signal and the stable routing protocol on the location of the node, respectively. In paper [6], a stable routing protocol based on link survival time is proposed. In this paper the motion model of random nodes is analyzed by a simulation experiment. Through the experiment the probability distribution of the survival time of the link corresponding to the motion mode which can be used to calculate the stability factor of the link is got. But this approach requires a large amount of experimental data and it is also very sensitive to the network topology boundary conditions. That is what we don't expect. Article [9] proposing a stable routing algorithm based on the velocity of the node. As the algorithm describes, the velocity variance of the two nodes is used as the link

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stability coefficient between the two nodes and the routing whose overall link stability coefficient is the smallest is the first choice when choosing the routing path. This method has a good performance in term of routing overhead and routing delay when the network topology changes frequently. However, when the network topology tends to be stable, the growing number of hops will result in a significant increase in the end-to-end latency time. Because of that, this algorithm can't adapt to adjust the routing strategy and then makes the route overhead increased. In the literature [12], the signal power of the two nodes is used to judge the change of the relative position of the node. Whether the two nodes are in the stable state is decided by the threshold of the ratio of the power. If the two neighbor nodes are in the stable state, these two nodes are the prior choice for the establishment of stable routing. In this paper, we first introduce the concept of the neighbor node changing ratio, that means in a period of time how often the neighbor node changes. The neighbor node changing ratio reflects the network topology changes fast or slowly. The link stability coefficient between the two nodes is defined as the sum of square of the difference between the velocity on the vertical direction and the horizontal direction. The routing with the smallest number of hops or the minimum link stability coefficient is selected adaptively according to the change rate of the neighbor node. As a result, the problem that the routing established by the stable path algorithm will greatly increase the network latency and routing overhead when the network topology tends to be stable is solved.

2 Algorithm Quantifying High Dynamic Network Topology

It's hard to judge the simulation results of traditional AODV protocol and its modified versions in the same standard assessment because of the diversity of applications. There is no uniform standard for quantifying network topology changes and most research introduced the node velocity to solve this problem.

Even if the node velocity is same, whether the node is docked and the duration of node docking will both affect the network topology changes because of their different trajectories. That is the reason for simulation results varying widely when using NS2 to generate SCENE FILE even under the same node velocity. In this paper, network topology's change is measured by neighbor nodes' rate of change, then the relationship of the degree of topology change, the node velocity and node docking time is analyzed by NS2. Simulation parameters are set as Table 1 shows:

Using NS2"setdest" toolkit to generate SCENE FILE:

./setdest –v 2 –n 50 –s 1 –m 30 –M 30 –t 500 –P 1 –p 0 –x 1000 –y 300 >scen-50n-30 s-p0

The command generates the following SCENE FILE: The node randomly selects its destination in the set simulation area (1000 m * 300 m), moving at a constant speed of 30 m/s to the destination. After reaching the specified coordinates, the node stays for the specified time (0 s) and then repeats the above-mentioned movement.

Figure 1 shows the neighbor node changing ratio of a random node when the velocities varies based on above scene. As we can see from the figure, on the same node, the velocity and neighbor node changing ratio. when the velocity is less than 5 m/s, the neighbor node changing ratio increases with increasing velocity, when the

Table 1. Simulation parameters

Simulation parameters	Parameter values
Network range	1000 m * 300 m
Number of nodes	50
Network service	CBR
MAC protocol	IEEE 802.11b
Signal transmission range	250 m
Maximum carrier sense rang	550 m
Simulation time	300 s
Radio model	Two_Ray
Maximum queue	50
Packet size	512bits

velocity is greater than 15 m/s, the neighbor node changing ratio is random. Figure 2 shows the neighbor node changing ratio after enlargement of a certain period of time.

Figures 1 and 2 are the relationship between the neighbor node changing ratio and node velocity, to further verify the relationships, the normalization of neighbor node changing ratio on total network topology as shown in Fig. 3.

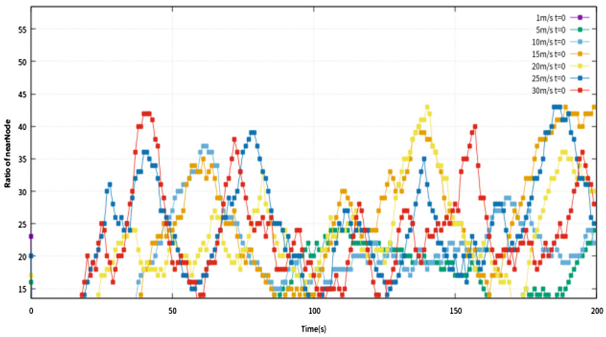

Fig. 1. Neighbor node changing ratio, when nodes velocities varies

We can see from the Fig. 3 when the node velocity is less than 15 m/s, neighbor node changing ratio increases with increasing node velocity, when the speed is greater than 15 m/s, there was no positive relationship between the neighbor changing rate and node velocity, in order to reduce the error due to the random network topology, decreases the velocity step simulation, we can get the results shown in Fig. 4, which proved the above conclusion further.

From the above analysis simulation, using the node velocity to measure the network topology changing rate is not exactly right. On the basis of this research, using node residence time to measure topology changing rate, we can get the following simulation results.

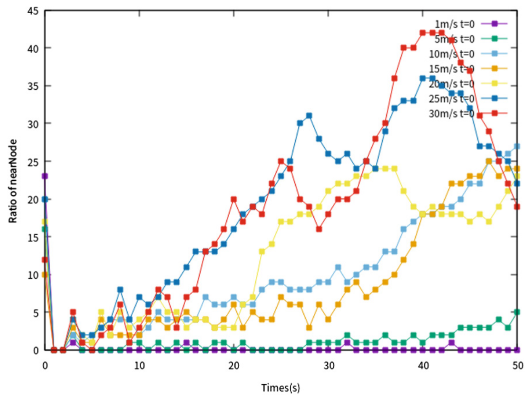

Fig. 2. Neighbor nodes changing ratio with velocities variation after enlargement

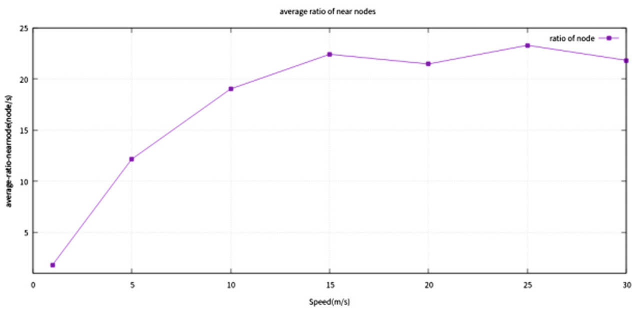

Fig. 3. Neighbor nodes changing ratio with velocities variation

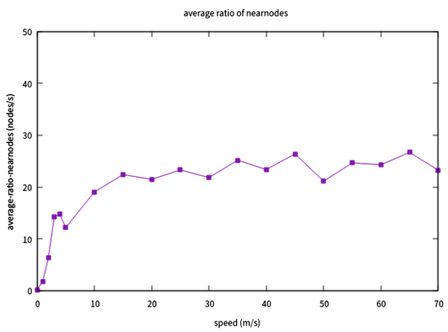

Fig. 4. Neighbor nodes changing ratio with velocities variation

Figure 5 is the relationship between the neighbor node changing ratio of some random nodes and the node residence time. It shows that There is no strict linear relationship between the neighbor node changing ratio of the single node and the node residence time. After normalization analysis, we can get Fig. 6. The figure shows that when the node velocity is constant, with the increase of residence, neighbor node changing ratio is gradually reduced. When node residence time is more than 20 s, the average neighbor node changing ratio decreases slowly, with the maximum residence time continue to increase, the average neighbor node changing ratio will gradually approach 0, namely when the network node keeping static, the neighbor node changing ratio is 0.

The simulation results show that using the residence time as a measure of the degree of network topology's changing is more convincing. In this paper, the rest simulation will use the node residence time to measure the frequency of network topology changes.

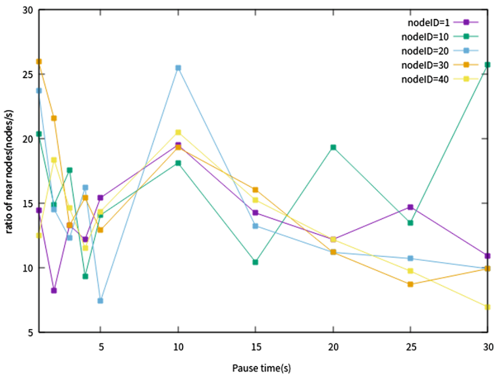

Fig. 5. Neighbor node changing ratio of some random nodes with node residence time varies

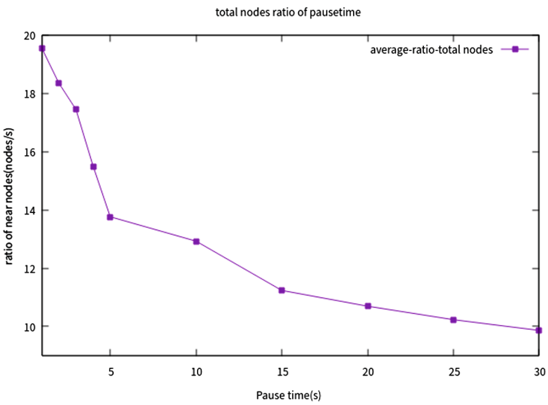

Fig. 6. Neighbor node changing ratio of total network topology, when node residence time varies

3 Link Stability Calculation and Routing Strategy

In high dynamic networks, the relative speed between nodes is the main factor that affects the life cycle of the link. When the velocity of two nodes are relatively large, the distance between nodes will increase rapidly, which leads to the interruption of the link. A new parameter is introduced here "σ_{ij}", It is defined as:

$$\sigma_{ij} = (v_{xi} - v_{xj})^2 + (v_{yi} - v_{yj})^2 \quad (1)$$

σ_{ij}: Stability coefficient between node i and node j
v_{xi}: Node i in horizontal velocity
v_{yi}: Node i in vertical velocity
v_{xj}: Node j in horizontal velocity
v_{yj}: Node j in vertical velocity

The sum of the stability coefficients of each adjacent two nodes on the link is defined as the link stability factor, defined as "σ_{sum}".

On this basis, Modify the AODV routing protocol RREQ and RREP, Add $v_x, v_y, \sigma_{sum}, \theta_{node}$ three data fields. v_x, v_y are used to store the node level and vertical direction velocity, σ_{sum} is used to store the link stability coefficient, θ_{node} is used to store the neighbor node changing ratio.

In the routing request phase, firstly, the source node obtains the velocity of itself and the neighbor node changing ratio which will be stored separately in v_x, v_y, θ_{node}, and then sets the link stability coefficient σ_{sum} to "0". Secondly, broadcasting the route request message to their neighbor nodes, when a neighbor node received this route request message, it will calculate the stability coefficient between the last hop node and itself according to Eq. (1), then update σ_{sum} in the routing request message. Also, the received routing request message's v_x, v_y were updated to its own velocity. Forwarding this RREQ until the destination node received it. The destination node will select the route request message through the neighbor node changing ratio θ_{node} or the stable coefficient of link σ_{sum} to reply before it created a routing. If θ_{node} is greater than 10, the destination node select the routing which has a smaller σ_{sum}, otherwise, the routing which has minimum hop will be selected.

4 Performance Simulation

4.1 Calculation of Performance Index

In this paper, packet loss rate, end-to-end delay, routing initiation frequency, normalized routing overhead are simulated.

The main performance evaluation criteria for the stable path algorithm is the normalized routing control overhead, and the other auxiliary evaluation criteria are routing initiation frequency, end-to-end delay and packet loss rate.

(a) Routing initiation frequency, the ability to maintain the stability of the routing protocol. The formula is as follows:

$$Request\_rate = \frac{count(route\_request)}{time_{stop}} \tag{2}$$

(b) Normalized routing control overhead, the number of routing control packets required to send a packet to the destination node. The smaller the normalized routing control overhead is, the lower the cost of routing protocol is, the better the protocol performance is. The formula is as follows:

$$Load_{Normalization} = \frac{count(control\_packet)}{max(packet\_id)} \tag{3}$$

(c) The packet loss rate, investigate routing protocol packet delivery ability of the source node to destination node, the packet loss rate is the number of packets lost accounted for the ratio of the number of total package, packet loss rate is small, the agreement will show that packet delivery success more ability to better the performance of the agreement. The formula is as follows:

$$Rate_{loss} = \frac{count(send\_packet) - count(receive\_packet)}{count(send\_packet)} \tag{4}$$

(d) Average end to end delay, the average value of the packet passing from the source node to the destination node, which reflects the speed of the packet passing through the routing protocol. The formula is as follows:

$$average\_delay = \frac{sum(T_{end\_time}(i) - T_{start\_time}(i))}{count(T_{end\_time}(i))} \tag{5}$$

Among them, T is the effective time, that is, at this time the packet can be received by the destination node. Taking NS2 as the simulation platform, the improved algorithm is simulated and compared with the traditional AODV routing protocol. The feasibility and correctness of the algorithm are verified by the parameter analysis model.

4.2 Analysis of Performance

Figure 7 shows Packet loss rate when the node residence time varies, compared with traditional AODV protocol, it has great advantages in packet loss rate when the residence time less than 20 s. With the increase in the residence time, the dynamic of network topology is reduced, the difference between these two routing protocol decreases, RAODV protocol may have a bit greater loss ratio than the traditional AODV protocol.

Figures 8 and 9 shows the routing average end to end delay according to the variation of residence time. We can see from the figure that the difference between

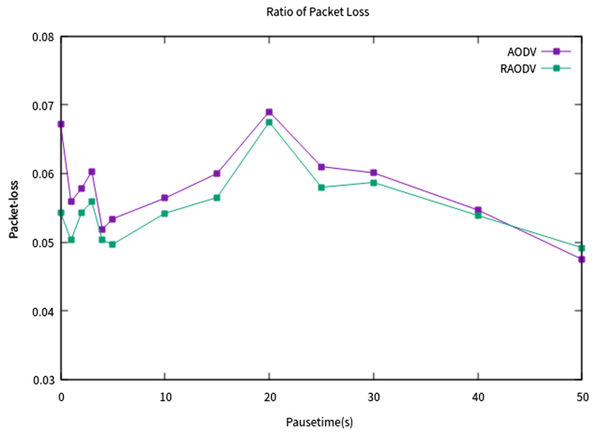

Fig. 7. AODV and RAODV Packet loss rate performance simulation

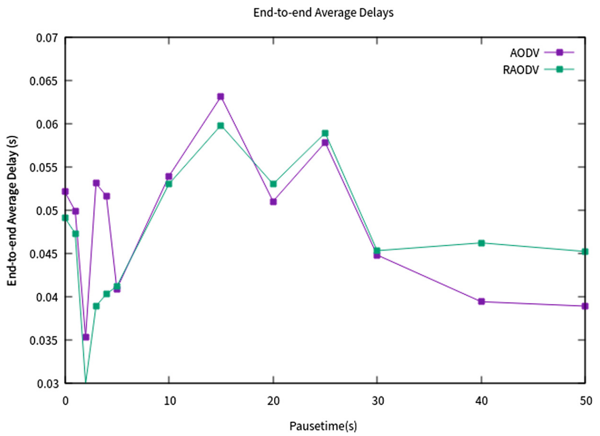

Fig. 8. Average end to end delay performance simulation

RAODV protocol and AODV protocol is small, with the increase in node residence time, the delay of AODV protocol reduces gradually, when the residence time is greater than 30 s, the delay performance of AODV protocol is better than RAODV protocol, the reason is nodes hop, although the outage probability of stable routing is small, the routing repair process decreases can make delay decreases, but due to the choice of the stable routing is not minimum hop routing, packet transmission delay caused by the increase in the residence time is very small, when the network topology changes frequently, the advantages of stable RAODV protocol is apparent, the overall delay is slightly better than that of the AODV protocol, with the increase of time to stop the network topology changes frequently decreased, then AODV protocol routing outage probability decreases, at this time the AODV protocol to establish the minimum

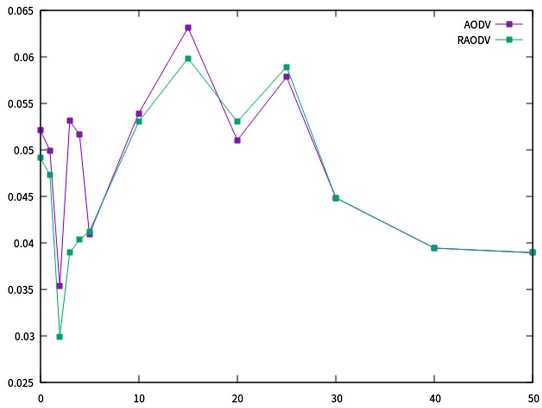

Fig. 9. Average end to end delay performance simulation

number of hops routing strategy is reflected in the overall delay will be lower than the RAODV protocol. When we take into consideration, as the neighbor node changing ratio less than 10, we may select the minimum hop routing instead which will decrease the end to end delay.

5 Conclusion

In this paper a modified AODV protocol based on the node velocity is introduced. When the network topology changes frequently, this improved protocol enables to reduce the overhead of route discovery process. Also, end to end delay is reduced as a result of considering self-adaption routing discovery. Simulation results shows that the proposed protocol has better end to end delay compared with traditional AODV protocol.

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