Improved method of OGM packet statistics and measurement calculation in BATMAN. Adv routing protocol

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Abstract. In the performance test of mesh network routing protocol, it is found that BATMAN. Adv routing protocol has better performance than the existing multi-hop routing protocol, but it also has the defects of poor routing convergence and slow response to network topology changes. Based on the detailed analysis of BATMAN. Adv routing protocol, this paper proposes an improved method. First, the statistical method of OGM package was redesigned, the cumulative sliding window method is used to improve the influence of the latest serial number of OGM, and the calculation method of TQ value is changed from average accumulation to weighted accumulation to further improve the influence of the latest TQ value. At the same time, an improved mechanism is proposed in order to solve the problem of link blocking caused by sudden node failure. Finally, through simulation experiments, the performance of the packet delivery rate and end-to-end delay of the three routing protocols in two different scenarios is compared. It shows that the improved protocol can effectively improve the packet delivery rate, reduce the average end-to-end delay, and improve the network performance.

1. Introduction

Wireless Mesh network is a communication network with Mesh topology built by multiple nodes through wireless links. It integrates the advantages of wireless local area network and mobile self-organization network, and is a network with large capacity, high rate and wide coverage [1-2]. BATMAN. adv is a new prior routing protocol for wireless Mesh networks, which realizes dynamic rate control, power control, carrier monitoring and channel allocation of WMN [3]. BATMAN-adv works in the MAC layer of OSI model. And it has the advantages of simple routing table establishment process, unique routing judgment standard and low network load, but it also brings its poor convergence of routing protocol and slow response to network topology changes [4].

2. Protocol analysis

2.1. Basic principles of Batman. adv routing protocol

Batman. Adv periodically broadcasts OGM (Originator Message) packets to inform other nodes of the information of this node, the node that sends the OGM packet is called the source message node, and
the neighbor node rebroadcasts the OGM packet to their neighbor node according to specific rules to announce the existence of the source message node. Each node rebroadcasts the received OGM packets at most once. Node A knows the existence of node D by receiving OGM packets, which are rebroadcast by neighbor nodes B or C that hop with node A. It determines the optimal next hop of arrival node D based on the number of faster and more stable OGM packets received from neighbor nodes. And build up the routing path step by step. See figure 1.

![Figure 1. Flooding mechanism](image)

2.2. Source node list
For each node, there is a list of source nodes that maintain routing information. This list provides functionality similar to the wired network routing table, which finds the best path through the list information and updates the data in the list based on the OGM message, as shown in figure 2.

![Figure 2. Source node list structure](image)

2.3. Calculation process of TQ value
In the process of route discovery and maintenance, the coordinator selects the optimal next-hop node according to the measurement value TQ (Transmission Quality) of the link. TQ is obtained by calculating the values of RQ (Receive Quality) and EQ (Echo Quality). Two sliding Windows are set for each node. One RQ_WINDOW is used to record the number of OGM generated by neighbor nodes, and the other EQ_WINDOW is used to record the number of OGM sent from this node to neighbor nodes and sent back, as shown in figure 3. The size of the sliding window is fixed and the window moves as the sequence number in the OGM message is updated. See figure 4.
Figure 3. RQ and EQ

RQ: \( A \xrightarrow{\text{OGM}} B \)

EQ: \( A \xrightarrow{\text{OGM A echo}} B \)

Figure 4. Batman. Adv sliding window

Set \( \text{rec}_\text{ogg}_\text{count} \) as the number of valid OGM received from neighbor nodes, and \( RQ\_\text{WINDOW\_SIZE} \) as the size of sliding window, and EQ in the same way, See the Eq. (1):

\[
RQ = \frac{\text{rec}_\text{ogg}_\text{count}}{RQ\_\text{WINDOW\_SIZE}}
\]

For the same link, if the link quality from node A to node B is very different from that from node B to node A, then the link is an asymmetric link. For this reason, the local transmission quality of penalty coefficient is considered as Eq. (2):

\[
TQ(\text{Local}) = \frac{EQ}{RQ} * (1 - (1 - RQ)^3)
\]

Then we calculate the transmission quality of a path. When re-broadcasting, the node will recalculate a global transmission quality TQ (link) according to the local transmission quality, the hop penalty and the extracted TQ field in OGM, and then put it into the OGM package and re-broadcast it. See Eq. (3):

\[
TQ(\text{Link}) = \frac{EQ}{RQ} * (1 - (1 - RQ)^3) * TQ_{\text{OGM}} * hop_{penalty}
\]

As a result of routing protocols in statistical RQ and TQ values did not distinguish between old and new serial number OGM, this leads to TQ (local) value is not the size of the real-time response current path quality, at the same time batman - adv protocol in order to quickly set up network topology, will strictly in accordance with the local link average TQ values to forward OGM, such network system cannot response in time when network topology change quickly, causing a sharp drop in network performance.

3. Agreement improvement

In view of the above situation, the following improvement ideas are proposed: the sliding window increments the serial number from left to right, the default window size is 64, and the number of OGM
packages with the latest 2, 4, 8, 16 and 32 Windows is counted respectively when calculating the TQ value. See the Eq. (4).

\[ ogm\_count = \sum_2 \text{ogm\_sum} + \sum_4 \text{ogm\_sum} + \sum_8 \text{ogm\_sum} + \sum_{16} \text{ogm\_sum} + \sum_{32} \text{ogm\_sum} \]  

The influence of the latest 10 OGM messages with serial Numbers before the improvement is \(10/64 = 15.6\%\), and that of the latest 10 OGM messages with serial Numbers after the improvement is \((2+4+8+10+10)/64 = 53.1\%\).

Meanwhile, the improvement method of TQ (link) based on sliding window mechanism is as follows: multiply the TQ value in the sliding window by the weight coefficient \(p\) to increase the weight of TQ value of the new serial number OGM. Where \(\text{Max\_window\_size}\) is the size of the sliding window, \(\text{win}_{\text{pos}}\) is the current window, \(\text{win}_i\) is the window I, see Eq. (5).

\[ p_i = 2 \times \beta e^{-2x_i} \quad \text{with} \quad x_i = \text{Max\_window\_size} - (\text{win}_{\text{pos}} - \text{win}_i) \]  

The improved TQ weighting formula is:

\[ TQ = \sum_i^{\text{Max\_window\_size}} p_i \times TQ \quad \text{with} \quad \sum_i^{\text{Max\_window\_size}} p_i = 1 \]  

Through calculation, the weights of the latest 5 TQ values are 0.4018, 0.2437, 0.1377, 0.0826, and 0.0526 successively, and the probability accumulates to 0.9184. Therefore, the improved TQ (link) value is mainly determined by the latest 5 TQ values in the sliding window. Batman. Adv under the default setting, the global sliding window size is 5, the weight coefficient of the latest TQ value is \(1/5 = 20\%\), and the weight coefficient of the latest improved TQ value is 40.18\%, so the improved TQ (link) calculation method increases the influence of the latest TQ value, and can improve the perception ability of path quality change.

At the same time, a mechanism is proposed to solve the problem of node failure. For any source node A, the local node records the latest sequence number of A, denoted by \(S(A)\). \(S_B(A)\) is used here to represent the latest sequence number of source node A obtained from neighbor node B. In order to avoid the defects of the original protocol, a parameter \(\text{MAX\_SN\_DIST}\) is introduced, denoted by \(d\), which is used to maintain the state of the link.

\[ TQ_{\text{NEWAB}}(V) = \begin{cases} 0 & \text{if } S_B(A) < S(A) - d \\ TQ_{\text{NEWAB}}(V) & \text{otherwise} \end{cases} \quad \text{with } S(A) = \text{Max}(S_B(A)) \]  

\hspace{1cm} (7)
Where, $TQ_{NEWAB}(V)$ represents the TQ value of the path from local node V to source node A through neighbours node B. If the sequence number of the OGM message obtained from the neighbour node B differs by more than the $MAX\_SN\_DIST$ parameter from the latest message recorded by the local node, then the link through node B is considered to have failed and its path TQ value is 0. Otherwise, the path TQ of this link is $TQ_{NEWAB}(V)$.

4. Simulation verification

In the simulation experiment, NS2 network simulation software is adopted. There is no module directly used to support BATMAN. adv routing protocol simulation in the original NS2 software. Therefore, NS2-based mesh 802.16 patch module is installed in this paper, which can provide the basic functions of MAC layer 802.16 protocol. In order to better analyse the improved performance of the protocol, set up two simulation scenarios. The simulation parameters are set as shown in Table 1 below.

4.1. Node movement speed change scenario

Firstly, we changed the speed of nodes from 0m/s to 50m/s (5m/s apart) under the same number of nodes (30 network nodes) and the same CBR stream transmission speed (150kB/s) to observe the performance of BATMAN. Adv, new-batman. Adv and AODV protocols under different circumstances. The simulation results of packet delivery rate and end-to-end delay were obtained, and then gnuplot was used to draw the change curve as shown in figure 6 and figure 7.

| Table 1. Simulation parameter Settings |
|--------------------------------------|
| **Simulation Parameters**             | **Parameter Value**               |
| Working frequency band                | 2.4Ghz                            |
| Transmission power                    | 19dBm                             |
| The Mac layer protocol                | IEEE 802.16d mesh protocol        |
| Network scenario                      | 1000m*1000m                       |
| Node signal range                     | 100m                              |
| Maximum on-line number                | Article 10                        |
| Ifq Queue maximum length              | 2000                              |
| Simulation duration                   | 500s                              |
| Routing protocol                      | AODV / BATMAN. adv                |
| The application layer                 | CBR packet, size 512Kbit          |

Figure 6. Packet delivery rate varies with node rate
Analysis 1: According to the chart, when node movement speed is greater than 15 m/s, three kinds of protocol packet delivery rate began to rapidly decreased, but the new BATMAN. adv protocol rate decrease significantly improved, 25% higher than the other two protocol, in node moving at high speed, the new BATMAN. adv can quickly response to the change of network topology, the convergence performance improvement, make the network communication is more stable and reliable, better than the other two protocols.

Analysis 2: When the node moves at a low speed, the three protocols perform very well. However, when the node moves faster than 35m/s, the end-to-end delay of the BATMAN. adv protocol starts to increase sharply until it exceeds 4s, while the end-to-end delay of the new-BATMAN. adv protocol increases, but still within 2.5s. It can be seen that in the case of high-speed transmission, new-BATMAN. adv has a strong transmission capability, which reduces the impact on network quality.

4.2. Node density change scenario
We set the node movement speed (15 m/s), the same CBR stream of sending the same speed (100 KB/s), change the number of nodes, gradually increased from 10 to 100 (interval to 10), observation of AODV, BATMAN. Adv, new BATMAN. Adv three protocol performance in different situations, it is concluded that the packet delivery ratio and end-to-end delay of the simulation results, and then use the gnuplot change curve drawing tool as shown in figure 8 and figure 9.
Figure 9. End-to-end delay varies with the number of nodes

Analysis: When the number of nodes is large, the packet delivery rate of the new-BATMAN. adv protocol can still be more than 20% higher than BATMAN. adv. And when the number of nodes is 100, it can maintain a packet delivery rate more than 70%, and the performance is good. When a larger-scale wireless mesh network needs to be established, the improved new-BATMAN. adv protocol will show greater advantages.

5. Summary
This paper analyses the algorithm process of BATMAN. Adv routing protocol in detail, and designs a new statistical method and calculation method. Simulation results show that the improved routing protocol can effectively improve packet delivery rate and reduce end-to-end delay in the case of high-speed multi-node. This improved method improves the response speed of the protocol to network topology changes and improves the convergence performance of the protocol.

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