AODV Protocol Optimization based on Node Congestion State

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Abstract

Nodes will discard the incoming data when nodes are congested in wireless ad hoc network. Congested nodes will discard the incoming data. If other nodes in the network still use the congested paths to transmit data, which will aggravate network packet loss and reduce network performance. To solve the congestion, a congestion control strategy with node current status is introduced in this paper. The congested nodes will broadcast congestion information to neighbor nodes by using the routing error (RERR) message with node congestion information in AODV protocol when nodes congestion status changed. After the neighbor nodes receive the RERR from congested nodes, it will transmit a new RERR with unreachable destinations to affected nodes. Finally, nodes in the network can obtain the congestion status of nodes in the transmission path in advance. It selectively sends data according to the path congestion state, which improves the overall performance of the network. Simulation results show that the average input throughput, average end-to-end delay and packet loss rate are significantly improved under different network scale.

Keywords

Ad Hoc Network; Congestion; AODV Protocol; Optimization.

1. Introduction

In wireless ad hoc networks, each node can act as an intermediate forwarding node of data. When a node is a forwarding node of multiple destination nodes, the node will receive large amount of data, and may be congested due to too much data to be forwarded [1]. Once a node is congested, its transmission path will also be congested, while other nodes in the network continue to compete for the channel and use the congested path to transmit data[7], which will lead to data accumulation in the congested node. The data which is receiving will be discarded because it can not be forwarded in time, and the packet loss in the network will become serious, wasting channel resources and reducing network performance. This paper proposes a modified AODV protocol, which allows the transmitting node to choose whether to send data according to the congestion of the nodes in the transmission path before sending data[6].

The rest of the paper is organized as follows. AODV protocol is introduced in SectionII. The modification scheme of AODV protocol is proposed in SectionIII. The experiments and analysis are described in SectionIV. Finally, we conclude the paper in SectionV.

2. AODV Protocol

AODV protocol is divided into routing request and routing maintenance. In the first part, the sending node broadcasts a routing request (RREQ) message in the network. The destination node receives RREQ and sends a routing reply (RREP) message to the source node. When the source node receives RREP, it establishes a routing entry to the destination node in the routing table and sends data.

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2.1 Route Maintance

AODV monitors the link status with the neighbor node by periodically broadcasting Hello messages to the neighbor node. If the active node in the network does not receive the same route within the Hello interval and the neighbor node sends Hello messages, it indicates that the link with the neighbor node has failed, and sends RERR to upstream nodes to notify the relevant node to delete the route entry to the failed node.

2.2 Routing Error (RERR) Message Transmission Process

RERR is generated by the upstream neighbor node that sends data to the failed node. The upstream node fills the IP address and serial number of the failed destination node into the unreachable destination IP address and unreachable destination serial number fields in RERR and deletes the route to the destination address, and updates its own routing table or invalidates it. When generating RREP, each node in AODV protocol will generate and save an upstream node list [2], which contains the IP address of each node and its neighbor nodes, which will be used as the next hop to the destination node. The upstream node determines which nodes to forward the RERR to through the list of upstream nodes. After receiving the RERR, these nodes look up whether there is a route entry to the destination address in the routing table according to the unreachable destination IP address in the RERR. If there is a route to the destination address, judge whether the node sending the RERR is the next hop node to the destination node, If it is the next hop node, the current node deletes or invalidates the route to the destination node in the routing table, and continues to forward RERR to the upstream node according to its own upstream node list until all affected nodes receive RERR. The data which use broken route entry to transmit is stored in the buffer and transmitted after a new route is generated.

3. AODV Protocol Optimization Method based on Node Congestion State

In Figure 1, there are two transmission paths, node A to node F and node B to node H. Both A and B are within the transmission range of each other, and there is a congestion node E in the transmission path from A to F. Before A and B ready to send data, they need to compete for the channel. If A competes for the channel, B needs to wait for A to complete the transmission before competing for the channel again. However, there is a congested node E in the transmission path of A, and the data is discarded after reaching E. The transmission result of A is failed. Because there is no available channel, the data of B cannot be sent out in time. Thus, A wastes channel resources.

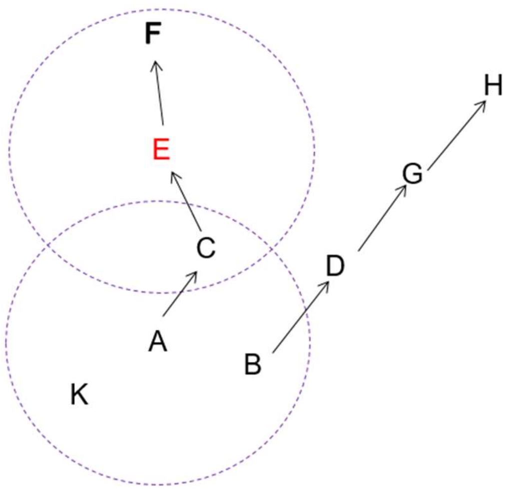

Figure 1. Congestion nodes in transmission path

In order to solve the above problems, RERR is selected to carry the congestion information according to the characteristics that RERR can send hop by hop through the list of upstream nodes in the node.

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The congestion node broadcasts and sends the RERR carrying congestion information to its neighbor node by triggering transmission. After receiving the congestion RERR, the neighbor node determines whether it uses the congestion node as the routing entry of the next hop. If so, modify the congestion status of these routing entries, indicating that there are congestion nodes in the current path, The destination node address of these routing entries is stored in the new congestion RERR, and the new congestion RERR is sent to other affected nodes in the network according to the list of upstream nodes in the node. After receiving it, other nodes modify the congestion state of the corresponding routing entry in the routing table according to the destination address carried in the congestion RERR. When a node needs to send data, it should look up for the congestion state of the routing entry used for transmission and select whether to send data.

3.1 The Design of RERR Structure with Congestion Infomation

The congestionPkt bit which means the RERR is sent by congestion node is added to RERR. The neibourCongestionPkt bit which means the RERR is sent by the neighbor node of the congestion node is added to RERR. The congestionInfo bit which means the RERR carries congetsion information is added to RERR[3]. By designing the congestion identification bit, the RERR carrying congestion information can be distinguished from the RERR sent by AODV protocol. When nodes receive different types of RERR, they can make corresponding operations.

3.2 The Congestion Node Triggers to Generate and Send a RERR Message with Congestion Bits

When the data size in the buffer changes, if the data size in the buffer has reached the data size that the buffer can store, which indicates that the buffer of the current node is full. Other nodes continue to send data to congestion node, resulting in data loss. Congestion node fills its own IP address into the RERR and sets the congestionPkt and congestionInfo in the RERR to 1. Then it broadcasts and sends the congestion RERR to the neighbor nodes. If the size of the data in the buffer is smaller than the size of the data that can be stored in the buffer, which indicates that the node has changed from a congested state to a non congested state, the node will send the information to relieve the congestion state, and store its own IP address and the destination IP of the route entry in the congested state in the current routing table in the RERR to be sent, and sets the congestionPkt in RERR to 1 and the congestionInfo to 0, and broadcasts to the neighbor nodes. Trigger sending RERR ensures that other nodes can update the routing congestion status in time [3].

3.3 Design and Update of Congestion Bit in Routing Table

In the routing table of AODV protocol, each routing entry is set with a congestionRT to indicate whether there is congestion node in the transmission path of the current routing entry.

When the neighbor node receives the RERR with congestionRT bit 1 from the congestion node, it traverses its own routing table to find the route entry that takes the congestion node as the next hop, and modifies the congestionRT value of the corresponding route entry, and store the destination address corresponding to the routing entry in the new congestion RERR with neibourCongestionpkt bit 1 and congestionInfo bit unchanged. When the upstream node of the neighbor node receives a new congestion RERR, it traverses its own routing table to find the routing entry to the destination address carried by the RERR, and modifies the congestionRT value of the corresponding routing entry, and continues to forward the new congestion RERR to the upstream node until all affected nodes receive the congestion RERR.

3.4 Transmission Process of Congestion RERR

After the neighbor node of the congestion node updates its own routing table and generates a RERR with neibourconggestionpkt bit 1, the node selectively forwards the congestion RERR to the upstream node by querying the local upstream node list. After receiving the RERR with neibourCongestionPkt bit 1, if there is a routing entry to the destination node carried by the RERR in the routing table of the upstream node, and the node sending this RERR is the next hop node to the destination node, it will

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modify the congestionRT bit 1 of the corresponding route entry according to the congestionInfo value in the congestion RERR, and continue to forward this RERR to the upstream node. After receiving it, the upstream node will perform the same operation until all affected nodes in the network receive the congestion RERR.

3.5 Congestion Rerr Process

When the node is congested, it broadcasts the congestion RERR to the neighbor nodes, and the neighbor nodes send the congestion RERR with the destination node address to other nodes until all affected nodes receive the congestion RERR. When a node wants to send data, it is necessary to check the congestionRT bit of the routing entry to the destination node in the routing table. When the congestionRT bit is 1, it indicates that there is a congestion node in the current transmission path. The transmitting node saves the data to be sent into the buffer and sends the data of other non congested paths.

4. Experimental Simulation and Result Analysis

Experimental simulation is based on exata simulation platform, which is a network simulation software designed for wireless network technology. It supports the development of new protocol modules to be added to the system, which greatly facilitates wireless network simulation [4].

In this paper, the modified congested AODV protocol and AODV protocol are simulated in the same simulation environment. The performance of the protocol is evaluated according to the average network throughput, average end-to-end delay and network packet loss rate of the two protocols. The main parameters of the simulation scenario are shown in Table 1.

Table 1. Simulation scenario and numerical simulation

Simulation parameters	numerical value
Simulation scene size	1500m*1500m
Application layer	FTP
Packet size	512bytes
Transport layer protocol	Semi-TCP
Network layer protocol	Congestion AODV AODV
MAC protocol	CSMA/CA
Physical layer	802.11b
Data rate	2Mbps
Transmission power	15dBm
Dynamic topology mobility model	Random Waypoint

Fig. 2 is a scenario established in the simulation platform. The comparison of network average reception throughput of different number of nodes is shown in Fig. 3. The simulation results shows that with the increase of the number of nodes in the network, the average network receiving throughput of congested AODV protocol and AODV protocol is constantly changing, and the average network receiving throughput of congested AODV protocol is higher than that of AODV protocol. This is because the number of nodes in the network is increasing, the amount of data transmitted in the network is increasing, there are more nodes with congestion in the whole network, the number of discarded packets is increasing, and the congestion of the network is increasing. The congestion AODV protocol sends the situation of the congestion node to the affected nodes in the network through the RERR carrying congestion information. After receiving the RERR, these nodes modify the congestion state of the route entry where the corresponding congestion node is located. When the node sends data, if there is a congestion node in the transmission path, the data packets to the congestion node will be stored in the buffer and sent after the congestion is completed, which reduce the occurrence of packet loss in the network and increase the average receiving throughput of the network.

Fig. 4 shows the change of average end-to-end delay with the number of nodes. With the increase of the number of nodes, the average end-to-end delay of congestion AODV protocol is lower than that of AODV protocol. When congested nodes appear in the network, the sending node cannot know whether there is a congested node in the transmission path to continue to send data, resulting in that the data stored in the buffer in the congested node cannot be sent out in time, and it takes more time to empty the buffer. If there is a congested node in the path to the destination node, the sending node will store the data to the congested node in the buffer and send the data of the non congested path first, so that the network resources will not be wasted to transmit the impossible data, which speeds up the emptying of the cache and reduces the average end-to-end delay.

Fig. 5 shows the change of network packet loss rate with the number of nodes. The figure shows that with the increase of the number of nodes in the network, the node load increases, and the probability of congested nodes in the network increases, resulting in serious packet loss in the network. The congestion AODV protocol is mainly aimed at judging and sending data according to the congestion of the transmission path, and avoids sending data to congested nodes and reduces the network packet loss rate, so the packet loss rate of congested AODV protocol is lower than that of AODV protocol.

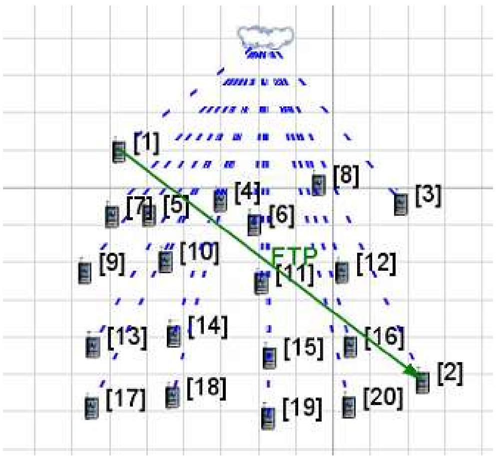

Figure 2. 20 node topology network scenario

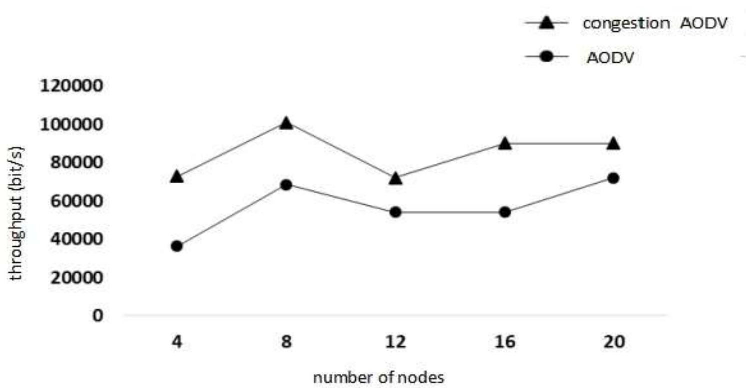

Figure 3. The average receiving throughput varies with the number of nodes

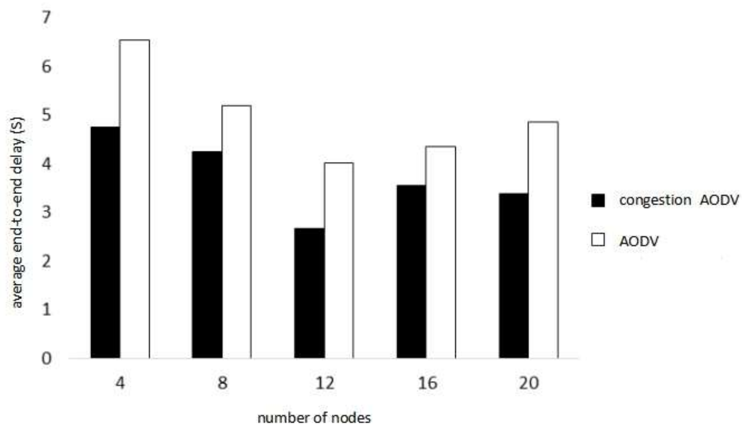

Figure 4. Variation of average end-to-end delay with the number of nodes

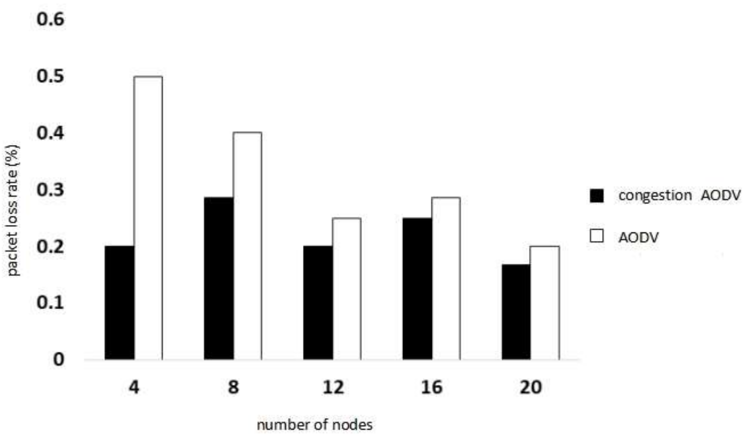

Figure 5. Change of packet loss rate with the number of nodes

As it shown in Fig. 3, Fig. 4 and Fig. 5, with the increase of the number of nodes in the network, the congestion AODV protocol is superior to the AODV protocol in terms of average network reception throughput, average end-to-end delay and packet loss rate. In conclusion, congestion AODV protocol has good performance in transmission performance.

5. Conclusion

Aiming at the problem of packet loss and channel waste caused by other nodes continuing to compete for the channel to send data without knowing the congestion of the current transmission path in the network, a modified AODV protocol method is proposed. This method uses RERR in AODV protocol to carry the node congestion information and send it to the affected nodes in the network through the upstream node list, other nodes update the congestion status of the route entry where the corresponding congestion node is located after receiving it. When sending data, judge whether there is a congestion node in the current transmission path according to the congestion status in the route entry to send data, and finally enable the congestion node to report the congestion situation in time through the triggered transmission method, It ensures that the affected nodes can update the congestion status of the corresponding routing entries in the routing table in time, which improves the performance of the network. By changing the number of nodes in the network and increasing the number of congested nodes in the network, the feasibility of this method is verified. The results show

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that compared with AODV protocol, congested AODV protocol has a great improvement in network average receiving throughput, network average end-to-end delay and network packet loss rate.

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