A Study of Link Buffering for OLSR

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Abstract - **In this paper, we propose the extension of Optimized Link State Routing (OLSR) [1] protocol based on link layer notification, "link buffering" and "packet restoration". When link disconnection is detected by link layer notification, the route entries having the disconnected link to the next hop become invalid. An incoming packet is stored in the link buffer if its route entry is invalid. Packet restoration method is used to save packets in the MAC queue, for which next hop is disconnected and to give them another chance of transmission based on updated route information. Specifically two methods, "simple restoration" and "full restoration" are specified. We implemented these functions into OLSR and compared their performance using GloMoSim [2].**

The simulation results show that OLSR with packet restoration method has high performance in the packet delivery ration in high mobility and high loaded environments.

***Keywords* - mobile ad hoc networks, link layer notification, link buffering, packet clearance, packet restoration**

I. INTRODUCTION

In ad hoc networks with high mobility and high density, link connection and disconnection often occur. The mechanism of the quick search for new route to destination and the method of saving data packets, which encounter link disconnection are needed. In proactive routing protocols, such as OLSR, the routing table is built and maintained based on the information of neighbor table. Therefore, quick detection of link disconnection and neighbor table updates are necessary. However, under high mobility environment, the time required to detect link disconnection becomes not negligible to meet the requirement of quick detection. Many packets are then erroneously forwarded to the disconnected link, leading degraded performance in packet delivery.

Link layer notification method is defined in [1] as one of methods to detect link disconnection as fast as possible. In this method, data link layer detects link disconnection to neighbor node and informs it to network layer so that routing protocol can update routing table immediately. Also this method prevents from using disconnected link to destination and enables to rebuild routing table that contains more accurate route information in low mobility environment. However, in proactive routing protocol, it is difficult to keep accurate link information under high mobility environment even if link layer notification is used. This observation raises necessity of a new method for OLSR.

In this research, we propose two methods, link buffering and packet restoration, which are used together with link layer notification for informing link disconnection.

The remainder of this paper is organized as follows: Section 2 provides a brief overview of OLSR. Section 3 describes detail mechanisms and functions of "link buffering" and "packet restoration". Section 4 presents the results of performance evaluation based on simulation. Finally, section 5 concludes the paper and outlines directions for future work.

II. OLSR OVERVIEW

The OLSR, Optimized Link State Routing protocol is a proactive link state routing protocol, employing periodic message exchange to update topological information in each node in the network. OLSR uses two kinds of control packets: hello packet and TC packet (Topology Control). Each node uses Hello packet to update the neighbor table and compute its multipoint relays (MPR). The idea of multipoint relays is to minimize the overhead of flooding message in the network. TC packet broadcasted by a MPR node to the entire network contains the list of its neighbors. These control packets are used to build the routing table and to detect link disconnection. A node detects link disconnection to a neighbor node if not receiving a hello packet from a neighbor node within lifetime of the link. If link layer's information regarding connectivity to neighbor nodes is available, it is used together with the information from hello packet to maintain the neighbor table and the routing table. In link layer notification method, when a node doesn't receive CTS after RTS transmission or doesn't receive ACK after data packet transmission, the link is identified as disconnected and link disconnection will be known to network layer. Then disconnected link will be discarded from neighbor table and routing table. When the packet transmission fails due to link disconnection, this packet is deleted from the MAC queue. However, other packets, which will use the same link, may exist in the MAC queue. If these packets are not removed from the MAC queue, unnecessary transmission will be repeated in the MAC layer, leading congestion. Incoming packet is dropped if a node has no route to the destination. To solve these problems, the mechanism to follow up detection of link disconnection is needed.

III. BASIC CONCEPT

In this section, we describe the extension of OLSR based on link layer notification. It has two functions, "link buffering" and "packet restoration". We explain these functions below.

A. Link buffering

Two states, route_valid and route_invalid, are defined for existing route in the routing table. Normally, a route entry is in the route_valid state. If a node is informed of link disconnection by link layer notification, it updates the neighbor table and changes all route entries with the disconnected link as the next hop to route_invalid. If the node receives a control packet (Helllo or TC message), updates the routing table and has a route for the destination in the route_invalid state, the state of the route entry transits to route_valid.

When a node receives a data packet, it behaves according to the route entry and its state. If there is no route for the destination, it discards the packet. If the state of the state of the route entry is route_valid, it forwards the packet to the next hop. If the state of the route entry is route_invalid, it saves the packet in the link buffer. Every moment the state transition occurs from route_invalid to route_valid for a route entry, the node forwards all packets destined to the destination in the route buffer to the next hop. If a route for the destination isn't built within BUFFERING_TIME, all packets destined to the destination in the link buffer are deleted.

B. Packet restoration

Packet restoration method has two types, which are termed "simple restoration" method and "full restoration" method. In simple restoration method, when a link disconnection is detected by link layer notification, the packet in the MAC queue, for which transmission failure occurs, is restored as the IP packet in the link buffer. At the same time, all packets with the same next hop in the MAC queue are cleared (packet clearance). Full restoration method is an enhanced method, where all packets with same next hop in MAC queue are restored as corresponding IP packets in the link buffer.

IV. PERFORMANCE EVALUATION

A. Simulation model and assumptions

Several version of enhanced OLSR can be considered and are defined as below.

OLSR-C: OLSR with packet clearance.

OLSR-LB: OLSR with packet clearance and link buffering.

OLSR-SR: OLSR with packet clearance, link buffering and simple packet restoration.

OLSR-FR: OLSR with packet clearance, link buffering and full packet restoration.

Their performances are evaluated by computer simulation. We use the simulation code of OLSR for GloMoSim [3], [4]. Simulation model and parameters used in simulation are listed in Table1. Parameters of OLSR and link buffering are in Table 2.

Table-1 Simulation model and parameters.

Parameter	**Value**
Simulation time	900 [sec]
Terrain range	300 × 1500 [m]
Number nodes	100
Propagation model	Two-ray ground
Power range	100 [m]
Bandwidth	11 Mbps
Mobility model	Random way point, Pause time = 0 [sec]
MAC protocol	IEEE802.11
MAC queue size	50
Traffic type	CBR: 4 packets /sec, 64 [byte]

Table-2 Parameters of OLSR and link buffering method.

Parameter	Value
Hello interval	1 [sec]
TC interval	1 [sec]
Holding time of neighbor information	1 [sec]
Holding time of topology information	3 [sec]
Link buffer size	Unlimited
BUFFERING TIME	3 [sec]

B. Results

In figure 1,2,3 and 4 there is no difference of packet deliver y ratio between OLSR-C and OLSR-LB. Link buffer is used when link is disconnected and no route to desination exists. I n this simulation model, even if a link is disconnected, it is possible that another new route is chosen to be used due to no de's high density. Therefore link buffer is expected to be rarel y used. Even if link buffer is used for storing a data packet, in valid route are apt to be used to retransmit a data packet beca use of high mobility. As a result, it is expected that there is no efficiency of link buffer. However, the efficiency of link buffe ring can be acquired by changing the parameter of node's den sity and the mechanism how to retransmit the packets in link buffer. In OLSR-SR and OLSR-FR, when link is disconnecte d, all packets with the same destination in MAC queue are sto red and retransmited. On the other hand, in OLSR-C and OL SR-SB, all packets with the same destination in MAC queue are deleted. Therefore, in OLSR-SR and OLSR-FR, the pack et's time to be stored in MAC queue and the number of overfl ow increases. It cause lower packet delivery ratio. In OLSR-C and OLSR-LB, on the other hand,there are no overflow of packet in MAC queue. When the number of flow increase, th e detection of link breakage increase. as a result, invalid route are deleted and the stability of routin table increases. And in OLSR-C and OLSR-LB, the packet delivery ration increases while the number of flow increases. In figure 2, the packet de livery delay doesn't fluctuate in OLSR-SR while the packet d elivery delay increases in OLSR-SR. In OLSR-FR, all packet s in MAC queue are stored in link buffer when link are disco nnected. Therefore, OLSR-FR keeps more packets in link buf fer than OLSR-SR and has longer packet delivery delay while the number of flow increase. Figure 3 indicates that the packe t delivery ratio decreases while the mobility gets higher. It is difficult to keep valid route information and the packet delive ry ratio decrease while the node's mobility increases. OLSR-S R, FR has better perfomance that OLSR-C, LB in high mobili ty. And link breakage happens frequently in high mobility. Ac cording to packet restoration, the number of packets retransm itted increases and it results in high packet delivery ratio. The more packets are retransmitted, the more packet delivery dela y in increasing mobility.

V. CONCLUSIONS

In this paper, we proposed “link buffering” and “packet restoration”, which are used with link layer notification to improve the performance of OLSR. We conducted the performance evaluation based on simulation.

Simulation studies indicate, that, for low mobility environments, OLSR with full restoration method has little impact on the packet delivery ratio, whereas, for high mobility environments, the impact is significant. In the future, the performance evaluation of "link buffering" and "packet restoration" is needed for other ad hoc network routing protocols.

REFERENCES

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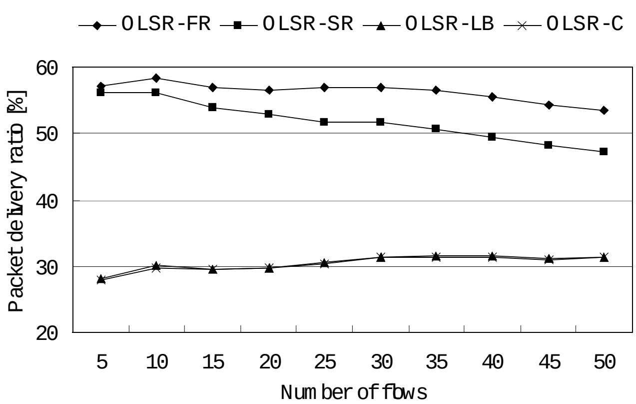

Fig. 1 Packet delivery ratio with 100 nodes and 20-40 m/s.

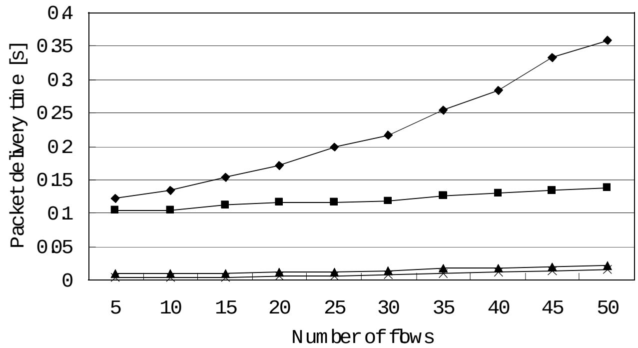

Fig. 2 Packet delivery time with 100 nodes and 20-40 m/s.

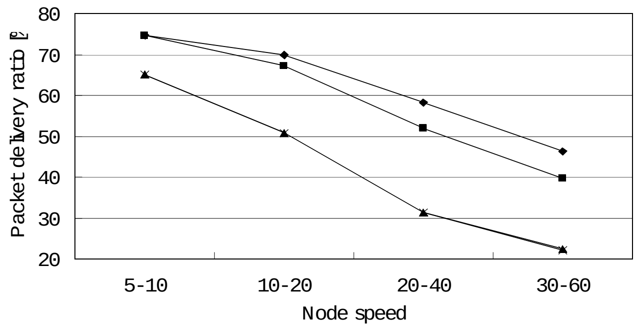

Fig. 3 Packet delivery ratio with 100 nodes and 30 flows.

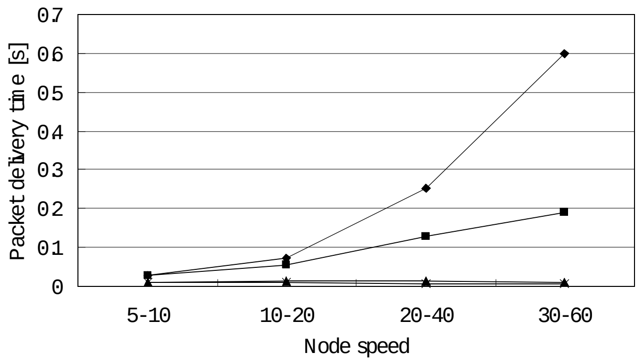

Fig. 4 Packet delivery time with 100 nodes and 30 flows.