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Block-based Transmission with Adaptive Reliability Control for Ad Hoc Networks

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Abstract: In ad hoc networks, each node communicates with other nodes directly or with multi-hop transmission. However, a packet loss rate between a source node and destination node tends to be high due to the mobility of nodes or radio interferences. Owing to this problem, a lot of packets have to be sent between end nodes until the destination node receives the data correctly. Therefore, conventional transport protocols for wired networks cannot perform their potentials in ad hoc network, since they employ an end-to-end acknowledgement for reliable data transmission. Although reliability control mechanisms for ad hoc network are proposed, they are not sufficiently suitable to the environment where the network topology is unstable and broadcast-based transmission are existed. In this paper, an adaptive reliability control mechanism for ad hoc networks is proposed, and the performance is shown by computer simulation.

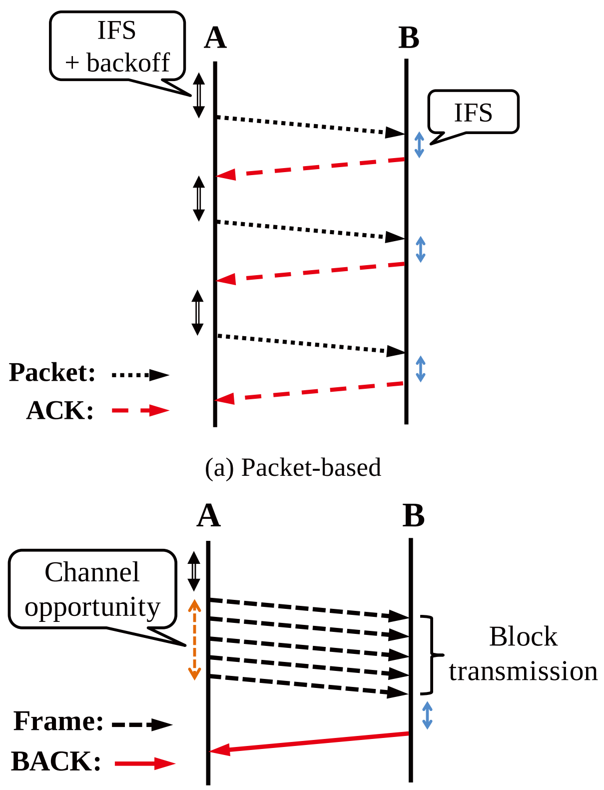
Keywords- **Wireless, Ad hoc network, Transport protocol, Reliability**

1. Introduction

Ad hoc network is composed of only nodes, namely it does not require any network infrastructures such as wireless access points and base stations. A node communicates with other nodes directly or with the help of other nodes' forwarding. However, the network topologies frequently change due to the mobility of nodes and radio interference that often occurs in wireless network. These characteristics make the end-to-end packet loss rate much worse than that of wired networks. Thus, conventional transmission control protocols used in wired network [1] are not applicable because they are assumed to be implemented under stable network environments. Therefore, a transmission control protocol that has another manner to handle packet transmissions under poor communication environments needs to be discussed.

2. Related Work

1-hop reliability control mechanism is proposed for ad hoc networks [2]. The 1-hop reliability control employs block transmission. The block is composed of many frames, and they are transmitted in channel opportunity as many as possible. With the block transmission, the transmission overhead will be reduced because the number of inter frame space (IFS) to obtain channel opportunity will decrease [3]. Figure 1 shows a comparison between a packet-based and block-based transmission. As can be seen in Figure 1(a), a receiver node B responds to a packet from node A with ACK on the packet-based transmission. On the other hand, it responds to a block with BACK (Block ACK) on the block-based transmission as is shown in Figure 1(b). Therefore, the number of frames acknowledged by one control packet will increase, and thus the efficiency of packet transmission is expected to be improved. The 1-hop reliability control utilizes the block transmission for poor channel conditions in ad hoc networks.



(a) Packet-based

(b) Block-based

Figure 1. Comparison between Packet and Block.

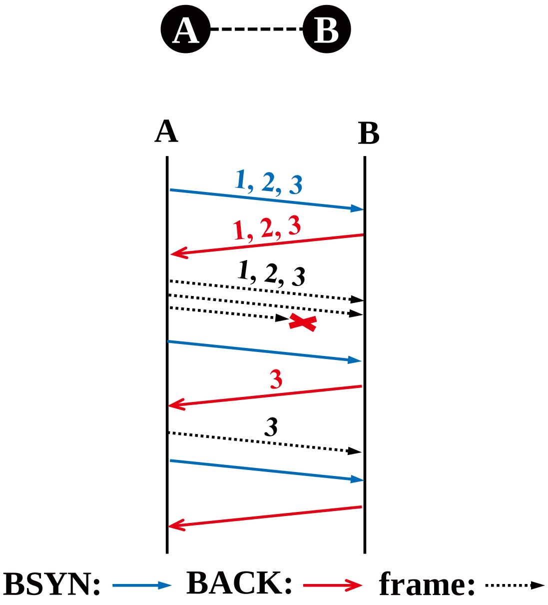


Figure 2. Frame Exchange Sequence of 1-hop Reliability Control.

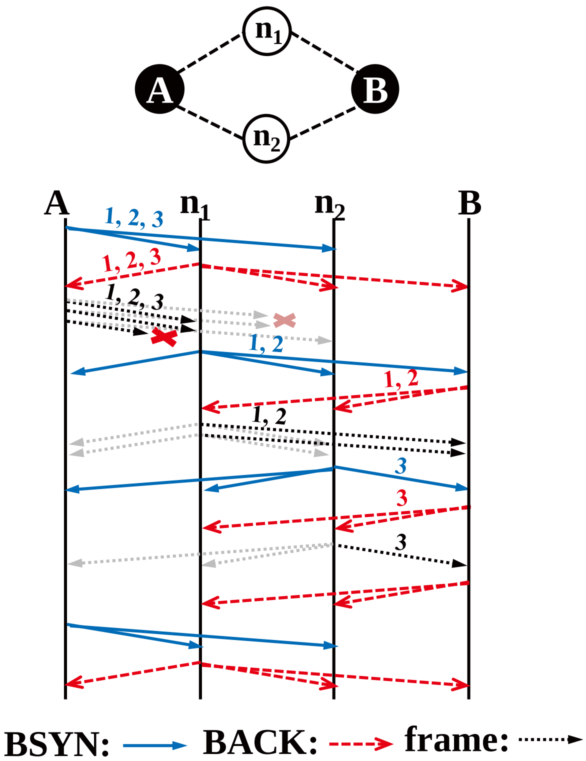


Figure 3. Frame Exchange Sequence of 2-hop Reliability Control.

We describe the procedure with Figure 2. The figure shows that node A sends BSYN (Block SYN) in advance of the block transmission. Then, node A transmits frames until node B, which is 1-hop neighbour of node A, receives all the frames. Node B responds to the burst transmission with BACK, and notifies node A of an incomplete frame. Then node A retransmits the frame and node B receives all the frames. The 1-hop reliability control is suited to unicast routing protocols such as AODV [4] or OLSR [5] since the control is basically implemented between two specific nodes. However, the reliability control is implemented between only two certain nodes, that is, the nodes which overhear some frames are not able to complement the block that the receiver node has.

Another method [6] that utilizes characteristic of wireless communication for more efficient communication is proposed. In a wireless network, all the packets are broadcasted even though a sender sends them with unicast and some neighbouring nodes of the sender can receive or overhear them simultaneously. By applying this characteristic to a routing strategy, an opportunistic routing (OR) that the receivers make a forwarding decision according to some basis opportunistically is proposed [7]. Namely, packets are forwarded through various route using nodes with a potential to deliver the packets to a destination without depending on a certain route in OR. Thus, 2-hop reliability control is compatible with OR as the reliability mechanism allows each frame composing a block to traverse various routes. With this method, a sender conducts reliability control with 2-hop neighbour nodes. Figure 3 describes the procedure of the method. At first, node A transmits frames to relay node n_1 and n_2 and assume that they receive a part of the frames. Then, we assume that node n_1 transmits frame 1 and 2 to node B in this case. After that, node n_2 can complement the block that node B has by transmitting frame 3 to it. Therefore, this method can leverage overhearing nodes for a block complement. However, a sender node can not choose the partner of reliability control from 1-hop or 2-hop neighbour nodes. If there is only one relay node, no other node can complement a block and it just increases the end-to-end hop count. This may cause higher packet loss rate between end nodes and may invoke more packet retransmissions from the original node of the reliability control. Hence, another method that can adaptively change the hop count of the reliability control is required.

3. Proposed System

We propose an adaptive reliability control mechanism with block-based transmission employing a handshake process to cope with the problem mentioned above. In our proposed method, a sender node checks the number of relay nodes preceding the block transmission. After this procedure, it determines a partner for reliability control from 1-hop or 2-hop neighbour nodes according to the above condition. We define this as one unit of reliability control procedure. This procedure is implemented steadily, and continues until a destination node acquires a block completely. We describe the details of the proposed method in the following.

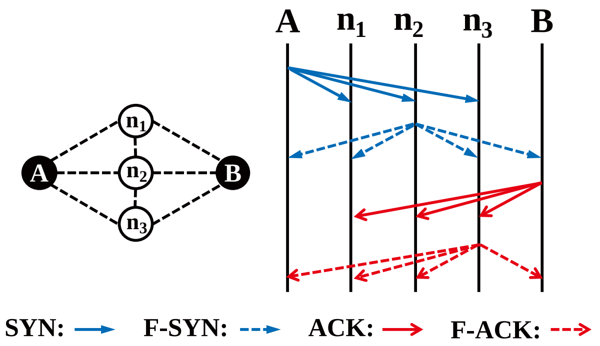


Figure 4. Handshaking to Obtain the First Priority.

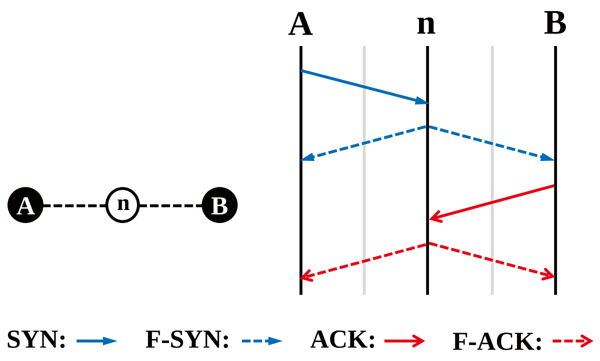


Figure 5. Handshaking to Obtain the Second Priority.

First, a sender node broadcasts SYN, and one of the receiver nodes forwards it to a destination node. And then, the receiver node broadcasts ACK and one of the receiver nodes forwards it according to the following principles.

(1) The relay nodes that heard both SYN and forwarded SYN (F-SYN) obtains the first priority to transmit the forwarded ACK (F-ACK). Figure 4 shows an example of obtaining the first priority. Node n_1 and n_3 heard both SYN and F-SYN, and they obtain the first priority. In this situation, n_3 broadcasts F-ACK to the neighbours by chance. Actually, we have not arranged how to give preference of forwarding F-ACK to the nodes in the same priority so far. Consequently, F-SYN and F-ACK are transmitted by n_2 and n_3 respectively. Thus, node S can know there are more than two relay nodes with a capability of complementing frames that node D will have. Then, the reliability control is implemented between 2-hop neighbour nodes.

(2) The node that transmitted F-SYN obtains the second priority. Figure 5 shows an example of the procedure. Assume that there is no node that would get the first priority, then node n acquires the second priority and it is to transmit both F-SYN and F-ACK. Thus, node S can know there is only one relay node. In this case, the reliability control is implemented between 1-hop neighbour nodes since choosing 2-hop neighbour node in this situation may increase retransmission of frames.

4. Performance Evaluation

We evaluate the proposed method by a computer simulation. In the simulation, we choose 2-hop reliability control [6] as a conventional method to compare with. The simulation environment and parameters are given as follows: There are 6 nodes on the topology shown in Figure 6. In the simulation, the source node S transmits 1,500 frames with the size of 1,000 Byte as a block to the destination node D through relay nodes. 10 frames are transmitted in a transmission opportunity (TXOP). The size of a control packet including SYN, F-SYN, ACK and F-ACK is set to 100 Byte. We evaluated the methods with the following viewpoints varying the packet loss rate of each link from 0.1 to 0.4: transmitted control packet size, transmitted data packet size, and total transmitted packets size.

As can be seen in Figure 7, the proposed method requires more control packets than the conventional method with the range of 0.1-0.3 packet loss rate. This is inevitable for the proposed method due to the handshaking necessary for the reliability control. However, the margin is small when the packet loss rate is more than 0.3. Under the high packet loss rate, packet retransmission frequently occurs and many control packets will happen to be flooded. In such a situation, the proposed method seems to enable relay nodes to cooperatively complement a block that node D has as suppressing retransmissions from an original node of each reliability control process. Meanwhile, the conventional method requires more retransmission from node S than the proposed method. Thus, the higher packet loss rate is, the narrower the margin becomes despite the handshake overhead is inevitable in the proposed method.

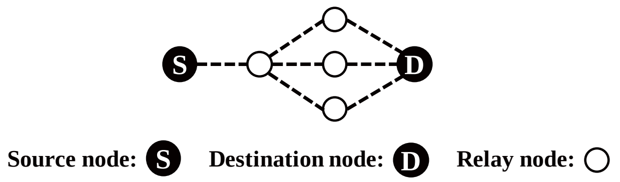


Figure 6. Network Topology for Simulation.

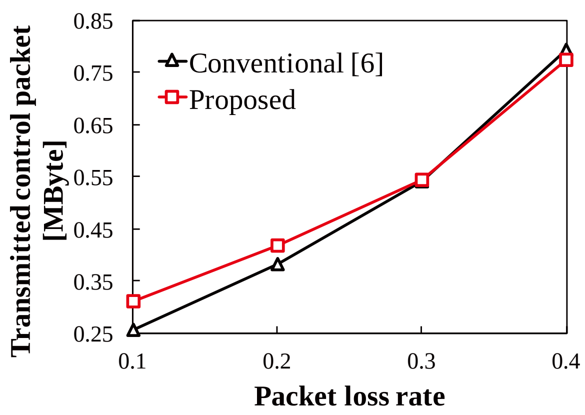


Figure 7. Transmitted Control Packet Result.

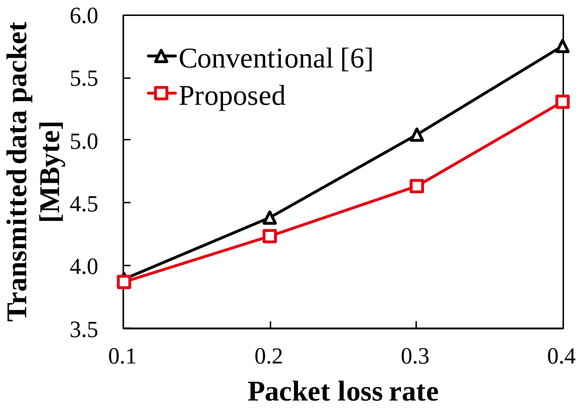


Figure 8. Transmitted Data Packet Result.

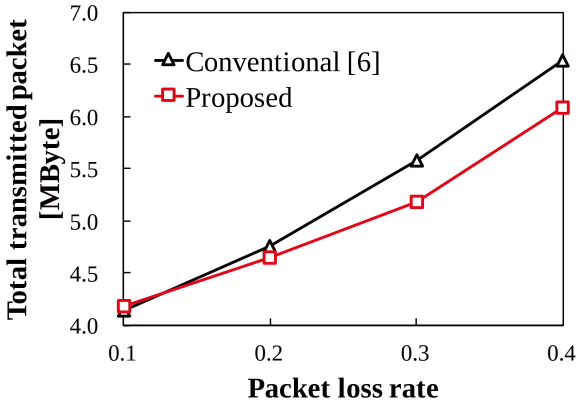


Figure 9. Total Transmitted Packet Result.

On the other hand, as shown in Figure 8, the transmitted data packet size of the proposed method is smaller than the conventional method. This result indicates that the proposed method leverages overhearing nodes more efficiently than the conventional method and suppresses retransmissions from an original node of each reliability control process. By comparing the total number of transmitted packet, the proposed method requires less packet transmissions than the conventional method especially with the higher packet loss rate as can be seen in Figure 9.

5. Conclusion

In this paper, we proposed an adaptive reliability control mechanism for ad hoc networks. The proposed method adopts handshake procedure preceding a block transmission and enables flexible selection of communication partner for a reliability control. As a result of simulation, we show that the proposed method achieved a reduction of the total number of transmitted packets comparing to the conventional method.

As our future works, we have to focus on the following issues: First, we have not designed how to give a preference of transmitting F-SYN or F-ACK to nodes of the first priority. In this process, the nodes wait a random back-off time and obtain an opportunity to forward them. However, we have not found which node should wait less time and which node should do much. We anticipate that the order of precedence affects the spatial pipelining of wireless communication. Therefore, we have to design the best order considering existence of some data flows. Second, we did not consider a specific routing procedure in the simulation. Cooperating with routing protocol, the proposed method will be able to omit the handshake procedure in some cases. Thus, we will design suitable routing protocol for the proposed method. Furthermore, we consider to leverage an additional control packet of the handshake for a media access control. They are broadcasted to neighbouring nodes, so a sender node can apply network allocation vector (NAV) to its neighbours or it can manage a schedule for TDMA. Managing media access control, we assume that packet collisions will be suppressed and the reliability of transmission will be improved.

Acknowledgement

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