Centralized Retransmission Management with SDN in Multihop Wireless Access Network

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***Abstract*—In this paper, a centralized retransmission management with Software Defined Network (SDN) is proposed in order to handle packet loss in multi-hop wireless access networks. The proposed scheme manages retransmission persistence for Automatic Repeat Request (ARQ) in all wireless links, which satisfies a delay constraint and maintains end-to-end throughput. Simulation results show that the proposed scheme allows both throughput improvement and less average delay than a delay constraint by adjusting the trade-off between throughput and wireless delay.**

Keywords – SDN; retransmission; management

I. INTRODUCTION

Quality of Service (QoS) in wireless networks is an important issue because of the increase in the number of applications for delay sensitive services. Because a high wireless error and variable delay can occur in wireless links, a reliable data transmission and satisfying end-to-end delay constraint should be considered in order to support QoS in wireless networks.

Automatic repeat request (ARQ) is one of the general transport protocols in wireless networks and ARQ-based error control is an efficient methodology because ARQ can optimize packet loss recovery for a specific wireless link and can prevent a reduction of congestion window of higher layer by shielding the wireless error. However, one of the weak points of ARQ is an additional delay caused by ARQ, which can cause a degradation of high layer performance due to an inaccurate Round Trip Time (RTT) estimation. The main factor for this phenomenon is a retransmission persistence of ARQ which refers to a degree that an ARQ tries the retransmission.

There are several works attempting to improve end-to-end performance by managing the retransmission persistence for ARQ [1]-[4]. Retransmission persistence is defined as the maximum retransmission number in data link layer. In the previous works, the fundamental assumption in order to improve end-to-end performance is that wireless access networks should be single-hop wireless networks. If the network environment expands to multi-hop wireless network, the previous methods are insufficient to ensure end-to-end performance. Thus, multiple ARQs are mutually operated in order to support end-to-end performance in multi-hop wireless network.

In order to consider end-to-end performance in multi-hop wireless network, all wireless links should be estimated and handled. One solution is to apply a centralized method such as Software Defined network (SDN) [5] in order to handle all wireless links.

In this paper, we focus on an SDN-based solution for a retransmission management in multi-hop wireless network. In the proposed scheme, a SDN controller monitors all wireless links and determines the retransmission persistence of ARQ in each wireless links, which handles not only wireless delay but also end-to-end throughput.

II. CENTRALIZED RETRANSMISSION MANAGEMENT WITH SDN

The main feature of the proposed scheme is to manage the retransmission persistence for ARQ according to end-to-end throughput and wireless delay in a multi-hop wireless network. The proposed scheme is composed of two stages. In the first stage, an SDN controller monitors the state of all wireless links and compares the link state between wireless links. Then, in the second stage, centralized retransmission management is performed not only for satisfying a delay constraint, but also for improving wireless throughput depending on the state of all wireless links.

A. Monitoring status of wireless links

The main objective of the monitoring method is to discover a bottleneck link or a good link for satisfying end-to-end performance. The SDN controller monitors a link delay (D_l), a link delay variance and the retransmission persistence (RP) of ARQ in each wireless links. This link information is written in each wireless access points and the SDN controller gathers the information in all wireless access points. In the monitoring method, queuing delay is only considered in order to calculate the link delay because the link delay is mainly determined by queuing delay and other factors such as link propagation and processing delay are negligible and uncontrollable.

B. Centralized retransmission persisence management

The main object of this management is to satisfy a delay constraint as well as to maximally maintain end-to-end throughput using the retransmission persistence management. In order to perform the above operation, SDN controller should maximally increase RP in all wireless links without a delay constraint violation. It is because the increasing RP can

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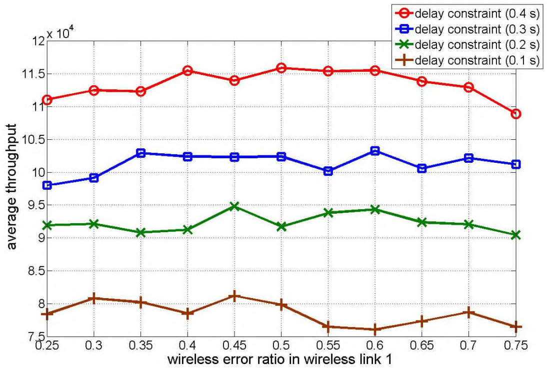

Figure 2. Throughput versus wireless link error in link 1.

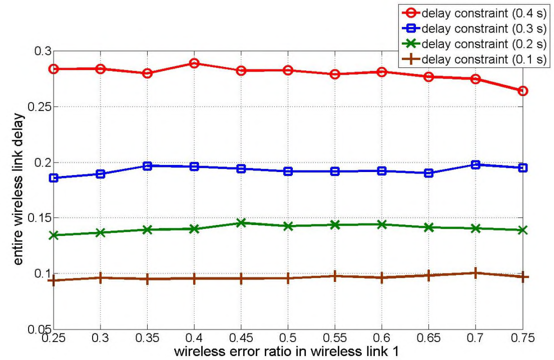

Figure 1. Entire wireless link delay versus wireless link error in link 1.

shield wireless error, which improves end-to-end throughput. Thus, the proposed management reduces or increases RP only when a cumulative delay in all wireless links exceeds a delay constraint or the cumulative delay is sufficiently small, respectively. By using the monitoring information in all wireless links, the SDN controller estimates a cumulative delay of all wireless links and discovers a bottleneck link among all wireless links. If the cumulative delay exceeds the delay constraint, SDN reduces RP in the bottleneck link. Conversely, the SDN controller increases RP in the bottleneck link when the cumulative delay is sufficiently less than the delay constraint. The delay threshold for increasing RP can be set according to the management policy.

III. Simulation Results

A simulation is conducted in order to evaluate the performance of the proposed scheme. The client and the server are connected by two serial wireless links (wireless link1 and wireless link 2) and the wireless links are connected with the SDN controller. As a transport protocol, Transmission Control Protocol (TCP) is applied. We operate the simulation by changing the wireless link error rate. Each wireless link error rate is variable but the cumulative wireless error rate is fixed (0.2). In this simulation, the delay threshold for increasing RP is a half of a delay constraint.

Figure 1 shows the average end-to-end throughput versus error rate in wireless link 1. The x-axis indicates the error ratio of wireless link 1 to the cumulative error rate. The results show that average throughput performance tends to decrease with the decrease in the delay constraint. It is because the wireless error is less recovered in order to satisfy the delay performance. In other words, the proposed management can improve the average throughput as the delay constraint increases. It means that the proposed management can adjust the throughput performance according to the delay constraint.

Figure 2 shows the total average delay in wireless links versus the error rate in wireless link 1. The results show that the proposed management can achieve lower average delay than the delay constraint. It is because, when the delay over wireless links exceeds the delay constraint, the proposed method reduces RP in the bottleneck link, which can improve the delay performance by reducing the recovery time of ARQ due to wireless error.

IV. Conclusion

In this paper, a centralized retransmission management with SDN is proposed to handle wireless error in a multi-hop wireless access network. The proposed scheme monitors and handles all wireless links for satisfying end-to-end delay requirements and improving end-to-end throughput. The simulation results show that the proposed scheme can manage the trade-off between throughput and delay, which can improve end-to-end throughput without a delay constraint violation. In the future, we plan to consider general scenarios and other factors in wireless networks.

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