QoS Evaluation of MPTCP over a Multi-Hop Wireless Network for IoT Devices

Koki Izumi, Yoshihiro Ito and Kensuke Noda
Department of Computer Science
Nagoya Institute of Technology
Nagoya, 466-8555
Japan
Email: {izumi@en, yoshi@, noda@en}.nitech.ac.jp

***Abstract*—This paper evaluates Quality of Service(QoS) of MPTCP over multi–hop wireless networks for IoT devices by experiment. The experiment utilizes two multi–hop wireless experimental networks. Under one network, the signal strength of radio wave varies. On the other hand, the authors change both of the signal strength and the number of routers under the other network. The experimental result shows the followings. The degradation of the signal strength decreases the throughput. However, even if a router is inserted between routers to strengthen the intensity, the throughput of MPTCP cannot be improved. This reason is that the insert of another router causes the increase of the delay and the scheduler of a MPTCP module never select the strengthened path. Thus the authors proposes a new method to increase the throughput over multi–hop wireless networks.**

I. Introduction

Nowadays owing to both of the spread of mobile terminals and the improvement of access networks, a wireless LAN is widely utilized. As a result, many devices, such as home electrical appliances and stationary, that is IoT(Internet of Things) devices, can also connected to the Internet over a wireless LAN. However due to the physical characteristics of the electromagnetic wave, which is the transmission medium of wireless LANs, many problems can occur. For example, the coverage of the wireless LAN may be restricted, or the wireless communication can become unstable according to the environment.

In order to solve the above–mentioned problems over a wireless LAN, we can use a wireless multi-hop communication. In wireless multi-hop communications, each wireless devices relays data between neighbor devices. By using the wireless multi-hop communication, we can extend the coverage of a wireless LAN and consider plural routes between end-to-end devices. The plural routes can make the quality of service (QoS) high over a wireless LAN. Therefore, the multi–hop communication is very suitable for the devices such as home appliances.

On the other hand, we expect the wireless multi-hop communication to utilize TCP/IP protocol suits since it has become very popular and can be used at a low cost. However TCP[1], which is the connection-oriented transport layer protocol of TCP/IP protocol suits, cannot handle plural routes simultaneously. Therefore instead of TCP, we should adopt another transport layer protocol which can treat plural routes. This paper uses MPTCP (MultiPath TCP) [2] as a transport layer protocol among next–generation protocols for the following reasons. First, MPTCP can handle plural routes (paths) simultaneously. Second, MPTCP is compatible with legacy TCP.

In applying MPTCP to wireless multi-hop communication, we discuss the following issue. Since MPTCP is one of the transport layer protocols, MPTCP is not responsible IP routing and it only select existing routes. Therefore the paths selected by MPTCP are not always appropriate to MPTCP Expecially [3] shows that heterogeneous paths decreases QoS of MPTCP.

This paper evaluates QoS of MPTCP communications over multi–hop wireless networks for IoT devices by experiment. Moreover, based on the experimental results, we propose a new method to improve QoS over multi–hop wireless networks.

The paper is organized as follows. Section II and III show our experiments and their results. In Sect. IV, we propose a method of improving QoS over multi–hop wireless networks. Finally we conclude our research in Sect. V.

II. Experiments

In this experiment, we consider two kinds of experimental environments. One is an environment where the radio wave intensity between devices varies. The other is one under which both of the number of devices and the radio wave intensity change. We show an experimental network of the former and that of the latter in Fig. 1 and Fig. 2, respectively. Both of the experimental networks consist o three types of devices: a sender, a receiver, and routers. Every device has two wireless network interfaces. The routers forward packets between the sender and the receiver. Since we suppose that devices are home appliances, IoT devices and so on, we use Raspberry Pi 3[4] as the routers. The sender and the receiver communicate to each other over two independent paths with MPTCP. In order to clarify the effect of the radio wave intensity and that of the number of devices, we fix the two paths shown in Fig. 1 and Fig. 1. We refer to the paths as Path–1 and Path–2. In this experiment, we use TCP throughput as a QoS parameter and we measure it by using iPerf[5].

III. Results

Figure 3 and Fig. 4 display the throughput vs. the signal strength. We also plot the throughput of each path. From Fig. 3, we see that the throughput decreases as the signal strength

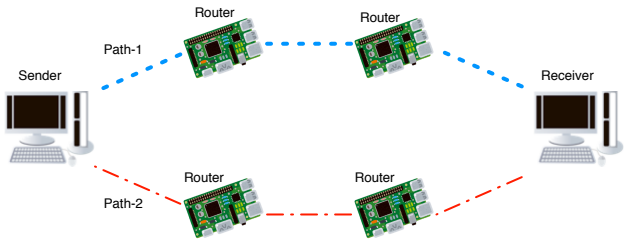

Fig. 1. Experimental environment (2 hops).

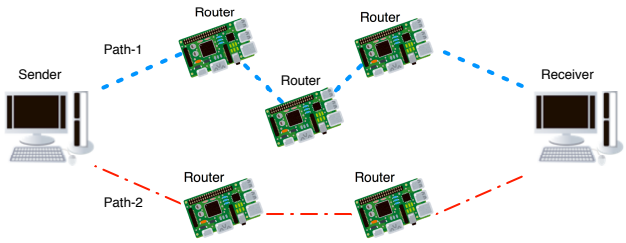

Fig. 2. Experimental environment (3 hops).

becomes lower. On the other hand, Fig. 4 indicates that the throughput is not always high when the signal strength is high. From Fig. 4, we also find that the throughput of Path–1 is very low. Thus when we analyzed the recored traffic over Path–1, we found that Path–1 was utilized little by the sender. The reason why the scheduler of MPTCP did not select Path–1 although Path–1 had been available is that the delay over Path–1 increased by the increment of the number of hops. Based on the above–mentioned issues, we can see that we cannot increase the throughput of a multi–hop wireless network even if we reinforce the signal strength by adding a router on the way.

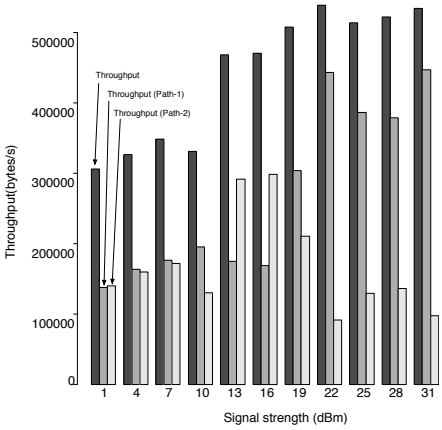

Fig. 3. Throughput vs. signal strength over network in Fig. 1.

IV. Proposal

From the results of the previous section, we would like to propose a new method of increasing the throughput of MPTCP over a multi–hop wireless network. In the method, a router adds delay according to the received signal strength to reduce the difference of the delay between paths. When we applied our method to the network of the previous section, we confirmed

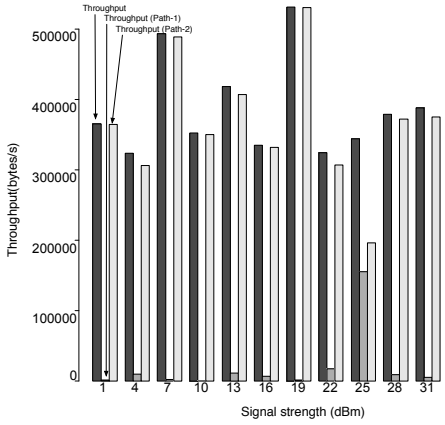

Fig. 4. Throughput vs. signal strength over network in Fig. 2.

that our method could able to increase the throughput between the sender and the receiver.

V. Conclusions

This paper studied QoS of MPTCP over multi–hop wireless networks for IoT devices by experiment. The experimental results show the following issues. First, the degradation of the signal strength decreases the throughput. Second, even if a router is inserted between routers to strengthen the intensity, the throughput of MPTCP cannot be improved. Based on the analysis of the results, we propose a new method of improving the throughput over multi–hop wireless networks.

We would like to show some issues as our future work. First, we will evaluate our proposed method in detail. Second, it is necessary to use the other QoS parameters for evaluation.

Acknowledgment

This work was supported by MEXT KAKENHI Grant Number JP 16K00122.

The authors thank Mr. Kento Hagiwara for his assistance in our research.

References

[1] K. R. Stevens and W. R. Fall,“TCP/IP Illustrated, Volume 1: The Protocols ,” Addison-Wesley Professional, Nov. 2011.

[2] A. Ford, C. Raiciu, M. Handley and O. Bonaventure,“TCP Extensions for Multipath Operation with Multiple Addresses ,” IETF RFC 6824, Jan. 2013.

[3] Y. Muraki and Y. Ito, “Study on Effect of Congestion Control of Multipath TCP on Web-QoE,” Proc. GCCE 2015 (Outstanding Paper Award), pp.3–4, Oct. 2015.

[4] “Raspberry Pi - Teach, Learn, and Make with Raspberry Pi,” https://www.raspberrypi.org/.

[5] “iPerf - The TCP, UDP and SCTP network bandwidth measurement tool,” https://iperf.fr/.