Audiovisual and Haptic Interactive IP Communications over Wireless LANs and their QoE

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***Abstract*—This paper assesses QoE of audiovisual and haptic interactive communications over wireless LANs. We evaluate the effect of two intra-stream synchronization control methods: the media adaptive buffering that sets appropriate playout buffering time for each media and the conventional buffering that sets the same playout buffering time for all the three media. We deal with three network configurations that differ access lines to our campus network; the configurations include wireless LAN access. Then, we assess QoE of the intra-stream synchronization control methods. As a result, even in the case of wireless LAN access, we find that the media adaptive buffering achieves higher QoE than the conventional buffering.**

I. Introduction

As a population of the Internet users has been increasing, the users have been expecting interactive communication services for their good life. On the other hand, research on haptic communications has been performed actively. The haptic media can represent the weight of things and the sense of touching things through a haptic interface device. We can experience haptic information of a remote place through the haptic interface device by communicating the information [1],[2],[3].

There are several studies on multimedia communications over IP networks in actual use. Reference [1] performs audiovisual and haptic communications over the Internet between Japan and Thailand. The paper employs a coding method which realizes high-speed image compression and then achieves reduction of transfer delay of the media streams; however, it does not assess QoE (Quality of Experience) [4]. Reference [5] evaluates QoE of several VoIP applications through a campus wireless LAN; the paper does not employ video and haptic media.

Isomura et al. have proposed a media adaptive intra-stream synchronization control for audiovisual and haptic IP communications [6]. The control performs intra-stream synchronization by considering the characteristic of each media; it sets the playout buffering time for each media separately. Audio, video and haptic media have different transfer rate, output interval, maximum allowable delay, and so on. As a result, the media adaptive intra-stream synchronization control can enhance QoE. However, Reference [6] employs a closed network for the experiment. In-service real networks are more diverse. Thus, we need QoE assessment in real network situations.

In this paper, as a first step of a study under real network environments, we evaluate QoE of the audiovisual and haptic interactive communications over the campus network in Nagoya Institute of Technology with wireless LAN access. From the result, we consider the effect of the intra-stream synchronization control on the wireless LAN environment in actual use.

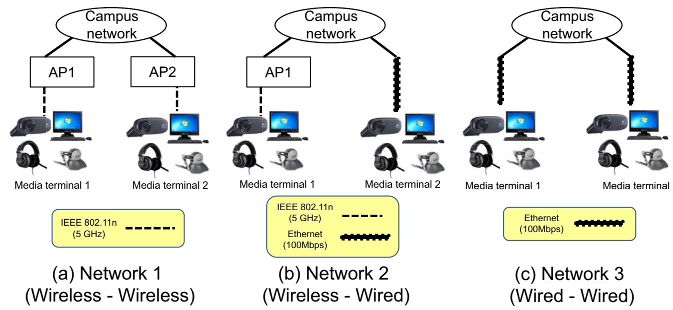

Fig. 1. Experimental systems

II. Experimental method

A. Experimental system

Figure 1 shows the experimental systems. These systems consist of two media terminals. We place the terminals in distinct rooms. We employ the wireless LAN system on the campus network. The system employs IEEE 802.11n operated with 5 GHz band; the maximum transmission speed is 300 Mbps. We compare three situations: (a) both terminals connect to the wireless LAN through distinct access points (it is called as Network 1, wireless – wireless), (b) one of the two terminals connects through the wireless LAN, and the other accesses through the Ethernet link (Network 2, wireless – wired), and (c) both terminals connect to the campus network with the Ethernet links (Network 3, wired – wired). As the wireless device of each media terminal, we employ NEC's AtermWL300NU-AG, which is a USB wireless device for IEEE 802.11n. We measured the radio signal strength transmitted by the access point; the average signal strength from AP1 at media terminal 1 is -43 dBm, that from AP2 at media terminal 2 is -72dBm.

Each media terminal is equipped with a Web camera, a headset, and SensAble Technologies' PHANToM Omni (the current product name is Geomagic Touch) as a haptic interface device. The two terminals transmit the audiovisual and haptic media each other. PHANToM Omni is a pen-type haptic interface device; it can input and output the force on the stylus (i.e., the pen) with 1 kHz sampling. The Web camera obtains the video. The encoding method is H.264/AVC (GOP IPPPP, 800×600 pixels, 15 slices/frame, 25 frames/second, 2 Mbps). A microphone of the headset captures the audio. The codec is Linear PCM (16 kHz, 8 bit, 1 ch, 128 kbps). The video is output by a monitor display, and the audio is output by a headphone of the headset.

An MU (Media Unit) is a unit for media synchronization control. In this paper, we assume a video frame as a video MU, a constant number of audio samples as an audio MU, and location information of the stylus as a haptic MU. When a video slice drops, the receiver performs error concealment and output the MU consisted from the slice. The bitrate of haptic media is 320 kbps, and the MU rate is 1000 MU/s.

Each media is transmitted as a separate UDP/IP stream. We experimented 13:00 to 17:00 on a weekday.

B. Playout buffering control

In this paper, we employ two media synchronization control methods: the conventional buffering and the media adaptive buffering. We employ the minimum buffering time (20 ms) and the maximum buffering time (150 ms) in [6] as the buffering time in this paper. We set the buffering time as the following way.

- Conventional buffering
  All the three media: 20 ms or 150 ms
- Media adaptive buffering
  Video and audio: 20 ms or 150 ms, Haptic: 10 ms

C. Task

This paper employs the same task as in [6]. A user (manipulator) moves an object at the other user's (indicator's) side using the PHANToM stylus. This task imposes time and burden on the assessors for moving the object. The manipulator needs to check the indicator's side with video and control the position of the stylus accurately. Thus, in the task, the assessors regard the output quality of media as important rather than the response. The duration of a task is 30 seconds.

D. QoE assessment method

We perform multidimensional QoE assessment with 11 adjective pairs. The assessor evaluates each adjective pair to be one of five grades. The best grade (score 5) represents the positive adjective, while the worst grade (score 1) means the negative adjective. The middle grade (score 3) is neutral. We then obtain MOS (Mean Opinion Score) by averaging the scores for each adjective pair. Because of space limitations, we deal with the adjective pair for overall satisfaction "Excellent – Bad" only in this paper.

In the experiment, we utilize the two media synchronization methods, the two values of the playout buffering time, and the three network types. For each networks type, four stimuli are presented randomly to each pair of assessors. The number of total stimuli is twelve. The total assessment time for each pair of assessors is about 40 minutes. The number of assessors is 16. They are students in our university.

III. Experimental results

Figure 2 shows the MOS for overall satisfaction. The values are the average scores of 16 assessors. We also show 95 % confidence intervals in the figure.

We notice in the figure that the MOS for the media adaptive buffering with the buffering time 150 ms (i.e., the buffering time for audio and video is 150 ms and the buffering time for haptic media is 10 ms) is the highest. This is because the method can absorb delay jitter for audio and video and can keep the response of haptic media. It brings high satisfaction to the users.

The output delay in haptic media can be noticed easily by inappropriate force feedback due to mismatch of stylus positions. On the other hand, too short buffering time decreases output MUs and then degrades output quality. The result is consistent with that on the closed network condition in [6].

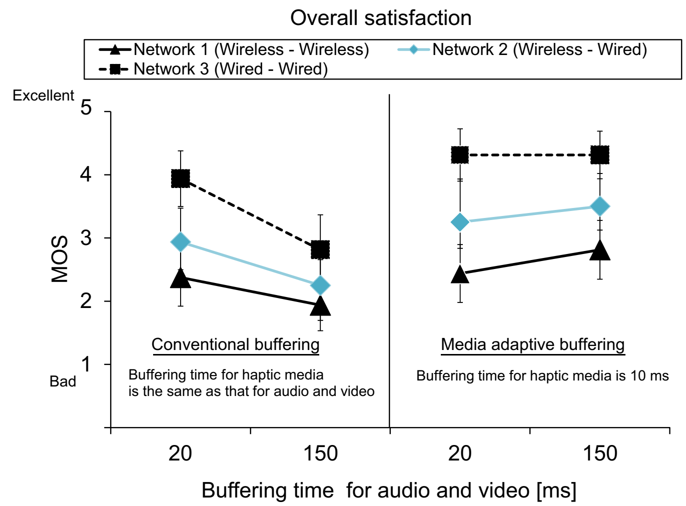

Fig. 2. Overall satisfaction

As for the difference of the network situations, the MOS in Network 1 is the lowest among the three situations. This is because Network 1 includes two wireless sections, and then more slices and MUs drop in Network 1 than in Networks 2 and 3.

IV. Conclusions

In this paper, we investigated the effect of two intra-stream synchronization control methods on QoE of audiovisual and haptic interactive communications over the campus network including wireless LAN connections. We then found that the media adaptive buffering is effective for QoE enhancement on the networks. In addition, the wireless LAN connections can cause QoE degradation.

In our future work, we need to perform experiments under various networks, various situations, and various types of tasks. Also, we will devise a method for mitigating QoE degradation on wireless LAN connections.

References

[1] J. Arata, H. Takahashi, P. Pitakwatchara, S. Warisawa, K. Tanoue, K. Konishi, S. Ieiri, S. Shimizu, N. Nakashima, K. Okamura, Y. Fujino, Y. Ueda, P. Chotiwan, M. Mitsuishi, and M. Hashizume, "A remote surgery experiment between Japan and Thailand over Internet using a low latency CODEC system", Proc. IEEE ICRA2007, pp. 953-959, Apr. 2007.

[2] J. Marsh, M. Glencross, S. Pettifer, and R. Hubbold, "A network architecture supporting consistent rich behavior in collaborative interactive applications", IEEE Trans. Visualization and Computer Graphics, vol. 12, no. 3, pp. 405-416, May/June 2006.

[3] M. Eid, J. Cha, and A. El Saddik, "HugMe: a haptic videoconferencing system for interpersonal communication", Proc. IEEE VECIMS2008, pp. 5-9, July 2008.

[4] ITU-T Rec. P. 10/G. 100, Amendment 5, "New definitions for inclusion in Recommendation ITU-T P. 10/G. 100", July 2016.

[5] M. -D. Cano and F. Cerdan, "Subjective QoE analysis of VoIP applications in a wireless campus environment", Telecommunication Syst. (2012) 49, pp. 5-15, 2012.

[6] E. Isomura, S. Tasaka and T. Nunome, "QoE enhancement in audiovisual and haptic interactive IP communications by media adaptive intra-stream synchronization," Proc. IEEE TENCON 2011, pp. 192-196, Nov. 2011.