Experimental Evaluation of Adaptive Bitrate Live Streaming over Information-Centric Networking

Yusaku HAYAMIZU†, **Masaki BANDAI**††, ***Members*, *and* Miki YAMAMOTO**†††, ***Fellow***

1. Introduction

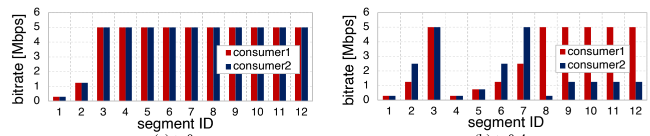
Adaptive Bitrate (ABR) streaming is one of the hopeful technologies for providing better service quality to users under various network conditions of the Internet. The combination of the ABR streaming and Information-Centric Networking (ICN) [1] is a promising solution to reduce traffic amount while keeping high Quality of Experience (QoE) by in-network caching and multicast [2], [3]. Studies on ABR streaming of Video on Demand (VoD) contents have been well-investigated thus far, and their effectiveness has been proven owing to lots of efforts by various ICN research communities. However, an application of ICN to ABR *live* streaming is still an open issue.

One of the important features of live streaming is *synchronization* of streaming users. Timing of the users' content request would highly synchronize, and ICN would be good fit for this situation because ICN natively supports multicast and in-network caching at the network protocol level. However, multiple streaming users geographically located at different locations have *heterogeneous* communication qualities. This might bring some negative influences on transport functions also known as an out-of-synch problem studied in [4]. When a user has better communications quality, she/he can quickly start to fetch the video segment compared to the other users which have poor communications quality.

In this paper, to confirm our assumption, we newly developed a live streaming framework using a real ICN software, Cefore[5] compliant with CCNx1.0 protocol and conducted an experimental evaluation of ABR live streaming over ICN. Experimental results showed that ICN's functions such as multicast and in-network caching positively and negatively affect users' QoE depending on the users' context caused by the communication heterogeneities.

2. Experiment

To investigate basic performance, we conducted an experimental evaluation through our newly-developed ICN-based live streaming framework. For implementing ICN routers, we used Cefore[5], an open-source ICN software platform. We used a simple dumbbell topology in which two consumers download video segments from the one producer through the single bottleneck link with 10 [Mbps] capacity and 120 [ms] RTT. The ABR logic installed in the consumers is a throughput-based rate adaptation logic. For the transport mechanism, both consumers conduct an AIMD-based window control. To simulate the heterogeneities of the consumers, we introduced communications delay as the time lag parameter t to the consumer 2. We evaluated two cases where $t = 0$ and $t = 0.4$ [s]. Although we had investigated several parameters for communications delay, due to the space limitations, we just picked up these two cases.



(a) t=0 (b) t=0.4

Fig. 1 Downloaded bitrate characteritics.

Figure 1 shows throughput characteristics of each consumer. In the completely synchronized scenario, i.e. $t = 0$, ICN multicast works well, and both consumers can successfully retrieve the highest bitrate (5Mbps), owing to its high download throughput performance. When the time lag is 0.4 [s], the late consumer 2 quickly downloads most of segments from in-network cache. This problem is also known as *cache oscillation* [3], and consumer 2's throughput substantially increases. Thus, bitrate selection is significantly separated as shown in the segment #7, due to unexpected throughput fluctuations caused by in-network caches.

3. Conclusion

In this paper, we focused on the applicability of ICN to the ABR live streaming. Experimental results showed that ICN multicast and in-network caching positively and negatively affect users' QoE depending on the users' situations. In future work, we plan to develop more intelligent in-network computing mechanisms for mitigating negative influences caused by users' heterogeneities.

Acknowledgement

This work was partly supported by the JSPS KAKENHI 21H03434.

References

[1] L. Zhang, et al., "Named Data Networking," *ACM SIGCOMM CCR*, vol. 44, no. 3, pp 66–73, July 2014.
[2] S. Lederer, et al., "Adaptive multimedia streaming in information-centric networks," *IEEE Network*, Nov.-Dec. 2014.
[3] Y. Hayamizu, et al., "QoE-Aware Bitrate Selection in Cooperation With In-Network Caching for Information-Centric Networking," *IEEE Access*, 2021.
[4] J. Chen, et al., "SAID: A Control Protocol for Scalable and Adaptive Information Dissemination in ICN," *ACM ICN'16*, 2016.
[5] H. Asaeda, et al., "Cefore: Software Platform Enabling Content-Centric Networking and Beyond," *IEICE Trans. Commun.*, 2019.

†The author is with the National Institute of Information and Communications Technology (NICT), Tokyo, Japan.
††The author is with Sophia University, Tokyo, Japan.
†††The author is with Kansai University, Osaka, Japan.