Performance analysis according to segment length and buffer length in adaptive video streaming

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***Abstract*— In this paper, we review several MPEG-DASH's adaptive streaming algorithms that dynamically change the video bitrate with respect to network and watching environment. Then, the performance of each algorithm according to the video segment length and buffer length was analyzed on the video bitrate, rebuffering time, and viewing quality change rate, and finally compared with the QoE score.**

Keywords—adaptive video streaming, adaptive bitrate, video segment, quality of experience

I. Introduction

Streaming video has been a major part of today's Internet traffic over the past decade, driven by advances in network technology, user devices, and audio and video compression methods. Cisco's annual Visual Networking Index reports that video content accounted for 75% of global internet traffic in 2017 and is expected to reach 82% by 2022. Delivery of video over the internet is referred to as over-the-top (OTT) video streaming because the content or streaming service provider is usually different from the network provider. The emergence of mobile devices with high-performance video processing and rendering capabilities and the development of adaptive streaming technology have been key to the growth of video streaming services. In this paper, we review adaptive video streaming algorithms that have been recently applied to most OTT services, and discuss the quality of experience (QoE) performance for each algorithm according to the length of the video segment, which is the smallest unit of transmission.

II. Adaptive Video Streaming

Adaptive video streaming is a popular approach to delivering video by tailoring the content quality to the user's device and network environment. In this approach, the video content is divided into segments with a duration of a few seconds. Segments at the same playback point are encoded at different bitrates to accommodate a wide variety of devices and network environments. Bitrates range from 4K quality (about 25 Mbps) to SD quality (hundreds of kbps). Segment downloads can change the bitrate of each segment depending on the current network throughput. During video playback, a lower bitrate is downloaded when the network connection condition deteriorates, and a higher bitrate is downloaded when the condition improves [1].

Several adaptive bit-rate (ABR) algorithms are applied to adaptive video streaming. In particular, Moving Picture Experts Group (MPEG) - Dynamic Adaptive Streaming over HTTP (DASH) provides a standardized ABR algorithm as follows [2].

- *Bola*: A method that determines the bitrate of the next segment based on the playback buffer level alone.
- *Throughput*: A method of determining the bitrate of the next segment by estimating network throughput through the download speed of the previous segment.
- *Dynamic*: A method that determines the bitrate of the next segment by dynamically selecting *Bola* and *Throughput* depending on the situation.
- *Bola-E*: A method that compensates for *Bola*'s weakness in that it is difficult to quickly change to high video quality when the buffer level is low, and it cannot respond quickly to rapid network changes.

III. Performance Analysis of ABR Algorithms according to Segment Length

As mentioned above, in adaptive video streaming, video content is transmitted in segments with multiple bitrates and lengths of several seconds. However, no guidelines are given for determining the length of the segment. In this paper, we present the performance of each ABR algorithm according to the length to help when setting the segment length.

Table 1 below is the simulation environment applied for the analysis. Simulation is performed for 6 segment lengths from 1 to 6 seconds, the network applies 4G traffic of FCC and video content has 10 different bitrates (230 ~ 6,000 kbps).

TABLE I. Simulation parameters

Parameters		Values
Target buffer size (sec.)		15, 20
Network trace	Model	FCC 4G traffic
	Bandwidth (Mbps)	2.76 (average)
	Latency (ms)	20
Contents	Segment size (sec.)	1, 2, 3, 4, 5, 6
	Bit-rate (kbps)	230, 331, 477, 688, 991, 1427, 2056, 2962, 5027, 6000
	Playback time (sec.)	200 ~ 1,200

Figure 1 and Figure 2 show the performance of average bitrate for segment length. The higher average bitrate value means that it provides better quality video. We can see that all algorithms provide slightly worse quality (lower bit-rate) as the segment length is longer. *The Bola* shows the best performance while *Throughput* shows the worst performance. And we can see that the shorter buffer length, the worse performance by comparing Figure 1 and Figure 2. That is, the

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longer the buffer length, the better quality video can be provided.

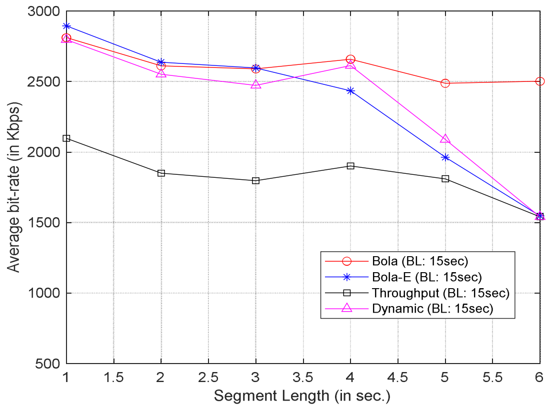

Fig. 1. Bit-rate comparison for segment length@BL: 15sec.

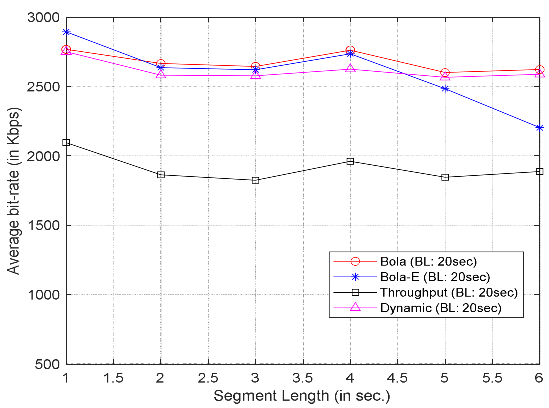

Fig. 2. Bit-rate comparison for segment length@BL: 20sec.

Figure 3 and Figure 4 show the performance of rebuffering time for segment length. Rebuffering means that playback stops for a while, and this occurs when the segment corresponding to the playback time is not downloaded in advance. In these comparisons, it can be seen that most of the algorithms increase the rebuffering time as the segment length is longer. Similar to the results of Figure 1 and Figure 2, shorter segment length provides better performance.

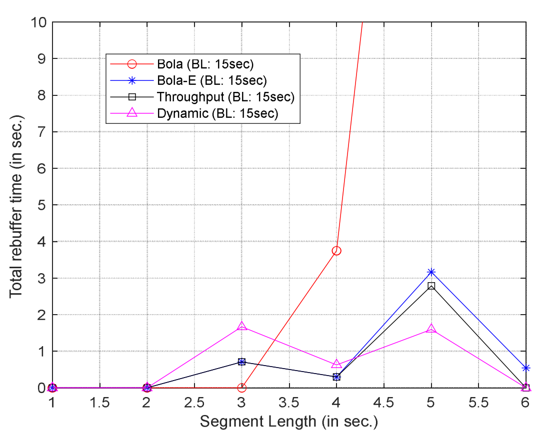

Fig. 3. Rebuffering time comparison for segment length@BL: 15sec.

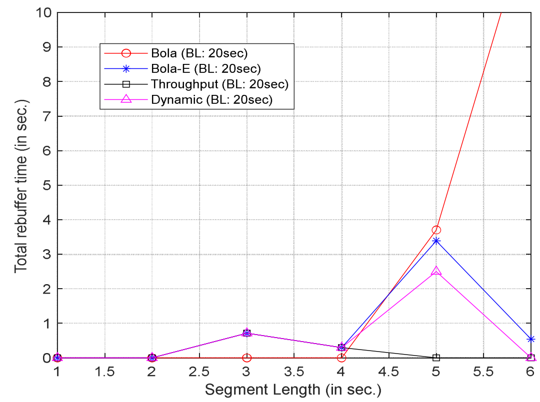

Fig. 4. Rebuffering time comparison for segment length@BL: 20sec.

However, contrary to the bit-rate comparisons of Figure 1 and Figure 2, in the rebuffering time comparison of Figure 3 and Figure 4, *Throughput* shows the most stable performance. This result is due to the reduced download time as the algorithm takes video segments of relatively lower bitrate. Also, we can see that larger buffer length shows better rebuffering time performance from the comparison of Figure 3 and Figure 4.

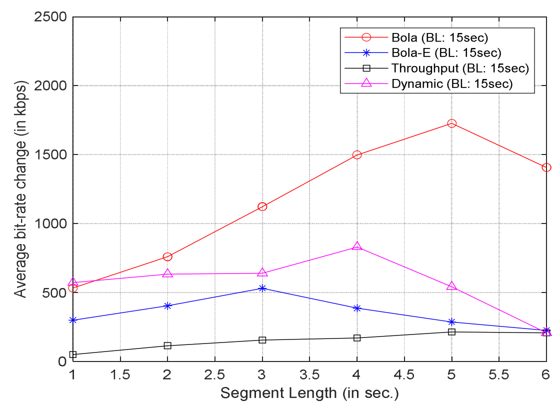

Fig. 5. Rebuffering time comparison for segment length@BL: 15sec.

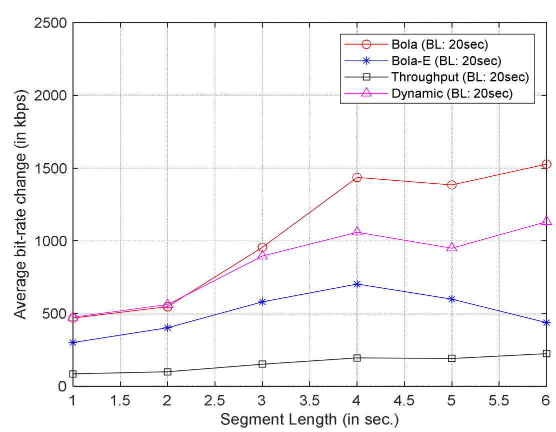

Fig. 6. Rebuffering time comparison for segment length@BL: 20sec.

Figure 5 and 6 shows the performance of average bitrate change for segment length. The amount of change in bit rate means the degree of change in video quality. Frequent changes in video quality cause great inconvenience to viewers. Therefore, a smaller bit rate change provides a better viewing experience. From these comparisons, it can be seen that *Throughput* has the least change (best performance) and *Bola* has the most change (worst performance). However, slightly different from the previous results, the effect of segment length on performance was not clear. Also, in the comparison of the results of Figure 5 and Figure 6, some algorithms show better performance when the buffer length is shorter.

Finally, the QoE metric of (1) is used to evaluate the overall performance of each ABR algorithm,

$$\text{QoE} = \sum_{n=1}^{N} q(R_n) - \mu \sum_{n=1}^{N} T_n - \sum_{n=1}^{N-1} |q(R_{n+1}) - q(R_n)| \quad (1)$$

where, R_n is the bitrate of the n-th downloaded segment, T_n is the rebuffering time generated when the nth segment is downloaded, μ is a weight value and 2.66 is used here, and the equation defined in *Bola* is applied as $q(R_n) = log(R/R_{min})$ [3].

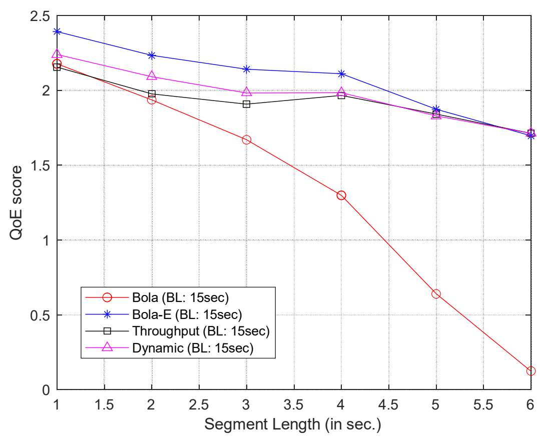

Fig. 7. QoE comparison for segment length@BL: 15sec.

Figure 7 and 8 shows the QoE score obtained through (1) according to the segment length for each ABR algorithm. It can be seen that the QoE performance of the *Bola-E* is the best for all segment lengths. And, It can be seen that shorter segment length leads to higher QoE score. Also, in the comparison of the results of Figure 7 and Figure 8, we can see that shorter segment length provides better QoE performance for each ABR algorithm.

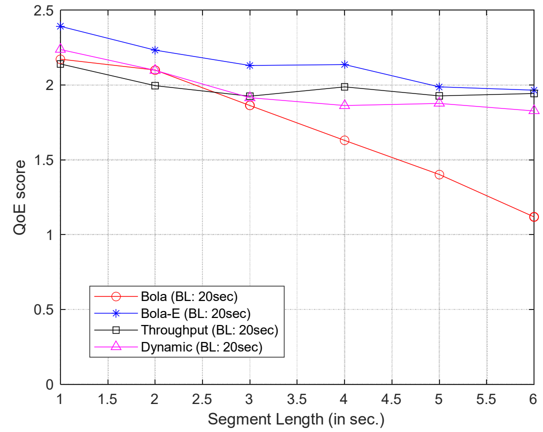

Fig. 8. QoE comparison for segment length@BL: 20sec.

IV. Conclusions

In this paper, the performance of various ABR algorithms according to the video segment length and buffer length was analyzed on the video bitrate, rebuffering time, and viewing quality change rate, and finally compared with the QoE score. From the results of section III, we can see that a short segment can quickly adapt to network changes and a large buffer length provides a more stable viewing environment. However, it is required to select an appropriate segment length because a short length segment may cause a decrease in video compression efficiency and an increase in transmission overhead. In addition, it is good that the buffer length is large, but it is related to the resource of the terminal device, so it is necessary to determine an appropriate length through an experiment.

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