Video Streaming QoS Prediction based on Downlink Control Information of LTE Cell

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***Abstract*—Although 5G networks are becoming more active, there is still a high reliance on LTE networks at least 5G networks are operated in Non-standalone (NSA) mode. Accordingly, it is necessary to continuously monitor and evaluate the quality of service (QoS) of LTE. In general, quality measurement of an LTE network is conducted with a small number of devices during the short time. In this study, to overcome the existing quality measurement limitations, we propose a method of predicting the quality evaluation of video streaming services using downlink control information of targeted LTE base station, enhancing assessment scope and accuracy.**

Keywords—PDCCH, DCI, LTE, QoS, Video Streaming

I. Introduction

With the spread of 5G devices, the number of 5G network users is increasing, and it is expected to surpass LTE users in the next few years. However, in Korea, most 5G networks operate in NSA mode[1], and due to the nature of 5G radio wave, which is vulnerable to radio interference, the share of LTE networks in total traffic is still significant. Therefore, it is necessary to continuously monitor and evaluate the QoS of LTE.

In order to evaluate the QoS of LTE/5G network, it is common to measure temporary downlink or uplink speed in various places using multiple User Equipment (UE). More accurate QoS evaluation can be performed if long term and wide range of measurements are made for all UEs that connected to a specific LTE base station denoted as eNodeB.

In this study, ALTETRI[2] which able to collects all scheduling information of eNodeB is used to collect Downlink Control Information (DCI) data for 9 hours from 9:00 to 18:00 of a eNodeB located in an area with a large floating population in the city. Using the obtained data, a method of predicting the QoS of video streaming sessions of the target eNodeB is proposed.

II. Video Streaming Session Filtering Process

A. Data Gathering and Preprocessing

LTE is provided as a multi-band service, and downlink data can be transmitted simultaneously from multiple bands through Carrier Aggregation (CA) technology. Since ALTETRI can collect DCI data of one band, DCI data for all bands of the eNodeB was collected by operating multiple ALTETRI as many as the number of bands used by the mobile network operator. Clocks of each band are synchronized and DCI information is constructed in units of LTE subframes, that is, units of 1ms.

B. Filter by Session Duration

In LTE, an identifier called C-RNTI (Cell Radio Network Temporary Identifier) is assigned for each UE. The duration of the session can be computed by obtaining the first and last timestamps using the C-RNTI.

Through analyzing the data we collected, most of the sessions belonged to the 10-20 seconds, and there are quite a few sessions of less than 10 seconds. It can be assumed that the case where the session duration time is short is a situation such as handover according to the mobility of UEs. In order to more accurately determine the service quality of eNodeB, in this study, sessions longer than 10 seconds were limited to the analysis target.

C. Filter sessions based on CA Configuration patterns

According to Hahm et al.[1], in the case of video streaming service, 5 multi-band CA is used. Of course, there are cases in which the number of usable bands is limited to four depending on the specification of the UE. Also, there are services that use 5 bands, such as audio streaming and file downloading.

In this study, sessions using 5 CA configuration mode were limited to the analysis target. Fig. 1 shows the traffic record of the session estimated to receive a video streaming. It can be observed that data is transmitted using 5 bands and there is traffic burst.

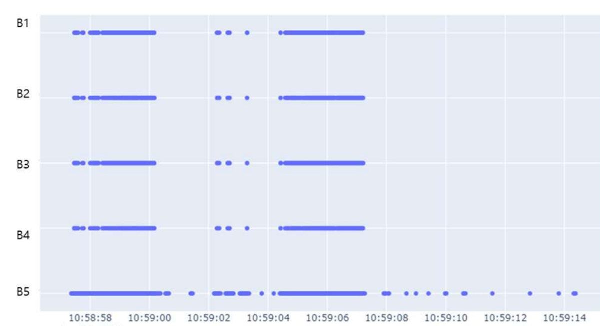

Fig. 1. Traffic record of video streaming session

D. Filter sessions based on bitrates

Through the transmission speed, a video streaming session can be differentiated from all sessions using 5 CA configuration mode. The bitrate criteria can be determined by considering the average bitrate according to the resolution of YouTube [3] and actual measured bitrates of audio streaming, file downloading, and web surfing.

In this study, the analysis target was limited to sessions with an average transmission speed of 1.5 Mbps or higher and 10 Mbps or lower.

E. Filter sessions based on traffic time-interval

Finally, considering that the traffic generation pattern of video streaming is not continuous and intermittent, the average traffic time interval for the filtered sessions so far is calculated. Through this, it is possible to filter out file downloading and web surfing sessions with an average transmission speed between 1.5 Mbps and 10 Mbps.

In this study, sessions with an average traffic time interval of 0.02 seconds or longer were limited to the final analysis target.

III. QoS PREDICTION USING SPECTRAL EFFICIENCY

Spectral efficiency (SE), usually expressed as "bits per second per hertz", is one of the important metrics for evaluating radio network performance [4]. Since the data we collected has Physical Resource Block (PRB) size, Transport Block Size (TBS) and frequency bandwidth fields, we can compute the average SE of each session. Fig. 2 shows the average transmission speed and average SE of the sessions selected through the proposed process. The radio wave environment of the corresponding session can be predicted through the SE.

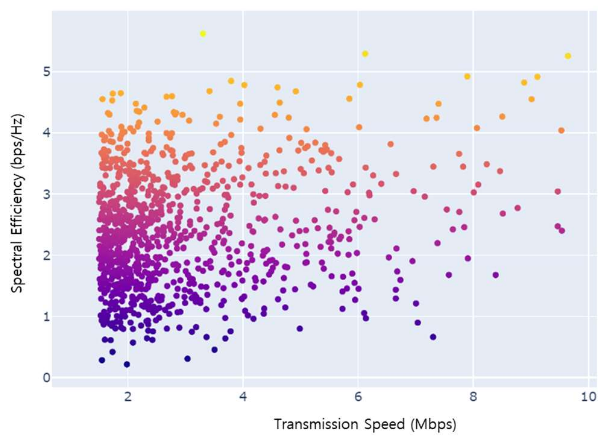

Fig. 2. Distribution of SE and Mbps of the filtered sessions

If a session with a low transmission rate has a low SE value, it is difficult to receive a video streaming service with a desired resolution because radio interference is relatively severe. On the other hand, if a session with a low transmission rate has a high SE value, it can be regarded as using a service with fixed low resolution even though the radio wave environment is capable of receiving high resolution video streaming.

In this study, we check the QoS of whether the target eNodeB can provide stable 1080 resolution streaming service. As in the case mentioned above, even if the radio wave environment is good, there are cases where fixed low-resolution streaming is provided. To handle this issue, in this paper, we compute a maximum possible transfer rate obtained when all idle PRB is allocated for each session. The equation for maximum possible transfer rate is:

$$\text{bps}_{max}(s) = bps_{real}(s) + \frac{PRB_{idle}(s) \times averageSE(s)}{Time(s)} \quad (1)$$

$$PRB_{idle}(s) = \sum\nolimits_{t \in TTI_s} (PRB_{total} - \sum\nolimits_{b_{idx}} PRB_t^{b_{idx}}) \quad (2)$$

$$\text{averageSE}(s) = \sum\nolimits_{t \in TTI_s} \sum\nolimits_{b_{idx}} \frac{TBS(s)_t^{b_{idx}}}{PRB(s)_t^{b_{idx}}} \quad (3)$$

where $bps_{real}(s)$ is actual bitrate of a session, PRB_{total} is a constant which is a summarized PRB size from each band, TTI_s is a set of timestamps that the corresponding session is serviced, $PRB_t^{b_{idx}}$ is total occupied PRB size at timestamp t in the band *idx*, and $TBS(s)_t^{b_{idx}}$ and $PRB(s)_t^{b_{idx}}$ is TBS and PRB value of a session at timestamp t in the band *idx*. It is assumed that all idle PRBs on the serviced 1ms timestamp of one session are allocated to the corresponding session, and the maximum bps can be calculated by estimating the TBS value using the average SE of the corresponding session.

Through our proposed approach, it is possible to identify a session in which 1080 resolution service is practically difficult for streaming. Fig. 3 shows the actual Mbps of each session and the maximum possible Mbps calculated by the method proposed in this study. Some sessions have a large difference from the actual Mbps value, while others do not. Based on the maximum Mbps value, sessions that do not exceed 5 Mbps, which is the bandwidth required for 1080 resolution video streaming, can be identified, so it is possible to measure a wide range of video streaming QoS of a specific eNodeB.

Fig. 4 is a histogram according to the appearance time of sessions with a maximum Mbps value of 5 Mbps or less. It can be observed that the occurrence frequency is high during rush hour and lunch hour.

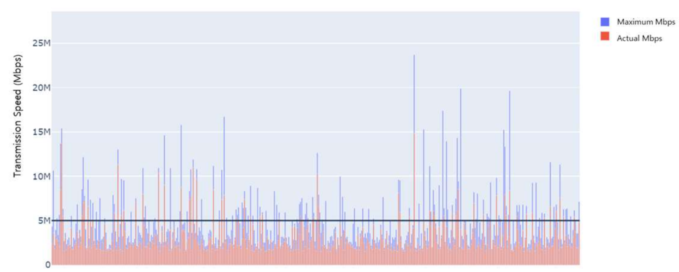

Fig. 3. Comparisons between actual Mbps and maximum Mbps

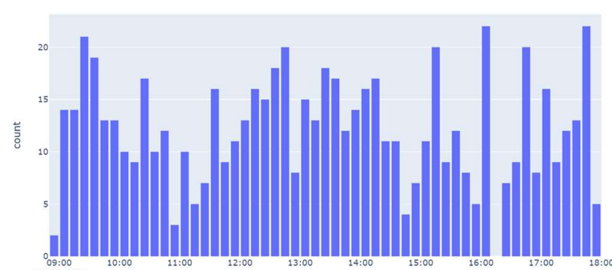

Fig. 4. Histogram according to the appearance time of sessions with a maximum speed of 5 Mbps or less

IV. CONCLUSION

In this study, we proposed a method for predicting the QoS of a video streaming service of a specific eNodeB in an LTE network. To this end, the process of distinguishing video streaming session using DCI information was introduced. In addition, a process of predicting the QoS of a video streaming service according to resolution was presented by calculating the maximum Mbps in consideration of the spectral efficiency.

In the process of session filtering, even video streaming sessions are filtered out, so additional research on more sophisticated session filtering techniques such as machine learning is needed. In addition, QoS analysis for other types of services such as video conferencing as well as streaming services is suitable for future research topics.

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