CLOUD-ASSISTED ADAPTIVE VIDEO STREAMING AND SOCIAL-AWARE VIDEO PREFETCHING FOR MOBILE USERS

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INTRODUCTION

- Leveraging the current cloud computing technology, they propose and discuss a framework to improve the quality of video services for mobile users, which includes two parts: cloud-assisted adaptive video streaming, and social-aware video prefetching.
For each active mobile user, a private agent is constructed in the cloud center to adaptively adjust the video quality (bit rate) by the scalable video coding technique based on the feedback of link condition.

Meanwhile, the online social network interactions among mobile users are monitored by the cloud-based agents, so that the videos that are shared among users will be effectively prefetched to mobile users in advance.
It is crucial to improve the Quality of Service (QoS) of mobile video streaming while utilizing the networking and computing resources efficiently.

In this article, we mainly focus on the two following questions as our main concerns:

- Can mobile users enjoy stable and continuous video streaming without disruptions?
- Can mobile users enjoy click-to-play video streaming with less buffering delays?
ADAPTIVE STREAMING WITH LITTLE DISRUPTION

- **Adaptability**: To address this issue, we need to tune the video bit rate adapting to the time-varying available link capacity of each mobile user, based on his/her feedback of the link quality.

- **Scalability**: The Scalable Video Coding (SVC) technique of the H.264 AVC video compression standard [3] defines a base layer (BL) with multiple enhancement layers (ELs).
By utilizing the SVC, a video can be decoded and displayed at the lowest quality if only the BL is delivered, while the more ELs are delivered, the better quality of the video stream can be achieved.

In the cloud, multiple instances of user agents can be maintained dynamically and efficiently depending on the time-varying user demands.
Therefore, we are motivated to design a new framework of mobile adaptive video streaming by using virtual agents in the cloud.
To this regard, a new trend to exploit the online Social Network Services (SNSs) for intelligent video prefetching is becoming more popular.

**Social Impact:** In the real world as well as the online SNSs, people mostly share interest content due to “word-of-mouth” propagation.
- **Locality**: User relationships and interests in SNSs have significant homophily and locality properties.

- **Access Delay**: Different mobile users have different patterns of accessing videos [11], which are per-user dependent mainly due to people’s different life styles.
We explore the possibility to prefetch the video (fully or partially) to user devices in advance, based on their online interactions in SNSs while also considering their access delays; once the user clicks to watch the video, the video can instantly start playing without buffering.
AN EMERGING FRAMEWORK OF CLOUD-ASSISTED MOBILE VIDEO SERVICES

The proposed framework leverages the SVC technique, and offers the scalable and adaptive streaming experiences by controlling the combination of video streams (layers) depending on the feedback of the fluctuating link quality from mobile users.
Also based on the analysis of the SNS activities of mobile users, the proposed framework seeks to prefetch the video clips in advance from user’s private agent to the local storage of the device.
CLOUD AGENT FOR MOBILE USERS

Figure 1. An illustration of the proposed framework.
- The VC also keeps running a collector to seek popular videos from the VSPs, and re-encode the collected videos into SVC format and store into tempVB first.
- Each sub-VC has a sub-VideoBase (subVB), which stores the recently fetched video segments.
Each mobile device also has a temporary caching storage, which is called local-VideoBase (localVB), and is used for buffering and prefetching.

If a video is accessed in the subVCs at a certain frequency threshold (e.g., 100 times per day), it will be uploaded to the tempVB; and if it is further accessed at a much higher frequency (e.g., 10,000 times per day), it will be stored with a longer lifetime in the VB.
In such a 2-tier system, the subVB and VB can always store fresh and popular videos in order to increase the reusage probability.
CLOUD-ASSISTED ADAPTIVE VIDEO STREAMING

- SVC defines diverse profiles of video streams with one base layer (BL) and multiple enhancement layers (ELs). These layers, or say substreams, can be encoded by exploiting three scalability features:
- Spatial scalability by layering image resolution (screen pixels)
- Temporal scalability by layering the frame rate
- Quality scalability by layering the image compression, and thus can offer videos for a high variety of quality with relatively less storage overhead
The mobile client keeps tracking on metrics, including signal strength, packet round-trip-time (RTT), packet loss and bandwidth, under a certain duty cycle. And the client will periodically report to the subVC.
SOCIAL-AWARE VIDEO PREFETCHING
SOCIAL CONTENT SHARING

In SNSs, users can subscribe to known friends, famous people, and particular content publishers; also there are various types of social activities among users in SNSs.
So we need to define different strength levels for those social activities to indicate the different possibilities that the video shared by one user may be watched by the recipients of his/her sharing activities, so that subVCs can carry out effective background prefetching at subVB and even may push to user’s localVB.
The amount of prefetched segments is mainly determined by the strength of the social activities and user’s link status.

And thus we classify the social activities in current popular SNSs into three kinds:

- Direct recommendation
- Subscription
- Public sharing
Author also define three prefetching levels regarding the social activities of mobile users:

- “All”: The video shared by the direct recommendations will be watched with a very high probability.
- “Parts”: Because the videos that are published by subscriptions may be watched by the subscribers with a not so high probability, we propose to only prefetch parts of the BL and ELs segments, for example, the first 10 percent segments.
“Little”: The public sharing has a weak impact, so the probability that a user’s friends (followers) watch the video that the user has watched or shared is relatively low.
VIDEO STORAGE AND STREAMING FLOW

- The two parts, cloud-assisted adaptive video streaming and social-aware video prefetching in the framework, have tight connections and will together service the video streaming and sharing: they both rely on the cloud computing platform and are carried out by the private agencies of users; while prefetching, the streaming part will still monitor and improve the transmission considering the link status.
PERFORMANCE EVALUATION

- They choose the U-cloud server (premium) in the cloud computing service offered by KT, and utilize the virtual server with 6 virtual CPU cores (2.66GHz) and 32GB memory, which is fast enough for encoding 480P (480 by 720) video with H.264 SVC format in 30fps near real-time.
First, they decode it by the x264 decoder into the YUV format, and re-encode it by the H.264 SVC encoder, the Joint Scalable Video Model (JSVM) software of version 9.1.

We split the video into segments by varied twin of 1s, 2s, 3s, 4s and 5s.
By JSVM, besides the base layer, we further generate 5 temporal layers (1.875, 3.75, 7.5, 15, and 15 fps), 2 spatial layers (240 by 360 and 120 by 180) and 2 more quality layer (low and high).
Firstly we examine whether there is a deep relationship between the measured bandwidth of last time window and the practical bandwidth of next time window.

They test the video streaming service via 3G/4G link, and move the device around in the building to try to change the signal quality.

Note that all tests are carried out for five times.
They collect the relative errors of the predicted bandwidth to the practical bandwidth for every time window, calculated by

\[
\frac{\left| \text{BW}_{\text{pred}} - \text{BW}_{\text{prac}} \right|}{\text{BW}_{\text{prac}}},
\]

So a short Twin for the accurate prediction is suggested in practical implementation.
VIDEO STREAMING IN SUBVC AND VC BY SVC

Figure 4. SVC encoding delays in the cloud.
Figure 5. SVC encoding overhead in the cloud.
Overall, an SVC stream should not contain too many ELs, that is, a high scalability practically brings high overhead.
Figure 6. Click-to-play delays for various cases.
CONCLUSIONS AND FUTURE REMARKS

- In this article, they discussed our proposal of the cloud-assisted adaptive mobile video streaming and social-aware prefetching, which efficiently stores videos in the clouds and elastically constructs private agent (subVC) for active mobile user to try to offer “non-terminating” video streaming by adapting to the fluctuation of link quality based on SVC technique, and to try to provide “non-buffering” video streaming experience by background prefetching based on the tracking of the interactions of mobile users in their SNSs.