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A Framework of IPTV Streaming and Sharing in the Clouds

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Abstract:

While demands on video traffic over networks have been souring, the wireless link capacity cannot keep up with the traffic demand. The gap between the traffic demand and the link capacity, along with time-varying link conditions, results in poor service quality of IPTV streaming over networks such as long buffering time and intermittent disruptions. Leveraging the cloud computing technology, we propose a new IPTV framework, dubbed framework-Cloud, which has two main parts IPTV streaming and IPTV sharing. Streaming and Sharing construct a private agent to provide streaming services efficiently for each user. For a given user, lets her private agent adaptively adjust her streaming flow with a scalable video coding technique based on the feedback of link quality. Likewise, Streaming monitors the social network interactions among users, and their private agents try to prefetch video content in advance. We implement a prototype of the Cloud framework to demonstrate its performance. It is shown that the private agents in the clouds can effectively provide the adaptive streaming, and perform TV sharing(i.e., prefetching) based on the social network analysis.

Keywords: **video streaming, sharing, scalability, adaptability, single stream, multi stream**

Introduction:

Over the past decade, increasingly more traffic is accounted by TV streaming. In particular, TV streaming services over networks have become prevalent over the past few years [1]. While the TV streaming is not so challenging in wired networks, other networks have been suffering from TV traffic transmissions over scarce bandwidth of wireless links. Despite network operators' desperate efforts to enhance the wireless link bandwidth (e.g., 3G and LTE), soaring TV traffic demands from users are rapidly overwhelming the wireless link capacity. While receiving TV streaming traffic via networks, users often suffer from long buffering time and intermittent disruptions due to the limited bandwidth and link condition fluctuation caused by multi-path fading and user [2] [3] [4]. Thus, it is crucial to improve the service quality of TV streaming while using the networking and computing resources efficiently [5] [6] [7] [8]. Recently there have been many studies on how to improve the service quality of TV streaming on two aspects:

Scalability: IPTV streaming services should support a wide spectrum of network devices; they have different TV resolutions, different computing powers, different wireless links and so on. Also, the available link capacity of a device may vary over time and space depending on its signal strength, other users traffic in the same cell, and link condition variation. Storing multiple versions (with different bit rates) of the same video content may incur high overhead in terms of storage and communication. To address this issue, the Scalable Video Coding (SVC) technique (Annex G extension) of the H.264 AVC video compression standard [9] [10] [11] defines a base layer (BL) with multiple enhance layers (ELs). These sub-streams can be encoded by exploiting three scalability features:

(i) Spatial scalability by layering image resolution (screen pixels),
(ii) Temporal scalability by layering the frame rate
(iii) Quality scalability by layering the image compression.

By the SVC, a video can be decoded/played at the lowest quality if only the BL is delivered. However, the more ELs can be delivered, the better quality of the video stream is achieved.

Adaptability: Traditional video streaming techniques designed by considering relatively stable traffic links between servers and users, perform poorly in network environments [2]. Thus the fluctuating wireless link status should be properly dealt with to provide ‘tolerable” TV streaming services. To address this issue, we have to adjust the video bit rate adapting to the currently time-varying available link bandwidth of each user. Such adaptive streaming techniques can effectively reduce packet losses and bandwidth waste. Scalable TV coding and adaptive streaming techniques can be jointly combined to accomplish effectively the best possible quality of video streaming services. That is, we can dynamically adjust the number of SVC layers depending on the current link status [9] [12].

Challenges in Multicast video streaming

In this section we begin by presenting basic video streaming challenges and then we discuss challenges introduced by the use of multicast communication in SETIT2005 video streaming.

Challenges related video streaming

The best effort service offered by the Internet leads to an uncontrolled quality of transmission which affects the stream reception quality for receivers. Three basic problems are to be treated to keep an acceptable QoS during video streaming: Bandwidth management, packet loss and delay jitter. Bandwidth management Regarding the important number of flows’ natures transmitted through the internet, the bandwidth management is still one of the critical problems to be solved. Actually, it’s hard to have an instantaneous estimation of the available bandwidth within a path in order to adapt the stream bit rate. It is also hard to achieve an acceptable fairness in bandwidth allocation between concurrent flows with different natures and requirements (video UDP streams and TCP flows). There are many techniques to adapt the stream bit rate to the available bandwidth; we can use multi-coded stream, transcoding or layered compression.

Multi-coded stream: One way for a source to adapt its stream to the available bandwidth is to preview a number of pre-encoded streams for the original video. These streams should be coded at a few well chosen rates targeted for common network access speeds (for example 128 Kbps for an ISDN access, 1.5 Mbps for an ADSL access, and 10-Mbps for an Ethernet access). Here it is the receivers’ role to choose the adequate stream depending on its own access speed to the network.

Transcoding: To adapt the bit rate we can just recompress the stream to the desired bit rate. The problem with recompression is that decoding and re-encoding leads generally to a lower quality than if the video was coded directly from the original source to the same bit rate. In addition recompression requires an extensive computation and may affect sensitive application. The solution is to use transcoding to recompress the stream. With transcoding techniques (Wee & al.1999)we selectively re-use compression decisions already made in the compressed media to reduce computation (work on the compressed data directly without decoding). This is possible because most codecs use similar compression techniques.

Layered compression:

A more elegant way to adapt the bit rate is to code the stream using a layered compression technique. It consists on mapping different video frames to a set of layers during the compression process; in general a basic layer and a set of enhancement layers. The way frames are mapped into layers depends on the used scalability parameter: temporal, spatial or quality scalability. For example, using the temporal scalability (used in H.263 and MPEG) layers are mapped to different frame types, for instance I and P frames compose the basic layer, and B frames compose the enhancement layer. In order to adapt the reception rate, the receiver should cumulate a set of enhancement layers in addition to the base lay.

Multicast video Streaming

We give, in this section, a detailed description of recent proposals for multicast video streaming. We classify these proposals depending on the used rate adaptation techniques well as on the source/receiver/network roles. We will focus essentially on layered adaptation technique which we believe to be the most promoting approach for the future. Readers can find exhaustive surveys about multicast video streaming [13] [14] [15].Table 2gives a summary of these approaches.

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Single stream with source rate adaptation

With this approach the multicast source uses only one copy for the video stream and adjusts the bit-rate based on the receivers/network feedback [16] [17]. This feedback can be based on RTP/RTCP quality reports. In order to adjust the stream rate the source can use transcoding. This simple approach has many drawbacks. First, it needs a scalable feedback mechanism [18]. Second, receivers' feedback should be synchronized, which is very hard to achieve. Finally, the adjusted rate should satisfy the lowest receiver resource, which penalizes all other receivers.

Multiple streams with receiver switching

In order to avoid feedback problems, in this approach the source uses a set of pre-encoded streams of the original video [16]. These streams are coded at a few well chosen rates targeted for common network access speeds (for example 128 Kbps for an ISDN access, 1.5 Mbps for an ADSL access, and 10-Mbps for an Ethernet access). The source sends each stream to a separate group address. The rate adaptation role is relegated to each receiver. After estimating the reception quality (loss rate), a receiver can adapt the bit-rate by switching between streams and joining/leaving the corresponding multicast group. To improve the efficiency of this approach, it can be combined with the first one. Actually, the source can use an intra-stream protocol to adapt the bit-rate for each stream using a less frequently feedback reports. Note that this is completely different from feedback reports in the first approach since no synchronization is needed between receivers. The source has to get, from time to time, some feedback to adapt the rate of each stream. Note that this technique is implemented in many commercial solutions such as Sure Stream from Real.

Layered Multicast Streaming

Layered video coding was proposed as an attractive and efficient solution for the problem of video adaptation in heterogeneous multicast sessions. In layered approaches, the raw video is encoded into a set of cumulative (or non-cumulative) layers [19] [21] [20]. A basic layer contains the essential video information with a basic low quality and a set of enhancement layers are used to improve the quality of the received video. In the case of MPEG-4 [22] coding, layers can be obtained by applying Temporal scaling, Spacial scaling of Fine Granularity scaling (FGS). The set of layers are sent over separate multicast groups. A receiver joins, first, the basic layer to obtain the basic video quality and then adapts the rate depending on its capabilities by joining/leaving enhancement layers. Depending on the set of joined layers, heterogeneous receivers will obtain different video quality. In the cumulative layered approach layers should be joined in a cumulative manner in the order of their relevance. However in non-cumulative approaches, layers are not ordered and receivers can join any subset of layers. Layered coding is also used in router (or agent) assisted techniques where rate adaptation is achieved by on-tree routers. In this approach, the quality adaptation is delegated to intermediate routers which accept or drop layers by filtering the video stream according to the congestion state of its interfaces. In the following subparagraphs we present a brief description of the state-of-art of layered multicast proposals.

Algorithm 1 Matching Algorithm between BW and Segments

$i = 0$
$BW_0 = R_{BL}$
Transmit BL_0
Monitor $BW_0^{practical}$
repeat
  Sleep for T_{win}
  Obtain p_i, RTT_i, $SINR_i$ etc., from client's report
  Predict $BW_{i+1}^{estimate}$ (or $BW_{i+1}^{estimate} = BW_i^{practical}$)
  k=0
  BW_{EL}=0
  repeat
    k++
    if $k >= j$ break
    BW_{EL}=BW_{EL} + R_{EL^k}
  until $BW_{EL} >= BW_{i+1}^{estimate} - R_{BL}$
  Transmit BL_{i+1} and EL_{i+1}^1, EL_{i+1}^2,..., EL_{i+1}^{k-1}
  Monitor $BW_{i+1}^{practical}$
  i++
until All video segments are transmitted

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EFFICIENT IPTV SHARING

Social Content Sharing:

In SNSs, users subscribe to known friends, famous people, and particular interested content publishers as well; also there are various types of social activities among users in SNSs, such as direct message and public posting. For spreading videos in SNSs, one can post a video in the public, and his/her subscribers can quickly see it; one can also directly recommend a video to specified friend(s); furthermore one can periodically get noticed by subscribed content publisher for new or popular videos. Similar to studies in [23] [24], we define different strength levels for those social activities to indicate the probability that the TV shared by one user may be watched by the receivers of the one's sharing activities, which is called a "hitting probability", so that subVCs can carry out effective background prefetching at subVB and even localVB. Because after a video sharing activity, there may be a certain delay that the recipient gets to know the sharing, and initiates to watch [25]. Therefore the prefetching in prior will not impact the users at most cases. Instead, a user can click to see without any buffering delay as the beginning part or even the whole TV is already prefetched at the localVB. The amount of prefetched segments is mainly determined by the strength of the social activities. And the prefetching from VC to subVC only refers to the "linking" action, so there is only file locating and linking operations with tiny delays; the prefetching from subVC to localVB also depends on the strength of the social activities, but will also consider the wireless link status.

We classify the social activities in current popular SNSs into three kinds, regarding the impact of the activities and the potential reacting priority from the point of view of the recipient:

Subscription: Like the popular RSS services, an user can subscribe to a particular TV publisher or a special TV collection service based on his/her interests. This interest-driven connectivity between the subscriber and the TV publisher is considered as "median", because the subscriber may not always watch all subscribed TVs.

Direct recommendation: In SNSs, an user directly recommend a TV to particular friend(s) with a short message. The recipients of the message may watch it with very high probability. This is considered as "strong".

Public sharing: Each user in SNSs has a timeline-based of activity stream, which shows his/her recent activities. The activity of a user watching or sharing a video can be seen by his/her friends (or followers). We consider this public sharing with the "weak" connectivity among users, because not many people may watch the TV that one has seen without direct recommendation.

Conclusion

In this tutorial we have discussed first important issues in IPTV streaming and sharing namely video compression techniques and standards. Then we presented the challenges in multicast video streaming and sharing. We then classified the different approaches proposed to overcome these challenges. Note that in all the approaches presented in this tutorial, there are a number of open issues that need to be treated. For instance, feedback implosion and receivers' synchronization in multicast sessions are still up-to-date challenges. In addition any proposed solution for multicast video streaming and sharing should take into consideration the problem of intersession fairness and should be TCP friendly. We believe that using multicast communication in IPTV streaming and sharing is a promising solution for the future especially for wide content distribution applications. But we also believe that a lot of effort should be done in this domain to propose efficient and viable solutions.

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