Recent and Future Trends in Mobile Video Streaming

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1. Introduction

Video streaming services to mobile and wireless devices, including smart phone and tablets, have recently grown greatly in popularity. Many wireless carriers currently offer on-demand and live video streaming services. Unfortunately, the distribution of video streams faces a significant scalability challenge due to the high server and network requirements. Additionally, the mobile and wireless environment imposes other significant challenges.

This paper discusses the current and future status of mobile video and the main challenges in mobile video streaming. It also discusses recent and future trends in the distribution of video streams to mobile devices.

The rest of the paper is organized as follows. Section 2 summarizes the current and future status of mobile data traffic. Subsequently, Section 3 discusses the main challenges in mobile video streaming. Sections 4 and 5 discuss the recent and future trends in mobile video streaming, respectively.

2. Trends in Mobile Traffic

A 2013 report by Cisco on global mobile data traffic forecast demonstrates a huge increase in mobile traffic in general and mobile video traffic in particular [1]. The trends of mobile data traffic in 2012 can be summarized as follows:

- The global mobile data traffic grew by 70 percent and was approximately 12 times the size of the entire Internet in 2000.
- Nearly a third of that traffic was offloaded onto fixed networks through Wi-Fi or femtocell.
- Mobile video traffic was 51 percent of the mobile data traffic.
- The speeds of mobile network connections more than doubled.
- Although 4G connections represent less 1% percent of mobile connections, they account for nearly 15 percent of the mobile data traffic.

The report's forecast for 2017 is not less dramatic.

- Two-thirds of the global mobile data traffic will be video.
- The traffic generated by mobile-connected tablets will exceed that of the entire mobile network in 2012.
- 4G connections will represent 10 percent of all connections and will account for 45 percent of the traffic.

With the rising popularity of mobile video, the higher connection speeds, and the wider spectrum of devices offered and used, the development of high quality video streaming services will become increasingly more important in the future.

3. Main Challenges in Mobile Video Streaming

Mobile video streaming faces significant challenges. First, delivering video streaming to a huge number of users is very demanding of server and network resources. Video streams require high data transfer rates and thus high bandwidth capacities and must be received continuously in time with minimal delay. Second, supporting heterogonous receivers with varying capabilities is hard to achieve efficiently. Mobile devices vary greatly in their capabilities, including screen resolution, computational power, and download bandwidth. Third, the unique characteristics of the wireless and mobile environment should be considered. These characteristics include noise, multi-path interference, mobility, and subsequently dynamic network conditions, and great variations in the actual download bandwidth over time.

4. Recent Trends in Distribution of Mobile Video Streams

The most common approach currently used for addressing the scalability challenge in video streaming is *Content Delivery Networks* (CDNs). As illustrated in Figure 1, the content in the origin server(s) is automatically stored in surrogate servers, located in many cities around the world. Therefore, the user's request for streaming a video is transparently transferred to a surrogate server close to the user's geographical location. The delivery of the content by a server close to the user leads to fast and reliable video streaming and reduces the contention on the Internet [2]. An accounting mechanism is typically employed to relay access information and detailed logs to the origin server(s).

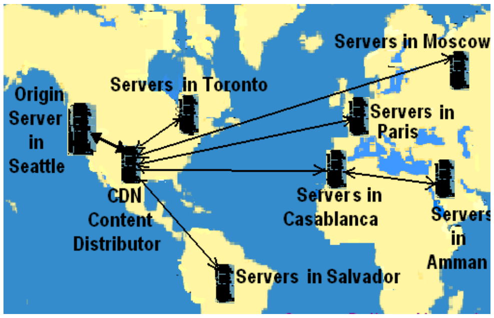

Figure 1: An Illustration of a Simple Content Delivery Network with Many Distributed Servers

To address the dynamic network and channel conditions and to support devices with varying resources (such as download bandwidth and screen resolution), many mobile video streaming services that are provided by wireless carriers started to adopt *Dynamic Adaptive Streaming over HTTP* (DASH), also known as MPEG-DASH. DASH uses HTTP because it is widely deployed in all Web servers and thus provides ease of development. In addition, HTTP allows the use of CDNs and offers firewall friendliness. The MPEG-DASH standard, published as ISO/IEC 23009-1:2012 in April 2012, allows interoperability between devices and servers of various vendors [3].

With DASH, videos are stored with different levels of quality, and users dynamically switch to the appropriate quality level based on the current device state and their preferences. More specifically, the video is encoded into video streams with different bitrates. Subsequently, the video streams are partitioned into segments. These segments are then hosted on origin server(s), along with metadata information describing the relationships among segments and how they collectively form a media presentation. This information is referred to as *Media Presentation Description* (MPD). The client fully controls the streaming session by making HTTP requests to selected segments at different times. Therefore, most of the intelligence is at the client, freeing the server from containing state information for the clients. For further details about DASH, please refer to [3, 4] and ISO/IEC 23009-1:2012.

5. Future Trends in Video Distribution

As discussed earlier, the main approach that has been used for addressing the scalability challenge is CDNs. Another approach is *Peer-to-Peer* (P2P). While the first approach requires maintaining a huge number of geographically distributed servers, the second still relies heavily on central servers [5, 6]. Both these approaches mitigate the scalability problem but do not eliminate it because the fundamental problem is due to unicast delivery [6]. Multicast is highly effective in delivering high-interest and high-usage content and in handling flash crowds. Recently, there has been a growing interest in enabling native multicast to support high-quality on-demand video distribution, IPTV, and other major applications [6, 7].

Multicast-based video delivery can be used to provide a true solution for the scalability problem. This delivery can be done on a *client-pull* or a *server-push* fashion, depending on whether the channels are allocated on demand or reserved in advance, respectively. The first category includes *stream merging* [8] (and references within), which reduces the delivery cost by aggregating clients into larger groups that share the same multicast streams. The achieved degrees of resource sharing depend greatly on how the waiting requests are scheduled for service. The second category consists of *Periodic Broadcasting* techniques [9] (and references within), which divide each video file into multiple segments and broadcast each segment periodically on dedicated server channels.

In contrast with stream merging, periodic broadcasting is cost-performance effective for highly popular content but leads to channel underutilization when the request arrival rate is not sufficiently high. Stream merging works well even for lower arrival rates. The most effective stream merging technique is *Earliest Reachable Merge Target* (ERMT) [10]. It is a near optimal hierarchical stream merging technique, which allows streams to merge unlimited number of times, leading to a dynamic merge tree. Specifically, a new user or a newly merged user group snoops on the closest stream that it can merge with if no later arrivals preemptively catch them [10]. To satisfy the needs of the new user, the target stream may be extended, and this extension may change that stream's merging target [8].

The practical use of stream merging has been hindered by few complications. First, user interactions (such as pause and jump) cause requests to leave ongoing streams, thereby negatively impacting the stream merging process and complicating the server design. Second, supporting heterogonous receivers becomes complicated. Third, supporting video advertisements along with premium video content is also complicated when stream merging is employed.

Fortunately, recent work has addressed most of these challenges [8, 9, 11, 12], and thus multicast-based video delivery is becoming more viable.

6. Conclusion

The interest in mobile video has increased dramatically, and mobile video is expected to account for two-thirds of the global mobile data traffic in 2016. In this paper, we have discussed the main challenges in mobile video streaming. We have also argued that while DASH coupled with CDN will offer the best solution for mobile video streaming in the near future, multicast-based video delivery will likely become more viable in the long term.

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Nabil J. Sarhan received the Ph.D. and M.S. degrees in Computer Science and Engineering at the Pennsylvania State University and the B.S. degree in Electrical Engineering at Jordan University of Science and Technology. Dr. Sarhan joined Wayne State University in 2003, where he is currently an Associate Professor of Electrical and Computer Engineering and the Director of Wayne State Multimedia Computing and Networking Research Laboratory. Dr. Sarhan is an internationally recognized expert in multimedia systems and multimedia computing and networking and has published extensively in top conferences and journals. His research projects have been primarily sponsored by the National Science Foundation. His main research areas include video streaming and communication, computer and sensor networks, automated video surveillance, multimedia systems design, energy-efficient systems, cross-layer optimization, and storage.

Dr. Sarhan is the Chair of the Interest Group on Media Streaming of the IEEE Multimedia Communication Technical Committee (MMTC). He is an Associate Editor of the IEEE Transactions on Circuits and Systems for Video Technology. Dr. Sarhan has been involved in the organization of numerous international conferences in various capacities, including chair, technical program committee co-chair, invited panel and speaker co-chair, publicity chair, track chair, and program committee number. He served as the Co-Director of the IEEE MMTC Review Board. He has served as a consulting expert in cases involving patent infringement in mobile video streaming.

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