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Streamphony: An Efficient Global Cloud for High Bit-rate Live Streaming

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Abstract

Though live streams have been reportedly distributed in the Internet, the approaches used often lead to hardly satisfactory user experiences in quality and delay, especially when the user pool is large. At HKUST, we have been developing a novel streaming network called Streamphony, which is a software suite optimized for large-scale live multimedia (video, audio and data) streaming over the public Internet. It enables an Optimized Global Streaming Cloud for high bit-rate and low-delay applications.

Streamphony employs an advanced and powerful "substream push" overlay distribution network seamlessly integrated with regional IP multicast, if any, to achieve efficient global streaming. The video is divided into multiple parts called substreams which are pushed in an optimal manner to distributed users. Using distributed optimization algorithms to construct multipaths, it overcomes bandwidth bottlenecks, supports high streaming rate with low delay. This network also consists of 2 tiers: the CDN (Content Delivery Network) proxy tier and the client network tier. Both tiers are optimized for bandwidth efficiency and user delay.

Prevailing Trend of Live Steaming and the Challenges it is facing

According to Cisco Visual Networking Index, the sum of all forms of video (TV, video on demand, Internet, and P2P) will reach approximately 86 percent of global consumer traffic by 2016[2]. The growth of mobile video traffic is particularly significant, with a substantial 66% of the mobile data transfer being video.

To meet streaming demand, the following challenges need to be addressed:

- A good-quality stream requires sustained high bandwidth
  Streaming requires sustained high bandwidth. For example, a video comparable to VCD quality needs 1.5 Mbps bandwidth. With merely 1,000 users watching it at the same time, 1.5 Gbps bandwidth is required. This is a high requirement from the server and network points of view.
- The Internet is “best-effort”
  The Internet has no guarantee on bandwidth and packet loss. It also makes no guarantee that the packets will arrive on time and correctly. When watching live streaming video, users hence may experience the following problems as shown on the screen capture:
  - Broken image
  - Long time lag
  - Stop playing or buffering
  - Unable to join the servers (due to network or server congestion)
- Error propagation problem as video is differentially coded

As video is differentially encoded, a packet loss may affect a substantial region or portion of a stream. This greatly degrades video quality. Achieving low loss despite network congestion is hence important.

It is clear from above that offering large-scalable live streaming solution is challenging. At HKUST, we have been developing a novel and effective streaming solution called Streamphony addressing the above issues at low cost.

Streamphony: A Global Streaming Cloud over the Public Internet

Streamphony is a software suite for large-scale live multimedia streaming (video, audio and data) over the public Internet. It enables an Optimized Global Streaming Cloud for high bit-rate applications. This cloud streams contents to a variety types of user devices: phones (iPhone, Android phone, Windows phone), tablets, smart TVs, set top boxes, PCs, etc.

Figure 1: Streamphony Overview

Streamphony Advantages and Innovations

CDN-P2P Technology

Many existing streaming solutions still use client-server model. Users directly obtain their streams from a central server (as shown in Figure 2). The server and bandwidth requirement in this model increases quickly with subscribers. Bandwidth is a direct operational cost of the operator. In addition, upgrading and maintenance of servers and backbone network is expensive in this approach.

As shown in Figure 1, Streamphony achieving its scalability by using reliable proxies that are distributed over the Internet to provide a robust, efficient and high-bandwidth “backbone” CDN. The CDN layer may be treated as a streaming cloud to distribute the live streams. Among devices that enables sharing; a client cloud can also be formed automatically to further scale up the system and reduce server bandwidth consumption. We discuss in the following the unique and novel features of Streamphony.

Constructive Push vs. Random Pull

More recent peer-to-peer streaming solutions are mostly based on BitTorrent[3]'s file sharing technology. Upon a video request, a user pulls streams from the other peers in a rather random manner as shown on the left side of Figure 3. With this approach, network resource is not utilized well, and the network is easily overwhelmed by streaming traffic. Furthermore, due to this ad-hoc connectivity, the end-to-end delay is unpredictable and long.

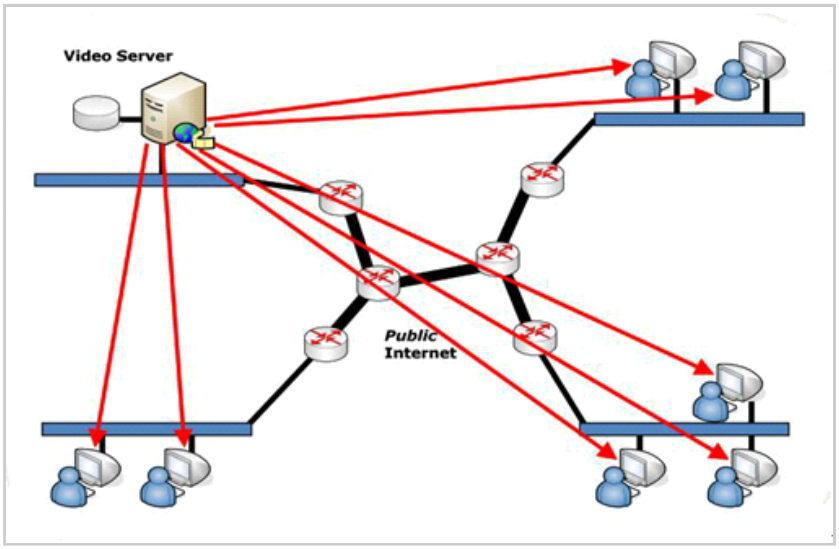

Figure 2: Traditional Client Server Model

To address the problem, we have designed Streamphony as a push-based optimized network (right side of Figure 3). Streamphony is among the world's first push-based streaming networks. With the push approach, Streamphony achieves extremely low delay within seconds, substantially lower than the other existing pull-based approaches. The network bandwidth can be better utilized, and hence lower the cost and improve video streaming rate.

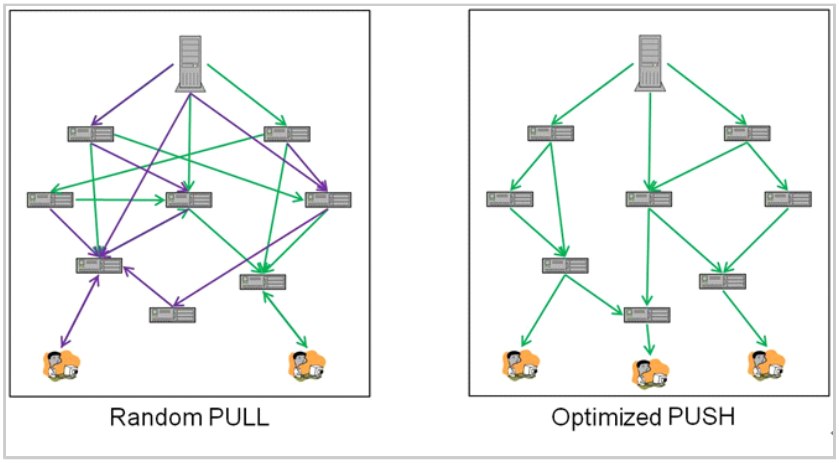

Figure 3: Optimized Push vs. Random Pull

Substream Technology

In Streamphony, the multimedia stream is divided into multiple substreams, where video stream is divided into multiple parts and are intelligently sent over multiple paths to distributed proxies as shown in Figure 4. The edge proxies are able to assemble a full stream by aggregating all the substreams. This multi-path approach effectively overcomes bandwidth bottlenecks in the network, making high bit-rate streaming in excess of multi-Mbps possible. The streaming cloud also employs a more robust and low-overhead recovery mechanism. Due to its innovative push-based protocol and distributed optimization, Streamphony achieves much lower end-to-end delay, link stress, server stress, and resource consumption as compared with other traditional overlay protocols. The streaming cloud is able to accommodate churns, and is distributed and self-improving.

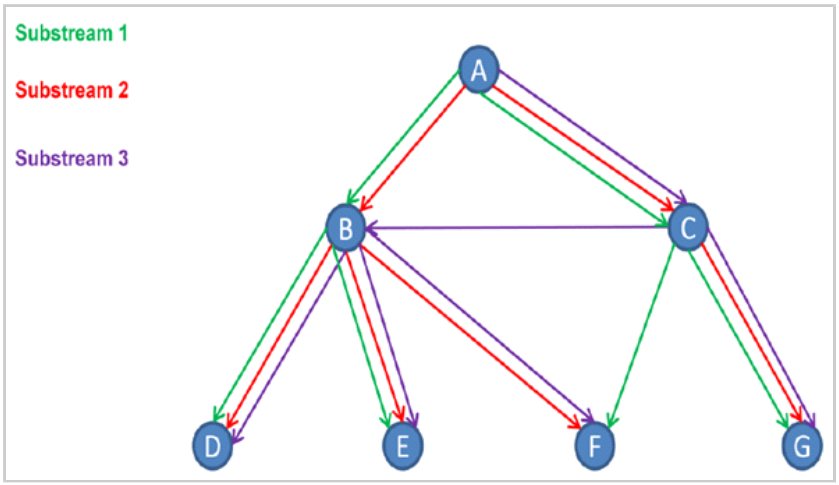

Figure 4: Substreams

Seamless integration with IP multicast
Streamphony fully utilizes IP multicast wherever it is available. Its patented technology allows seamless integration with IP multicast by optimized overlay bridges (Figure 5). Network bandwidth usage is significantly reduced and it translates into operational cost saving.

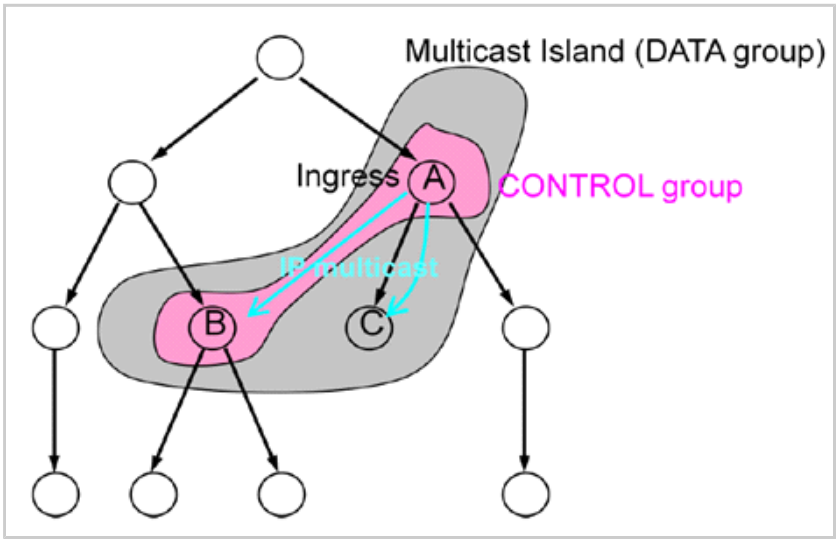

Figure 5: Streamphony Multicast Island Technology Wide Range of Applications

Streamphony serves as a streaming middleware, and it is transparent to applications. It supports all types of video streaming applications such as Internet TV, Mobile TV, Cyber University, Conferencing, etc (Figure 6).

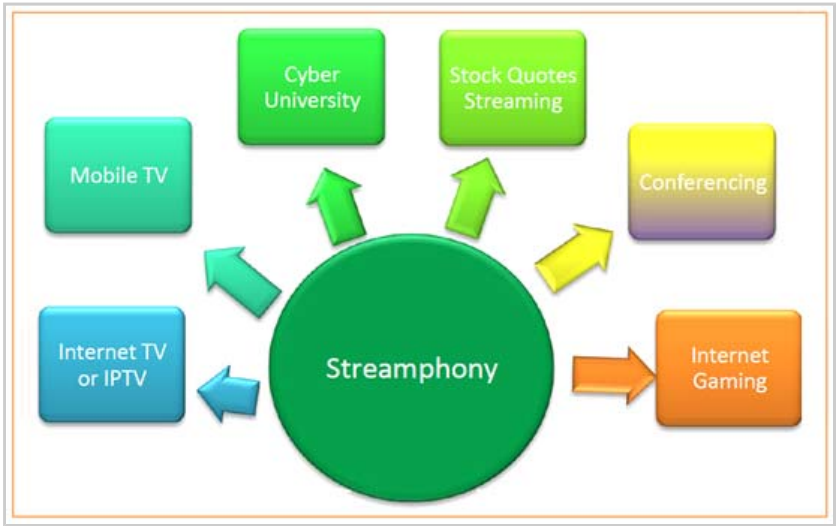

Figure 6: Wide Range of Applications of Streamphony

Streamphony is also useful to stream time-critical data, such as stock quotes (Figure 7). It achieves sub-second delay, much faster than multiple seconds as in many other existing stock-quotes streaming solutions. Streamphony is also expendable to support many potential high-quality media streaming features, such as 7.1 audio effect, Multi-language subtitle, 3D animation, etc.

Figure 7: Stock quotes Streaming

Streamphony has undergone many trials and tests at the lab and global testbed (figure 8). It is ready for technology transfer and deployment. It can be easily adopted by content providers & TV broadcasters.

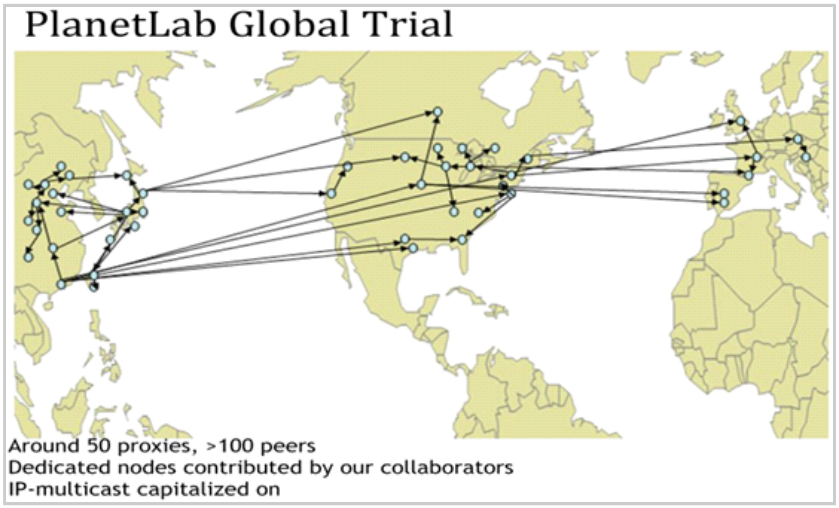

Figure 8: Global Trial

Visit us at http://mwnet.cse.ust.hk/streamphony/index.html for more information.

[1] See http://mwnet.cse.ust.hk/streamphony/aboutus.html for author's biography
[2] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html
[3] http://www.bittorrent.com/

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