A Demo for Affinity based Content Delivery Architectures

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ABSTRACT

Streaming video data over best effort networks is a challenging task concerning the quality of the received content. The quality decreases with the number of frames that are corrupted, lost or received after the playback time. The main reasons for lost, delayed or corrupted frames are overloaded streaming servers and crowded network paths.
In order to deal with overloaded streaming servers and crowded network paths, we present the prototype of an innovative architecture called Proxy-to-Proxy (X2X). The three main components in the architecture are proxies (provided by end users), videos (replicated from original servers) and end-clients (requesting shared content). The behavior of the three components is defined by the so-called affinity model which consists of three levels. The first level covers the content replication from original to surrogate servers (also called proxies), the second level covers the collaboration between the proxies, and the third level covers the delivery from the proxies to the end-clients.
Proxies, videos and end-clients have a certain affinity to each other. Only by changing the input parameters to the affinity functions, the overlay network behaves either like a classical 1) Content Delivery Network, 2) a Peer-to-Peer System or 3) a Proxy-to-Proxy overlay network — which is a combination and generalization of the two former ones.

Keywords

Multimedia Adaptation, Peer-to-Peer Systems, Content Delivery Networks

1. INTRODUCTION

Delivering videos in good quality over best effort networks can still be regarded as an unsolved problem. If a video is streamed from an arbitrary server to an arbitrary client, the perceived quality is typically a question of luck.
The classical server/client approach suffers from poor scalability and a single point of failure. In case of best effort based video delivery, an additional difficulty is the "long distance problem". Over long distances (high number of traversed network elements) packet delays accumulate and result in an unacceptable poor quality, even in case of lightly loaded servers.
An alternative to the classical client/server approach is provided by improved video distribution methods, such as Content Delivery Networks (CDNs) and Peer-to-Peer systems (P2P).
The basic principle of CDNs is transparent redirection of client requests from the origin server to a cluster of surrogates. Replication (from the servers to the cluster) is performed on demand, whenever the content is not cached. The main drawback is that CDNs have no notion of a quality of a video and of a streaming service. They try to find the best connected cluster, but will not check, whether this is good enough for video streaming.
As opposed to Content Delivery Networks (which are typically closed systems, with little public information), P2P file sharing has been investigated fairly well in the recent years [4]. A major drawback is the fragility of P2P systems, as clients, leaving the system, is treated as a normal case. If the time for streaming of a video and that of an on-line period of client machines are in the same order of magnitude then hiccups become "normal" — which is hardly acceptable.

2. THE ARCHITECTURE

The prototype of the Proxy-to-Proxy architecture is based on our affinity model that is aimed to handle the well known problems of video delivery over best effort networks. The model assumes three kinds of components: (1) videos (2) proxies and (3) clients. Each component has a so-called affinity function, and "strives for a world" with maximal affinity. The affinity function is different for each component-type, but the affinity-based behavior is common: (1) Videos, entering the system, let themselves replicate at places, to which they have a high affinity (hoping many interested consumers there). (2) Proxies, entering the system join a group of proxies, to which they have maximal affinity — which is a set of other proxies (3) Clients can receive independent parts of a video from at least one (the best one) or from possibly multiple proxies.
The affinity based behavior of the components allows to change the architecture dynamically between a classical Peer-to-Peer, Content Delivery Network as well as Proxy-to-Proxy behavior (which is a combination and generalization of the two former ones). Since the underlying network is not affected by the affinity based behavior of the proxies and videos, the prototype implementation of the overlay network

allows to compare different content delivery architectures (like Peer-to-Peer, Content Delivery Network and Proxy-to-Proxy Network) against each other.

3. PROTOTYPE IMPLEMENTATION

The prototype mainly relies on the NS-2 network simulator and an extended version of the Evalvid plug-in [2]. We have extended Evalvid to support the evaluation of multiple H.264 [5] sub streams that are delivered over the network topology defined within NS-2. The H.264 format is the latest coding standard proposed by ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group. H.264 has been selected in our prototype implementation since it achieves a much higher coding efficiency than the former MPEG standards (like MPEG-1,2 or basic MPEG-4). An innovative aspect is the combination of H.264 with polyphase Multiple Description Coding (MDC) [3]. We consider the usage of H.264 in combination with MDC as an alternative to the Scalable Video Coding (SVC) [6] approach. Both approaches (MDC as well as SVC) divide a video stream into multiple sub-streams, but the advantage of MDC is the independence between the streams. The price for the independence is higher bit rate requirement of each sub stream.

Encoding and decoding of the streams are achieved by using the X.264 codec together with FFMPEG library. We have extended FFMPEG in order to produce the descriptions, according to the polyphase Multiple Description Coding approach presented in [3].

The NS-2 network topology for simulating the content delivery is generated by using Brite [1] and represents best-effort (Internet) behavior. On top of the best effort network different affinity based overlay architectures (see section 2) can be formed by using the prototype implementation. The concrete overlay architecture layout depends on the user input - and can be Peer-to-Peer, Content Deliver Network or Proxy-to-Proxy like.

Any raw video (available in the YUV format) can be used as input and be delivered from an arbitrary node in the network to a user- defined set of receivers. The two main aspects of the prototype implementation are a) *the user defined, affinity based overlay topology generation* and b) *content delivery that is based on the latest MPEG codec called H.264 in combination with Multiple Description Coding (MDC).* These two aspects allow analyzing 1) the behavior of different content delivery architectures based on the same underlying network conditions and 2) investigating the effect of delivering MPEG's latest video codec combined with the polyphase Multiple Description Coding (MDC) approach.

3.1 Demo

In this section an example for the demonstration of the prototype implementation is presented. The number of generated network nodes in the best effort NS-2 network is 150. The NS-2 topology is used to simulate the delivery of a 5 minutes video sequence. The video has a resolution of 352x255 pixels and is encoded in the H.264/MDC format, using 4 descriptions in the temporal domain. The number of descriptions for this experiment has been selected randomly but could be any number between 2 and the size of the GOP (which is 16 for the test video). The effort for producing the descriptions is not of relevance for the experiment since they are produced offline (before the simulation starts). From the 150 nodes, 50 are selected randomly as receivers.

In the first run of the evaluation the affinity parameters are set to make all receivers request the content directly from the source. The video quality the clients experience is determined by using the Mean Opinion Score Metric [2]. With this metric the value for the best quality is 5 and the worst value is 1. In the graphical representation it can be seen that the bottleneck in the first experiment is at the uplink of the server - the resulting average quality for all receivers is *1.8*.

For the second experiment the affinity parameters are tuned to form an overlay network of peers. The video is forwarded from one receiver to the next by using application level multicast. By taking a look at the graphical representation, produced by the simulator, it can be seen that the bottleneck is very close to the root of the multicast tree and 45% of the data packets are lost - as a result the average mean opinion score of all (50) receivers is 2.57.

For the third experiment the affinity parameters are tuned to form four disjoint overlay networks. Each of the descriptions is delivered through a separate overlay. The descriptions only overlap at the last mile to the receiver that has sufficient bandwidth to transport the descriptions without loss. Each of the receivers gets the video in perfect (lossless) quality.

In this description we only have presented 3 comprehensive scenarios to show how the simulator works. The prototype implementation can be used to compare the delivery of H.264/MDC coded video sequences over many further alternative architectures against each other.

4. REFERENCES

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