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A Survey on Peer To Peer Video Streaming

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Abstract

In recent years Peer-to-peer (P2P) video streaming have become very popular. This paper presents a survey on the challenges and solutions of providing live and on-demand video streaming in P2P networks. We also describe two techniques content delivery networks (CDN) and multiple description coding (MDC) to distributing live streaming to a potentially large and highly dynamic population of hosts.

Keywords: P2P video streaming, Content Delivery Networks (CDNs), Multiple description coding (MDC).

Introduction

Video over IP applications have recently attracted a large number of users on the networks. The peer-to-peer (P2P) network a peer node serves as both a receiver and a supplier, will enables to upload bandwidth of peer nodes to be utilized efficiently while relieving burden of the server node. This will solves the scalability problem which is encountered in the traditional client–server model.

The P2P technology is becoming a popular solution for video streaming applications in recent years. This system is an effective way for content providers to distribute media content to a large set of users, with limited investments for network infrastructures. In P2P networks, a client serves as a receiver downloading packets from the server or peer nodes, while at the same time it plays the role of a supplier uploading downloaded packets to other peer nodes. Although P2P technology provides a good solution for video streaming, some characteristics of P2P systems also provide new technical challenges. Video streaming services are delay sensitive, which generally demand a large network bandwidth compared with voice or data traffic. To obtain good visual quality, P2P video streaming systems have to be error resilient and supportive to the dynamic and heterogeneous nature of P2P environments.

Video Streaming in P2P Networks

In this section, the advantages and challenging issues of P2P video streaming are described. The basic solution for streaming video over the network is the client-server service model. A client will set up the connection with a video source server and video content is streamed to the client directly from the server.

Advantages in video streaming

The advantages of P2P video streaming systems over the traditional client-server systems are summarized as follows.

More cost-effective self-scaling: There sources of individual peer nodes such as storage, uploading band-width, computational capability are efficiently utilized in the P2P systems. In this way, the burden of the server is alleviated, thus the server is able to handle more clients requests without demanding more resources, like purchasing new servers or additional bandwidth.

Higher data rate: Video streaming generally demands a large amount of content delivered in a timely manner. A peer node is able to receive video packets from the server and multiple peer nodes instead of relying on the several one, making video streaming services with high data rates possible.

Alleviation of capacity bottleneck: As video streaming services can be provided by other peer nodes, it is no longer restricted by the bottleneck link on the path from the server to the peer node.

Challenging issues in P2P video streaming

There are some inherent characteristics of P2P systems, which are summarized as follows,

Error resilience: Peer nodes distributing video contents in P2P networks are dynamic. Peer node arrivals and departures are frequent during a video streaming session, which may cause unreliable transmission. Furthermore, advanced video compression techniques remove data redundancy, and thus introduce high dependency among the resulting processed data. As a consequence, an error resilient solution becomes critical for video streaming in P2P networks.

Heterogeneity support: Individual and heterogeneous peer nodes have greatly varying downloading and uploading bandwidth. Some peer nodes have limited downloading bandwidth that only enables downloading of a portion of video packets, while other peer nodes have sufficient access bandwidth and desire for video streaming of high quality. Video streaming service of a receiver peer node with sufficient down- loading bandwidth may be constrained by the limited and varying uploading bandwidth and data availability of its supplier peer nodes as well. Therefore, a flexible video streaming solution that accommodates the het- erogeneity of peer nodes is important in P2P networks.

Incentives for participating peers: As observed in the empirical study of existing P2P file sharing systems peer nodes are unwilling to contribute resources, which results in the well-known free-riding problem. For example, some nodes leave the network immediately after downloading and seldom contribute their uploading bandwidth to other peer nodes. The performance of P2P systems relying on resource contribution of each peer node is largely affected by the free-riding problem, which necessitates incentive mechanisms in the P2P video streaming systems to eliminate or mitigate such a problem.

Content Delivery Networks (CDN)

The video streaming applications involve distributing video from a source server to a large population of interested clients. Due to the lack of widespread support of Internet protocol (IP) multicast, the basic solution of video streaming is the client–server model. Each client sets up a connection with the server to receive a specific video. A server unicasts the video to individual clients, even if all these clients are requesting the same video. The client–server model works well with a reasonable number of users but which is result into scalability problem. Several solutions have been proposed to solve the scalability problem, including purchasing additional bandwidth, more capable servers and using **content delivery network** (CDN).

In the CDN, copies of video content are stored on a set of content delivery servers at the edge of a network. A client is directed to a nearby content delivery server instead of the video source server. CDN is used to maximize the bandwidth, and to improve the accessibility, and also maintain correctness through the content replications. More specifically, CDN maintain multiple Points of Presence (PoP) with clusters of (the so-called surrogate) servers that store copies of identical content, like the user request are satisfied. In the CDN, the most highlighted advantages are:

a. Reducing the load on origin servers.
b. Reducing the customer's need to invest in Web site infrastructure and decreasing the operational costs of managing such infrastructure.
c. By passing traffic jams on the network, data is closer to user and there is no need to traverse all of the congested pipes and peering points.
d. Improving content delivery quality, speed, and reliability.

Content Outsourcing

There are three distinct content outsourcing practices are discussed.

Cooperative push-based: Content is pushed from the origin Web server to CDN surrogate servers. Initially, the content is prefetched (loaded in cache before it is accessed) to the surrogate servers after that, the surrogate servers will cooperate in order to reduce the replication and update cost. The CDN maintains the mapping between content and then to the surrogate servers, and each request is directed to the closest surrogate server, or the request is directed to the origin server.

Cooperative pull-based: Client requests are directed through DNS redirection to their closest surrogate server. The key in the cooperative pull-based CDN is that the surrogate servers are cooperating with each other in case of cache misses. Specifically, using a distributed the index and the surrogate servers find nearby copies of the requested objects and store them in their caches.

***Uncooperative pull-based**:* Clients requests are directed to their closest surrogate server. If there is a cache miss and the requested content is not found, the request is directed either to a peering surrogate server of the underlying CDN or to the origin server. More specifically, the surrogate servers, which serve as caches, pull content from the origin server when a cache miss occurs. A problem in this practice is that CDNs do not always choose the optimal server from which to serve the content. However, many popular CDN providers use uncooperative pulling (such as Akamai and Mirror Image), since the cooperative push-based schemes are still at the experimental stage.

Multiple Description Coding (MDC)

To ensure good visual quality, P2P video streaming systems have to be error resilient and supportive to the dynamic and heterogeneous nature of P2P environments. Among error resilient coding techniques, multiple description coding (MDC) is a promising technique to combat transmission errors by generating multiple descriptions for a single source. Each description is decodable, and reconstructed quality can be refined as the number of received descriptions increases. Thus MDC offers robustness to description and packet loss over unreliable P2P networks. The MDC packet scheduling generates a schedule that controls which MDC packets from which peer nodes to be downloaded.

Firstly, a portion of MDC packets are selected to be included in the schedule for each client, subject to its available downloading bandwidth. The packet selection algorithm aims to minimize a cost function of expected distortion due to packet losses. Then a peer node is determined for each selected packet in the schedule, by taking into account varying uploading bandwidth, data availability and heterogeneous path conditions of peer nodes.

MD coded video streaming in P2P networks

MD coded video streaming generates different encoded versions for the same video source. Each version is referred to as a description and transmitted separately over unreliable networks. Each description can provide a degraded version of the video source independently, when the finer reconstruction of quality can be obtained with increasing number of descriptions received. Generally the decoding of part of descriptions is known as side decoding associated with side distortion, while the decoding of all the descriptions is called central decoding with the smallest central distortion.

Various methods have been developed to produce multiple descriptions, which can be classified into pre-processing-based MDC, encoding-based MDC and post-processing-based MDC. In the preprocessing-based MDC, the original source is split into multiple subsources before encoding, and then subsources are encoded separately to generate multiple descriptions. For encoding-based MDC, the one-to- multiple mapping is performed by dedicated coding techniques such as MD scalar quantization, MD lattice vector quantization and MD correlating transform. The postprocessing-based MDC realizes the one-to-multiple mapping in the compression domain by transforming an encoded bitstream into multiple streams such as FEC-based MDC.

Error Resilience

One of the key challenges in P2P video streaming is to make content distribution resilient to peer transience. A natural approach to this problem is to introduce redundancy by transmitting redundant video over multiple paths in the networks. Split Stream system strips data across multiple multicast trees to tolerate faults. Another tree-based P2P system CoopNet in firstly uses MDC to introduce redundancy in the transmitted video content and strips them over multiple distribution trees like that in the Split Stream system. Constructing and maintaining an efficient distribution tree among the overlay nodes is a key issue in tree-based P2P systems.

In, the video streaming server, the root in the tree collects the information of all the nodes for tree construction and then maintenance. Such the centralized algorithm is efficient, but relies on a powerful and dedicated root node. Multiple multicast trees are constructed by spanning interested peers. As the peer nodes and their last-hop links are likely to be the causes of interruption, CoopNet focuses on building short and diverse trees to achieve the objective of resilience. Each peer is generally made an interior forwarding node in a few trees and a leaf node in the rest of the trees.

CoopNet MDC System Architecture

The video frames to be distributed are partitioned into groups of pictures (GOPs).Each GOP will then be independently encoded, error protected and packetized into N descriptions. For each GOP, a scalable bitstream is produced and rate-distortion information of this bit stream is collected. The expected distortion of a GOP, $\sum_{n=1}^{N} D(R_n)\, p(n)$ is minimized producing the rate points $R_1, R_2, R_3 \ldots R_N$ for optimal packetization, where the probability of receiving n out of N packet p(n) can be computed based on computed based on the feedback received from clients. Using these optimal rate points $R_1, R_2, R_3 \ldots R_N$ forward error correction codes (FEC) are added to protect these data according to their priorities producing N equally important descriptions.

These MDC descriptions are stripped across multiple multicast trees spanning the interested peers. The number of distribution trees can be equal to or smaller than the number of descriptions. Each peer receives substreams over a diverse set of paths. In case of failures of some nodes, it is highly likely that normal peer nodes will continue to receive majority of the descriptions and hence be able to reconstruct a video of reasonable quality. Similar to CoopNet, many other researchers advocate the use of transmitting MD coded video over multiple application-layer multicast trees. As a peer node in the mesh-based systems maintains relationships with multiple dynamic supplier peer nodes, delivery of MD coded video from multiple peers in mesh-based systems enhances its resilience to error as well. The benefits on video streaming are follows as,

a) When a server peer disconnects, client only loses a single description.
b)Each description has a low bit-rate.
c)Spread the load over the serving peers.
d)Multiplexing gains in the core networks.
e)Prevent illegal access to the video.

Conclusion

In this paper, we present a survey of P2P video streaming systems that leverage MDC to achieve robust. The MDC technique can provide a good solution for video streaming in a stable network in the case of a low packet loss rate, while MDC is more suitable for dynamic P2P networks with a high packet loss rate. Peer-to-peer networking with multiple description video coding is a promising technique for an on-demand video streaming service. Video quality can be maintained in the face of peer departures. Increasing the number of descriptions can improve the system performance.

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