A Modeling Framework for Performance Analysis of P2P Live Video Streaming Systems

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Abstract. Client/server media streaming systems exhibit streaming limitations when number of clients rises and the server can no longer sustain the upload load. At first, IP Multicast was proposed as an alternative solution to this problem but its deployment brought many practical issues in scalability and deployment that prevented it from wider use. Recently, a new promising technique emerged which is cost effective, easy to deploy and can support thousands of simultaneous users. It's a peer to peer network of logically connected clients which form an application level overlay network on top of the physical network. This new paradigm brings numerous advantages, but also a lot of open issues that need to be resolved. This paper exposes the fundamental characteristics of p2p live video streaming systems, gives a survey of p2p video streaming applications and presents a novel modeling framework for performance analysis of such systems as our main goal in future research.

Keywords: Petri nets, p2p networks, IP video broadcast, performance analysis.

1 Introduction

Today, the use of Internet video streaming services is spreading rapidly. Web locations for live video broadcast attract more visitors every day. In the classical client/server system architecture the increase in number of clients requires more resources in manner of high bandwidth transmission channels with large upload rates. Since they are extremely expensive it results in a limited number of unicast connections that a server can support at a given time.

In the early '90^s it was expected that IP Multicast will be the natural technology to satisfy the requirements of large number of users with lower cost. However, lack of support for functionality of higher level, scalability issues and requirements for hardware Internet technology changes have prevented its wider deployment. In the last decade, the limited deployment of IP Multicast has motivated the science community to work in the field of new approach for Internet video streaming by use of Peer to Peer networking technologies. In this paradigm every user (peer, node) maintains connections with other peers and forms an application level logical network on top of the physical network. Video stream originates at a source and every peer acts as a client as well as a server forwarding the received video packets to the next peer.

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P2P logical network is used to deliver video without the need of broadband server connections. This class of "One to Many" video streaming is easy to deploy because p2p technology does not require network infrastructure support and offers scalability of resources having peers act as clients or servers, leading to small bandwidth server being able to transmit video to hundreds of thousands of users. P2P networks have huge economical benefit in deploying and managing IP video streaming, but brings a lot of open issues and research challenges that need to be tackled. Besides the existing numerous applications, p2p video streaming systems are still in the early stages.

This paper is organized in 5 sections. Section 2 gives detailed overview of P2P streaming system's characteristics, technical challenges and issues that need to be addressed when modeling and designing p2p video streaming system for live video broadcast. Section 3 presents overview of existing p2p video streaming solutions. In section 4 our idea for new modeling framework for performance analysis of p2p video streaming systems is presented and the paper is summed up with concluding remarks.

2 Technical Characteristics of P2P Live Video Streaming Systems

Two types of data are used in these logical p2p networks. First type of data is control data that is used to organize participating peers into a logical topology on top of the underlying physical network, and manages connections between parent and child peers (*Control Scheme*). Second type of data is the data that needs to be disseminated through the network which in this case is the video data (*Data Scheme*).

Control scheme. Control scheme forms three different types of logical topologies used in such systems: Tree, Mesh or Hybrid. The tree topology can be formed as a single spanning multicast tree [10], [13], [14], [17], [35], [36], or multiple multicast trees [1], [3], [5], [6], [7], [8], [11], [15], [16], [18], [23], [24], [27], [30], [45], [46], [47], [53] where the root of the tree is the video source. Mesh topology, also called Unstructured, does not form any firm logical construction, but organizes peers in swarming or gossiping like environment [2], [4], [9], [19], [20], [21], [22], [25], [26], [29], [31], [32], [34], [38], [39], [40], [42], [48], [49], [50], [51], [52]. In hybrid systems combination of tree and mesh constructions is used [28], [37], [43].

Data scheme. In combination with control scheme, data scheme forms several different approaches for video data dissemination in p2p networks. *Source driven* approach means that data scheme is built as a tree on top of the control scheme, where data is pushed down the tree from the root (source) to the leaves (peers). This approach is also called Push based approach. Typically source driven approach forms tree data scheme on top of tree control scheme [14], [17], [18], [49], but some p2p protocols build tree data scheme on top of mesh control scheme such as Narada [2]. *Data driven* approach is data oriented and doesn't form data distribution trees. Instead peers periodically exchange information about pieces of video data they possess, and every piece of data is explicitly requested. This approach is also called Pull based approach [19], [51]. There are many efforts that combine these two approaches (Push/Pull) and present substantial results [21], [28], [29], [31], [40], [43]. At