A Step Towards Understanding Joost IPTV

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***Abstract*— Recently, Peer-to-Peer (P2P) streaming applications have drawn attention to both users and research community. The P2P approach for IPTV has the appealing feature of providing TV-like quality content distribution service (for both on-demand and live TV), which has been attracting a large number of users from across the globe. However, there is very little understanding about their network architecture and resource consumption. This work aims at having an in-depth understanding of Joost, a Video-on-Demand P2P system for distributing TV content, created by Skype and Kazaa founders. Results show that Joost relies on UDP for content delivery with an asymmetric bandwidth consumption of until 750 Kbps (download) and 480 Kbps (upload). We also evaluated the Joost control plane, which is mainly based on TCP. Along with other P2P IPTV technologies, such systems could have a great impact on network bandwidth utilization, even more than P2P file transfer ones.**

I. Introduction

The Internet has been witnessing an ever increasing interest on video streaming applications, headed by the YouTube phenomenon. A straightforward consequence is that the network traffic patterns and volumes changed suddenly. Previously, Peer-to-Peer (P2P) file sharing applications have been dominating the network traffic for some years, but now it is being challenged by video streaming [1]. All changes of this nature pose significant new demands on ISP network management and operation, as the differences in traffic profiles and volumes require different strategies. However, most of the current video streaming solutions (also YouTube) are based on the traditional client/server model, which sometimes is assisted by the use of content distribution networks (CDN) for providing additional performance to their users.

Recently, P2P streaming applications have drawn attention to both users and research community [2]. The P2P approach for IPTV has the appealing feature of providing TV-like quality content distribution service (for both on-demand and live TV), which has been attracting a large number of users from across the globe. Compared to client/server solutions, the main advantage of P2P streaming for ISPs is an increased cost-effectiveness, since the network capacity costs are shared among the participating peers, and self-scalability, since the more peers take part of the network, the more resources are available for exchanging the media data.

The main motivation for this paper is obtaining a better understanding of Joost [3], a Video-on-Demand P2P system for distributing TV content. Although other P2P video streaming applications exist, they have a more limited scope, since they generally fall into three not exclusive categories: regional applications (most Chinese) with content and users from specific communities, such as PPlive [4] and PPStream [5]; academic applications, such as Coostreaming [6] and AnySee [7] and applications that rely basically on unauthorized content, such as TVU Networks [8].

Our experiments revealed interesting results. In all time periods observed, most data received by a peer is provided by the top 5 contributors, whereas practically 100% is provided by the top 10 contributors (parent peers). Along with other evidences, this makes us believe the Joost relies on a mesh-based P2P streaming overlay. Another finding is related to peer stability. Usually, most peers that are actively transmitting in the beginning of the session are not the same at the end of the session. Also, we observed the Joost has a NAT detection mechanism where peers under the same NAT tend to serve each other preferentially.

The rest of the paper is structured as follows. Section II presents background and related work. Section III contains the methodology used in our experiments, whereas the results are presented in Section IV. Finally, Section V draws some conclusions and topics for future work.

II. Background and Related work: P2P Video Streaming and Joost

Video-on-demand (VoD) is a really popular service in today's Internet. Since this service mainly relies on a client-server approach to content distribution, in [9] the authors consider the design and benefits of providing VoD with the support of P2P technology. In [10], the authors study algorithms that provide high-quality VoD in a mesh-based P2P network, and proposed the use of network coding techniques for improving the overall efficiency. In [14], the authors present an analysis of the traffic generated by several popular P2P IPTV applications, such as PPLive, PP-Stream, SOPCast and TVAnts. In [15], they also evaluate the performance of PPLive and SOPCast, but from a different perspective. Their main contribution is a definition of a generic framework that can be used to evaluate performance

978-1-4244-2066-7/08/$25.00 ©2008 IEEE

of IPTV P2P systems. In [16][17], the authors propose P2Cast - an architecture based on a peer-to-peer approach to stream video using the patching technique. In [18], the authors designed and implemented a prototype of a P2P VoD system with DVD-like features called BulletMedia. The authors in [19] provide the results of some experiments on popular P2P streaming systems, such as PPLive, Coolstreaming, Anysee. Their main contribution is the identification and discussion of key trade-offs between bandwidth, buffers, and latency in the design and deployment of large-scale P2P streaming. In [20], the authors present the practical experience of GridMedia in broadcasting live content. They aimed at understanding P2P Live TV systems.

Regarding to Joost, the application was conceived with an innate built in Internet-like functions, such as chat between viewers and user program ratings. From the economic point of view, according to The Wall Street Journal, "*it could undermine the consumer market for cable and satellite TV packages and provide an alternative distribution channel for TV content owners*"[11].

In Joost's video content distribution and infrastructure requirements, Joost nodes are the main original providers of content. In fact, Joost servers handle the long-tail characteristics of the Internet content, which the infrequent video programs will be hosted within their infrastructure whereas popular programs are mostly wide available at peer's cache. Its P2P protocol shares the library with Skype which is mainly based on some well-known features, such as the use of UDP as the transport protocol.

III. METHODOLOGY

The experiments were performed using Joost software version 0.11.0, running into Windows XP service pack 2. We performed two sets of passive experiments collecting traffic from three sniffed PCs tuned on Reuters channel, at a campus network with 100 Mbps rate. The experiments were set into two scenarios (Figure 1), the first one using public IP (Public-IP) addresses and the second one using IP addresses under NAT (Under-NAT). shows these two evaluation scenarios.

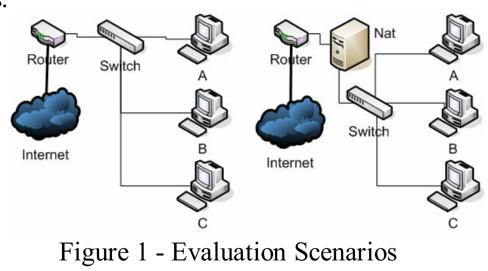

Figure 1 - Evaluation Scenarios

We choose Reuters channel based on the criterion of popularity, since it is included into the most popular index ranked by Joost application. We used a sniffer tool developed in C++ to capture only packets generated by Joost application, and also developed a set of scripts to analyze collected trace data.

The first set of experiments collected network traffic using public IP addresses on 08/15/2007 during 1h30min, starting from 18h00min. The second set of experiments collected traffic measurements using IP addresses under NAT during 1 hour on 08/22/2007, starting at the same time 18h00min. Table I shows the collected trace volume in Mbytes.

TABLE I. TRACE VOLUME (IN MBYTES)

PC	Public IP	Under-NAT
A	552.54	277.34
B	487.94	279.30
C	511.00	272.26

Toward a deep knowledge about network requirements and peers behavior at Joost network, we employed a set of common network measurement metrics combined with the peer-based ones. For the exploratory data analysis we have used network metrics such as *traffic volume per protocol*, *packet size* and *throughput*.

In order to understand the data plane dynamics, we studied the peer download policy and set up two metrics: *total volume per* peer and *peer volume per bin*. The *total volume per peer* metric shows the peers with a majority of data volume contributions during the complete period of measurements. The *peer volume per bin* shows how the volume of the top contributor peer accounted to the total volume of each bin (e.g. 1 minute).

IV. EXPERIMENTAL RESULTS

A. *Exploratory Data Analysis*

1) *Traffic Volume TCP X UDP*

Joost relies on UDP, with an average of 99% of all data volume. The choice of UDP Protocol to transport video segments is probably due to stringent time delivery for this kind of applications. It is worth mentioning that some P2P IPTV systems (e.g. PPStream, PPLive) rely on TCP, whereas TVAnts is more balanced between TCP and UDP [14].

As expected for VoD systems, we observed that downloaded UDP volume is similar for all peers. For the public IP addresses scenario, exactly 99.7% of collected data traffic from all peers is UDP, and for the under-NAT scenario, an average of 99.4%. Figure 2 shows the average UDP and TCP volume.

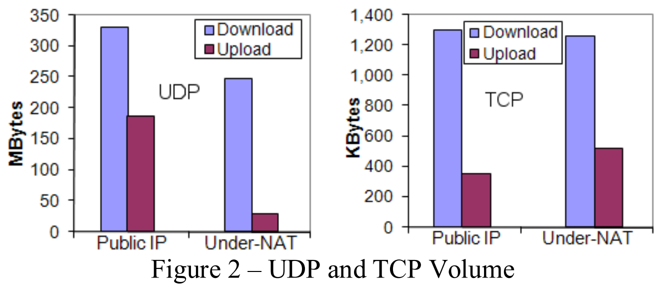

Figure 2 – UDP and TCP Volume

2) *Packet Size:*

In order to analyze the data plane we first need to separate control and data traffic. Figure 3 and Figure 4 show the packet size histograms for download and upload traffic.

We observe that there is a large number of TCP packets of small size, mostly fewer than 200 bytes for both at download and upload streams. These packets are basically acknowledgements. For UDP packets, we observed packet sizes of 1083 bytes and they carry data traffic [12].

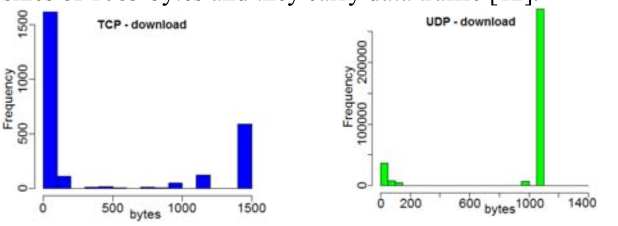

Figure 3 - Download packet size TCP and UDP

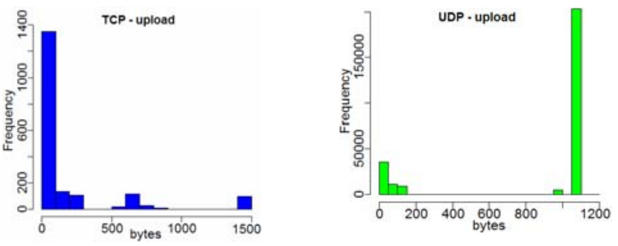

Figure 4 - Upload packet size TCP and UDP

3) *Throughput*

From the ISP's network management perspective, it is crucial to analyze bandwidth utilization for any application. The bandwidth requirements for the three peers are similar. Therefore, due to space constraints we will only present peer B traffic patterns. Figure 5 shows that the download throughput for Public (DL Public) and Under-NAT IP (DL NAT) scenarios presents a similar average, around 500 Kbps. Public IP scenario presents lower variation, ranging between a maximum of 750 kbps and a minimum of 320 kbps. For the NATed peer, we observe a traffic pattern a ranging from 300 kbps to 800 kbps.

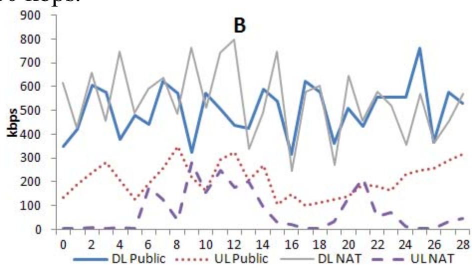

Figure 5 - Peer B Throughput

The upload rate for Public IP (UL Public) is around 200 Kbps, whereas for the Under-NAT IP (UL NAT) we see greater variation. For the NATed peers, we observe that at the beginning of the measurement period there is no data being uploaded to other peers. There are some possible explanations for this behavior. First, most algorithms for *hole punching* at NAT tables can take a considerable amount of time to open connections to NATed peers. Second, some Joost algorithms are IP prefix-aware, which means there are some intelligence to discover peers in the network neighborhood, which can also delay the beginning of sending video content to their partners.

B. Understanding the Data Plane

Continuous changing, activity and dynamism are intrinsic characteristics of P2P live streaming systems. In this section we try to understand the dynamics of data plane. For this analysis we consider just video data traffic, i.e., UDP data packets larger than 1 Kbyte. We studied the peers' contributions along the time and measured how much traffic each top peer accounts to the total volume received (*general top peers*) and how much the top peers are contributing with traffic for each bin (*top contributor by peer*).

B.1 General Top Peers

This analysis aims at understanding how peers are contributing to the total volume of video data. We used the metric *total volume by peer* in order to show the amount of data that a specific peer is contributing for the video stream.

Figure 6 shows the percentage of downloaded data received by this peer from the general top peers. It is clear that the top peer is always contributing with a significant portion of data. We also observe certain equilibrium from the second to the tenth top peer.

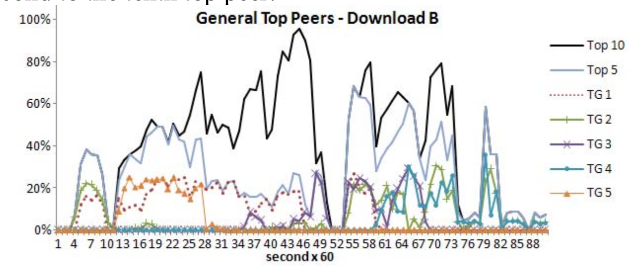

Figure 6 - General Top Peers – Download to Public IP B

Figure 7 and shows the percentage of the general contribution among peers along the time. In addition we observed that some of the top general peer contributors are Joost servers. From the analysis of data exchange under NAT we intend to understand how Joost mechanism deals with locality. We observed that there is cooperation between those peers. As the first peer to start the video was peer A, this peer sent data to the others as soon as they were tuned into the same channel. As depicted by Figure 7, the top peers that uploaded data from peer A were B(92%) and C(80%).

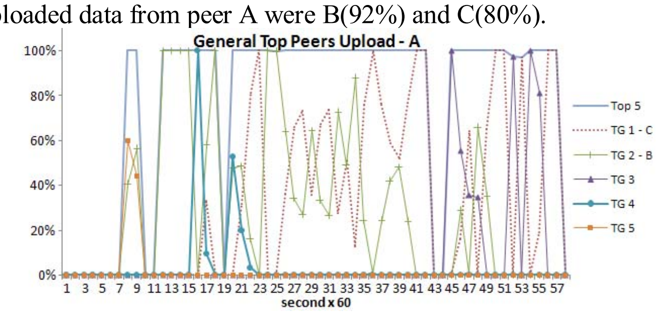

Figure 7-General Top Peers–Upload from Under-NAT IP A

B.2 Top Contributor Peer per bin

We used another metric, called *peer volume per bin* that calculates the top contributor peer into a specific time bin. The main goal here is to infer the dynamics of peers and the construction of the overlay network infrastructure. It will eventually be possible to evaluate the content delivery method associated to the overlay construction. For instance, it is typical for a mesh-based overlay to deploy pull-based mechanisms for delivering data. The Figure 8 shows the top peer contribution per one-minute bin for peer B (Public IP). Please note that in consecutive bins the Top Contributors peers (TC) are not necessarily the same ones. This is a typical behavior for mesh-based P2P networks.

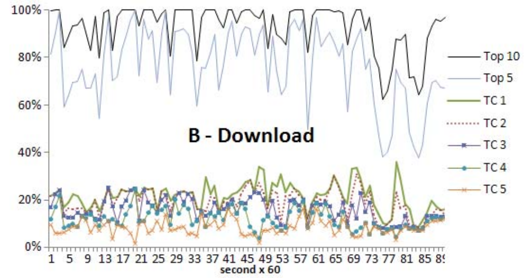

Figure 8-Peer contribution per bin–Download to Public IP B

We observe the top ten peers providing almost 100% of traffic along the time, except for the last 20 minutes. Also, each top contributor in each bin contributes with a few less than 20% of data. showing that a video segment is provided by at least five peers per bin. We can conclude that there is a high changing rate for those peers that effectively contribute with content. In other words, the top contributors in a specific bin are not the same for the next one.

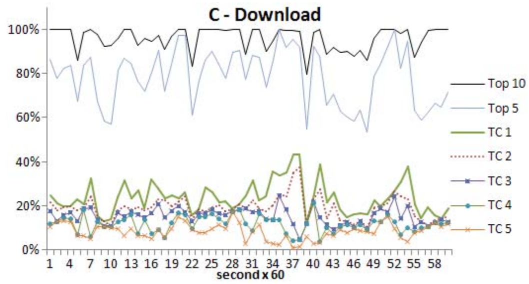

Figure 9 - Peer contribution per bin – Download to Under-NAT IP C

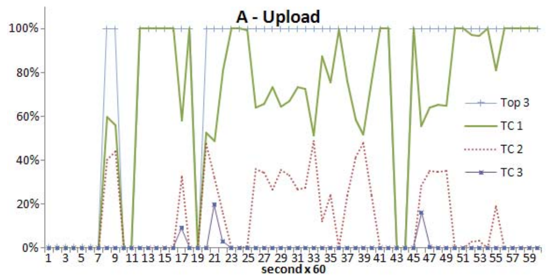

Figure 10 - Peer contribution per bin – Upload from Under-NAT IP A

V. CONCLUDING REMARKS

Joost is a P2P video streaming application with the potential of becoming one of the most contributors to traffic in the Internet in a near future, which may have significant impact on the operation and management of typical ISPs. In this paper, we conducted some experiments with Joost, mainly at the peer level, for understanding its basic traffic behavior.

Our results show that in all time periods observed, most data received by a peer is provided by the top 5 contributors, whereas practically 100% is provided by the top 10 contributors (parent peers). Along with other evidences, this makes us believe the Joost relies on a mesh-based P2P streaming overlay. Another finding is related to peers stability. Usually, most peers that are actively transmitting in the beginning of the session are not the same at the end of the session. However, there is a high probability that the top 10 contributors remain the same in consecutive time periods (bins). Also, we observed the Joost has a NAT detection mechanism where peers under the same NAT tend to serve each other preferentially.

As future work we intend to observe Joost as a moving target, by performing similar experiments periodically. Also, we intend to perform a comparative study with other P2P streaming applications.

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