Delay-Insertion-Based P2PTV Traffic Localization Using AS-Level Topological Information

Chitapong Wechtaisong, Hiroaki Morino and Takumi Miyoshi
Graduate School of Engineering and Science
Shibaura Institute of Technology
Tokyo, Japan
{nb13505, morino, miyoshi}@shibaura-it.ac.jp

***Abstract*— Most P2PTV systems select a neighbor peer in an overlay network by RTT or a random method without an underlying network consideration. Streaming traffic is shared on network without localization awareness, which is a serious problem for Internet Service Providers. In this paper, we present a novel scheme to achieve P2PTV traffic localization by inserting additional delay into P2P streaming packets. The additional delay length depends on the AS hop distance between the viewer and neighbor peer, which represents a realistic network topology distance. The results of our experiments is conducted in a real network show that our proposed scheme can perform efficient traffic localization of P2PTV applications.**

Keywords— Traffic localization, P2PTV, AS hop distance

I. INTRODUCTION

The demands of internet use are rapidly increasing, especially for internet video. Cisco forecasted that internet video traffic will constitute three-quarters of total internet traffic, 1.0 ZB, in 2018 [1]. P2P video streaming services called P2PTV have recently received attention due to greatly reducing the server load compared to conventional unicast-based services. P2PTV services exploit P2P multicast for live streaming and P2P for the delivery of recorded video to alleviate server load. Many P2PTV services such as PPLive, SopCast and PPstream are widely used with personal computers and portable devices, encouraging the increasing amount of video traffic on the Internet.

Although video streaming based on P2P is beneficial for reducing the server load, existing studies that analyze the network traffic caused by the current P2PTV services note that there are many cases in which the content delivery paths are not efficient in terms of network bandwidth utilization [2-3]. For example, each peer tends to select its upstream peers among the ones in different Internet Service Providers (ISPs), even though there are other peers joining the same P2PTV session in the same ISP. Network traffic crossing different ISPs generally increases the cost for both ISPs, and thus traffic localization in P2PTV is a prominent issue to be addressed.

Existing schemes for traffic localization in P2PTV can be classified into two categories: centralized control and decentralized control. In centralized control, ISPs cooperate with P2P services and operate an oracle service to provide them with information about underlay networks [4-6]. Although this approach can achieve high efficiency for traffic localization, there will remain the difficulty in cooperation between every P2P service and every ISP. In contrast, in decentralized control, each peer independently estimates the network distance towards their neighbor peers, such as router hop count or the ISP information they belong to, and also estimates network performance, such as delay or packet loss, and then selects appropriate upstream peers [7-10]. This approach is easier to deploy in that the disclosure of topology information by ISPs is unnecessary. In particular, the delay insertion scheme [9, 10] has the advantage that it does not require modification to P2P application software. However, the current scheme exploits coarse-grained distance information of whether the peer and the other peer belong to the same ISP or not, and the benefit of traffic localization is exhibited for limited peer distribution patterns. In this paper, we present a novel P2PTV traffic localization system based on the delay insertion scheme by exploiting a finer-grained network distance between peers based on ISP information. Our purpose indirectly leads the P2PTV application to operate so that a peer shares video packets with neighbor peers to which the network distance in the units of AS (Autonomous System) is as small as possible. This goal is achieved by inserting an additional delay into each data packet, where the amount of inserted delay is in proportion to distances between peers in terms of AS hops.

The rest of paper is organized as follows. We presents an evaluation methodology in Section 2. Section 3 present the finding of our experiment and conclude the paper in Section 4.

II. DECENTRALIZED TRAFFIC LOCALIZATION USING NETWORK DISTANCE INFORMATION

A. Methodology

As mentioned before, network traffic across ISPs generally creates extra cost for both ISPs. Thus, we focus on the number of different ASs (Autonomous Systems) through which a logical link connecting two peers passes in P2PTV and name this value the “AS hop distance” of the link. For example, the AS hop distance of a link is zero when two peers belong to the same AS, and it is one when two peers belong to

different ASs that are directly connected. We aim to localize P2PTV traffic by letting each peer establish logical links to neighbor peers with as small an AS hop distance as possible.

Our scheme is based on P2P-DISTO [9], which induces a logical link reestablishment preferable for traffic localization in P2PTV by intentionally inserting a delay for each packet depending on its destination address. This approach takes advantage of typical current P2PTV services' behavior, in which each peer tries to select its upstream peer so that the link delay to the peer is smaller than to any other peer. For example, by inserting a delay only for packets whose destination IP address belongs to a different ISP from the source peer's IP address, the source peer is less likely to select peers on a different ISP as its upstream peer because the RTT between the source peer and these peers becomes longer through the delay insertion.

To enhance the accuracy of traffic localization in this approach, our scheme introduces the new AS hop distance, defined above, as a metric to decide the value of the inserted delay in P2P-DISTO. Figure 1 illustrates the concept of the proposed scheme. It inserts a delay for each packet at the gateway router closest to the source terminal, and the amount of inserted delay is proportional to the AS hop distance between the source and the destination terminal.

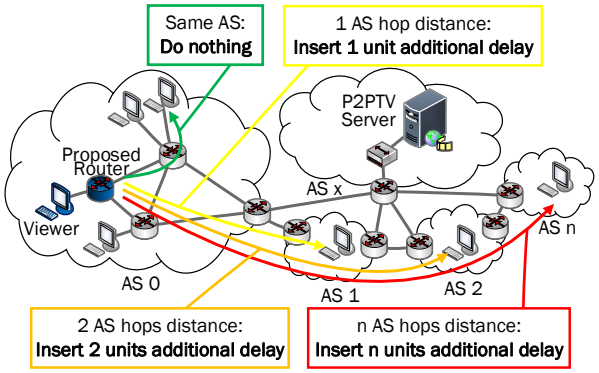

Fig. 1. Conceptual delay insertion relate to AS hop scheme.

Here, the amount of delay inserted for packets destined for the peer with h AS hop distance $t_{delay}(h)$ is defined as

$$t_{delay}(h) = t_{unit} \cdot h \qquad (1)$$

Here, t_{unit} is a constant time unit that will be configured depending on the characteristics of the underlying networks or P2PTV services. This delay differentiation will force the P2PTV application to maximally share streaming data with two peers within the same AS or a small AS hop distance away from each other.

B. Mechanism of delay insertion based on AS hop distance

The proposed IP router architecture were explained in [9] whose functions are screened P2PTV packets, identified AS hop information and inserted additional delay. The amount of delay to be inserted by using equation (1). We apply dummynet [11], a standard facility of FreeBSD, as the delaying function. In this architecture, the AS hop distance calculation module is the newly developed function to enable delay insertion for the packets depending on their AS hop distance. The AS hop distance is calculated using AS-path information, the route history of the BGP (Border Gateway Protocol) packets recorded in the packets themselves. The router periodically retrieves AS path information from an Internet topology database, such as the one in the RIPE Network Coordination Centre [12]. The router collects AS-path data, which either originate the AS in which the router is located or contain the AS as an intermediate AS. Using this AS-path information, an AS hop distance dataset can be created, as shown in figure 2, in which the AS number where the router is located is 4713. If the AS the destination peer belongs to is missing from this dataset, we use the hop count of the shortest path towards the destination AS derived by using AS neighbor information stored in the topology database. The estimation of Internet topology between ASs has been extensively studied, and it is reported that a path between a pair of ASs can change dynamically in certain cases [13]. The AS hop distance dataset obtained by actual routing information represents a realistic physical topology, and thus, we believe this approach of calculation to be effective enough to justify the benefit of the proposed scheme.

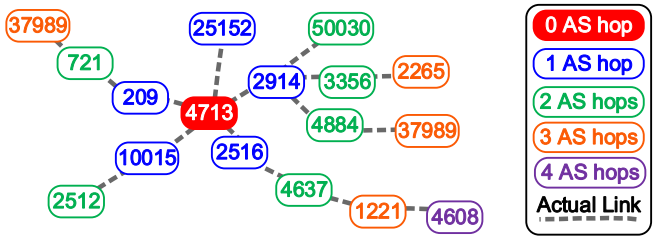

Fig. 2. An example of an AS hop distance database constructed using the collected AS-path data.

III. Performance Evaluation

A. Evaluation Environment

We implemented the proposed router on a PC with FreeBSD release 9.2, Intel Core i7 3.5 GHz processor, 8 GB RAM. We captured all the packets entering the router using the packet capture library (`libpcap`), obtaining the source and the destination IP address. The identification of AS number for each IP address is performed using the GeoLite ASN database [14]. For the delay insertion, we applied dummynet which allows emulation of bandwidth limitation, packet delay and packet loss.

The Internet access line of 100 Mbps was served by Open Computer Network (OCN), a major internet service provider in Japan. The proposed router was placed to connect the Internet access line and the private network accommodating the P2PTV peers. A statistical measurement function was implemented in the proposed router to capture traffic statistics. Three PCs were configured as P2PTV viewer peers in the private network for concurrent performance evaluation of the

P2PTV application under conditions with and without employing the delay insertion scheme at the proposed router. The delay insertion to P2P streaming packets is conducted in both the upload and the download links. Three peers simultaneously started to play the same TV program to obtain fair experimental results.

We used PPLive version 3.5.5.0815 in this experiment and played the drama program at the live channel. The average bit rate of this video streams was 354 kbps. Time duration of each experiment was 10 minutes.

B. Results

Figure 3 presents the cumulative amount of data received at the viewer peer versus the AS hop distance of each packet, while viewing PPLive programs. When the proposed delay insertion is applied, the data received from peers with low AS hop distance, which are either in the same AS as the viewer peer or in ASs one AS hop distance from the viewer peer, is more than half the total data size, 55% for the t_{unit}=100 ms scheme and 66% for t_{unit}=200 ms scheme. In contrast, only one-third of total packets were received from peers with low AS hop distance in the existing PPLive, shown as "no delay control". This result shows that the proposed scheme reduces traffic from peers with large AS hop distances.

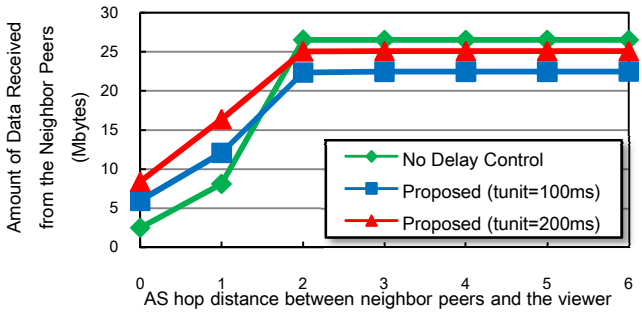

Fig. 3. Cumulative amount of data received for PPLive.

In the case of t_{unit}=100 ms and t_{unit}=200 ms, the total amount of data was reduced by approximately 15% and 5%, respectively, compared to the existing scheme. The reason the total data amount decreases with additional delay insertion is inferred to be that the PPLive application at the viewer peer judged logical links to some of the neighbor peers to be inappropriate to maintain sufficient video quality in terms of delay and quit some of the connections. We note that it nevertheless maintained good quality of video streaming in the case of t_{unit}=200 ms, presumably due to adaptive video coding control equipped with the PPLive.

IV. Conclusion

We presented a novel decentralized traffic localization scheme for P2PTV applications, in which the ISP's edge routers insert an additional delay for P2P streaming packets depending on the AS hop distance between peers to induce establishing logical links between peers with lower AS hop distances. Our experimental results showed that applying the proposed scheme achieved efficient P2P traffic localization, in which each peer downloads streaming packets from the neighbor peers in the internal AS or ASs with smaller AS hop distances. In addition, it was confirmed that sufficient streaming quality was maintained when the number of neighbor peers that are connected is smaller and the total amount of download traffic is reduced by inserting additional delay. The proposed scheme does not exploit the behavior of specific P2PTV services and can be applied to new services without modification of the software at each peer or at the streaming server. Additionally, in terms of deployment, the adoption of this scheme only by ISPs that need to reduce inter-AS traffic is sufficient to achieve the benefit for the ISPs, and collaboration with other ISPs is not necessary. However, considering available bandwidth between peers is need for reliable of video quality. We will develop bandwidth estimation function for our proposed router in the next study.

References

[1] Cisco Systems Inc., "Cisco visual networking index: Forecast and methodology, 2013-2018", White Paper, Jun 2014.

[2] T. Karagiannis, P. Rodriguez and K. Papagiannaki, "Should internet service providers fear peer-assisted content distribution?", Proc. of the Fifth ACM SIGCOMM conference on Internet Measurement (IMC '05), pp. 1-6, Oct 2005.

[3] S. Ali, A. Mathur and H. Zhang, "Measurement of commercial peer to peer live video streaming.", Proc. of ICST Workshop on Recent Advances in Peer-to-Peer Streaming, pp.1-12, Aug 2006.

[4] V. Aggarwal, A. Feldmann and C. Scheideler, "Can isps and P2P users cooperate for improved performance?", ACM SIGCOMM Computer Communication Review, vol.37, no.3, pp. 29-40, Jul 2007.

[5] H. Xie, Y. R. Yang, A. Krishnamurthy, Y. G. Liu and A. Silberschatz, "P4P: Provider portal for applications", Proc. of the ACM SIGCOMM 2008 conference on Data communication , pp. 351–362, Aug 2008.

[6] J. Seedorf, S. Kiesel and M. Stiemerling, "Traffic localization for P2P-applications: The ALTO approach", Proc. of the Ninth IEEE International Conference on Peer-to-Peer Computing (P2P' 09), pp. 171-177, Sep 2009.

[7] S. Lijie, D. Xuewen, S. Jianfeng and X. Kun, "Traffic locality in the emule system", Proc. of the First International Conference on Networking and Distributed Computing (ICNDC), pp. 387-391, Oct 2010.

[8] R. Lopes Pereira, T. Vazão and R. Rodrigues, "Adaptive search radius – using hop count to reduce P2P traffic", Computer Networks, vol.56, no.2, pp. 642-660, Feb 2012.

[9] T. Miyoshi, Y. Shinozaki and O. Fourmaux, "A P2P traffic localization method with additional delay insertion", Proc. of the Fourth International Conference on Intelligent Networking and Collaborative Systems (INCoS), pp. 148-154, Sep 2012.

[10] H. V. Hiep, Y. Shinozaki, T. Miyoshi and O. Fourmaux, "A router-aided hierarchical P2P traffic localization based on variable additional delay insertion", IEICE Transaction on Communications, vol.E97-B, no.1, pp. 29-39, Jan 2014.

[11] Dummynet. [Online]. Available: http://info.iet.unipi.it/˜luigi/dummynet/

[12] RIPE NCC. [Online]. Available: http://www.ripe.net/

[13] M. Roughan, W. Willinger, O. Maennel, D. Perouli and R. Bush, "10 lessons from 10 years of measuring and modeling the internet's autonomous systems", IEEE Journal on Selected Areas in Communications, vol.29, no.9, pp. 1810-1821, Oct 2011.

[14] MaxMind and GeoIP, "IP address location technology." [Online]. Available: http://www.maxmind.com/app/ip-location/.