LONGER, BETTER: ON EXTENDING USER ONLINE DURATION TO IMPROVE QUALITY OF STREAMING SERVICE IN P2P NETWORKS

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ABSTRACT

During recent years, the Internet has witnessed a rapid growth in deployment of peer to peer (P2P) based live media streaming systems. In this paper, we are motivated to investigate the problem of improving the streaming quality of service (QoS) of those systems by two universal recognitions: one is that the understanding to practical service experiences would benefit the performance enhancement, while the other is ”the more, the better” design philosophy in P2P networks. As an interesting approach, we first retrieve the practical online duration information of end users from service traces in our GridMedia system, and then intentionally extend the online duration of each peer, which would result in a more stable peer overlay. The comparative simulations with original real-world traces and modified ones demonstrate that the quality of streaming service would be better if peers stay longer in the community. We claim that, this simple but positive result essentially validates both the influence of end users' behaviors and the need of an incentive to encourage users to spend more time in P2P live streaming systems.

1. INTRODUCTION

The increasing growth of Internet and digital content industry introduces a new area of interaction between huge volume of information and end users. Particularly, streaming media contents, especially in the form of synchronous video and audio, to a large population of end users remains interesting and challenging. Due to the difficulty of Internet-wide deployment of IP multicast, the Internet has witnessed a rapid growth in deployment of peer to peer (P2P) based live media streaming systems, which, requiring minimal infrastructure, offers the most promising alternative to support large-scale [1-3]. In a typical P2P networks, each peer, also interchangeably termed node or user, plays the role of both client and server, removing most of load from the streaming source to the network edge. The cooperative paradigm among numerous end users has been evidenced by over 200,000 concurrent online users with relatively high bit rate (300-500 Kbps) by only one streaming server over the global Internet[2,3].

To improve the performance of P2P live media streaming systems, most papers in academia focused on either overlay construction protocols [4-7] or streaming scheduling algorithms [8,9]. However, since ”P2P reflects human society better than other types of computer architectures” [10], for instance, the high churn rate (that is, peers join or leave the system frequently and independently), *how to improve the streaming quality of service(QoS) with the practical user behaviors* is still a challenge issue and with few discussion.

Motivated by two universal recognitions in P2P networks-one is that the understanding to practical service experiences would benefit the performance enhancement, while the other is ”the more, the better” design philosophy-, in this paper we mainly make an interesting and different approach to catch the interplay between QoS and user behavior model. As the echo to first motivation, we retrieve the practical online duration information from service traces in our GridMedia system, which was deployed by CCTV to live broadcast Spring Festival Evening show with more than 200,000 concurrent online users in Jan. 2006. It could be observed nearly 30% users would leave the system in 180 seconds, exhibiting high dynamics in peer community. As the second echo, we intentionally extend the online duration of each peer with extra certain seconds, say 60 to 120 seconds, aiming to to examine the system performance in terms of a longer-life peer community. The comparative simulations with original real-world traces and modified ones demonstrate that *the quality of streaming service would be better if peers stay longer in the community*. Intrinsic to this simple but positive result is the more stable peer-pair cooperation and in turn the better streamed pipelines among those peers. We claim that, this paper contributes to the validation, in a more practical way, of both the influence of end users' behavior and the need of an incentive to encourage users to spend more time in P2P live media streaming systems

The balance of this paper is organized as follows. Sec.2 briefly reviews the related work. Sec.3 presents the practical online duration of end users from the service traces, as well as the extended online duration model, both of which would be leveraged to drive the comparative simulations in Sec.4.

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Sec.5 discusses future work and ends this paper.

2. RELATED WORK

At the system design stand, a rich body of literature discussed application layer multicast or overlay multicast approaches [1-9] in past years to tackle with the scalability problem without the need of network infrastructure support. Traditional overlay multicast can be classified into three categories in terms of the tree building approaches: tree-first (such as YOID [4]), mesh-first (such as NARADA [5]), implicit protocol (such as SCRIBE [6]). To utilize the upload bandwidth of end hosts more efficiently, some protocols based on multiple trees are also proposed (such as SplitStream [7]). Rather than building trees, recently proposed data-driven based protocols organize the nodes into an unstructured overlay network. These data-driven protocols include Chainsaw [9], DONet [1], PALS [8].

At the measurement study side, the prolific areas of research attempted to offer insightful understandings towards existing systems or protocols and essentially came in two flavors. The first category of previous work commonly examined server workload, user characteristics and streaming performance of traditional client-server (C/S) or CDN-based live video streaming service [11], while the other category [12] analyzed P2P traffic, system capacity and message protocols of P2P based file sharing and VoIP applications.

3. PRACTICAL ONLINE DURATION MODEL

A characteristic in P2P network is that the peers change their behaviors and join or leave the service group continuously and independently, resulting in high dynamic in overlay topology and peer membership. In particular, the frequent turnover of upstream peers substantially poses great challenge on comfortable visual quality at end users in streaming applications, which require stringent playback deadline for the arrival of packets. From this viewpoint, the stability of peer community is intuitively one of most vital factors for global system performance and thus we mainly focus on the online duration of end users in this paper.

In previous work, we have designed, implemented and deployed a practical P2P live broadcasting system over global Internet [2]. As a scalable and cost-effective alternative to C/S approach, it was adopted by CCTV to live broadcast Spring Festival Evening show at Feb. 2005 and Jan. 2006. In the second deployment, more than 1,800,000 users from about 70 countries subscribed the service and the maximum concurrent users reached its peak about 200,000 at Jan. 28th, 2006.

We retrieve the practical online duration information, that is, the synchronous arrival/leave time of end users from the service traces. Fig.1 depicts the cumulative distribution function (CDF) curve of various online time. Note that, for this 4.5-hour (8pm-0:30am) hot event, roughly 30% users left the system in 180 seconds and more than 35%users would like to

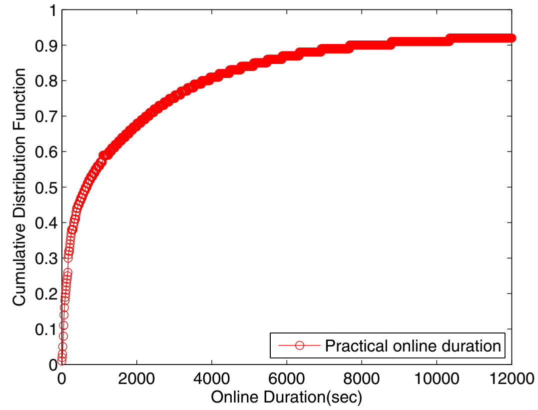

Fig. 1. Cumulative distribution function of practical online duration information of end users

enjoy the show for more than 1800 seconds. Although, the high churn rate in realistic user groups was accommodated by the unstructured overlay network, it still had fundamentally negative impacts on the system performance of peer-assisted streaming applications.

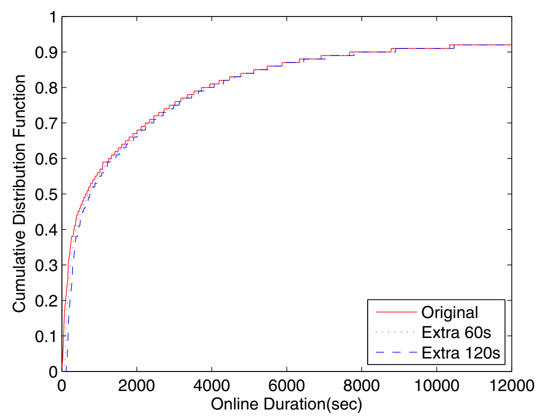

Fig. 2. Cumulative distribution function of extended online duration with extra 60s and 120s

In face of the fact that a more stable peer community will facilitate the cooperative stream patterns, we intentionally extend the online duration in a graceful manner. With extra 60 to 120 seconds, which means users would spend a little more time, we target a better QoS as assumed in many works. Actually, the significance of such an intuitive modification comes from the verification on whether the user behavior models would be important in terms of Qos in P2P live media streaming systems. As shown in Fig.2, the change on online duration results in a slight shift on CDF curves, and its influence on streaming quality will be evaluated through simulations in next section.

4. COMPARATIVE SIMULATION

In this section, we comparatively evaluate the system performance with different online duration models obtained from above.

4.1. Simulation Configuration

In our simulation experiments, we mainly utilize a discrete event-driven P2P simulator [2] to conduct streaming applications. For the underlying topology, we employ the random model of GT-ITM [14] tool to generate the experiment topology with 2000 routers and configure delays proportional to the distance metrics of this topology within [5ms, 300ms]. The size of user group in the experiments is set upto 1000 nodes, indicating that new join request beyond 1000 nodes will be rejected. We believe that, the fixed group size will not affect the simulation results since the modifications on online duration focus on the leave patterns, rather than arrival patterns.

For the peer-pair cooperation, each peer could randomly selects 12 other nodes as its neighbors (the favorable range of neighbors should be 6 to 14, as evidenced in [13]) in the simulations. Besides, it also estimates the end-to-end available bandwidth to one neighbor according to previous traffic in 5 periods, with each request period 3 seconds. The sizes of exchanging window and sliding window [2] are set to 10 seconds and 60 seconds, respectively. In terms of streamed contents, each data block has the same size of 1250 bytes.

For the incoming and outgoing bandwidth of end users, we reasonably employ the practical measurement results in [12]. There are three types of DSL/Cable connections with different proportions and bandwidth capacities, as listed in Tab.1. A certain fraction of LAN connection nodes are also considered in the simulations for the purpose of comparison.

Table 1. Bandwidth capacity in simulations

Type	Incoming	Outgoing	Proportion
DSL/Cable-1	512kbps	256kbps	30% in all DSL/Cable
DSL/Cable-2	1Mbps	500kbps	40% in all DSL/Cable
DSL/Cable-3	2Mbps	1Mbps	30% in all DSL/Cable
10M LAN	10Mbps	5Mbps	10% in all nodes

To evaluate the performance, here we define a metric important in streaming applications-*delivery ratio*, which could be calculated as the ratio of number of blocks arriving before or right on the playback deadline to the total number of streamed blocks. The delivery ratio of each peer essentially represents the streaming quality and throughput from the source to this node. Additionally, to evaluate the overall performance, we measure the average delivery ratio in the whole session.

4.2. Comparative Simulation

Our comparative simulations are driven by the different online duration models. In this subsection, we show the experiment results and perform comparisons for discussion.

In Fig.3, we first examine the system performance when all participating nodes are with DSL/Cable connections. In this case, there are 30% users with 512kbps incoming bandwidth, 40% users with 1Mbps incoming bandwidth and 30% users with 2Mbps incoming bandwidths, which is quite common in realistic scenario. For all those nodes, the outgoing bandwidth is reasonably limited to half of the inbound capacity. To this end, the connection bottlenecks occur only at the last-mile. As shown, when the streaming rate is low, say 250 Kbps, all of the different online duration models result in relatively high delivery ratio. However, as the streaming rate increasing, the performance exhibits a strong degressive trend. At the rate of 500 Kbps, the extended online duration model with extra 60 seconds behaves quite similar to the original online duration model in terms of average delivery ratio, while the model with extra 120 seconds still outperforms the others. As a whole, the longer-life of peer community contributes to a better QoS in P2P based live streaming applications (more precisely, when most of nodes have poor connection capabilities).

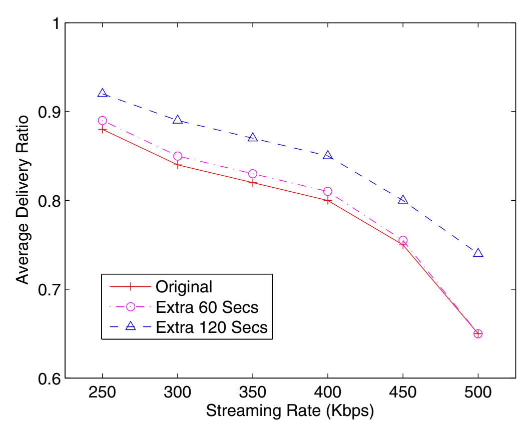

Fig. 3. Comparative average delivery ratio of different online duration models. All are DSL/Cable connection nodes.

In addition, we also consider another case where 10% users with 10Mbps LAN connections evenly join the streaming session. The rest of nodes follow the proportional distribution described in Tab.1. As illustrated in Fig.4, with those resourceful nodes existing, the system exhibits higher average delivery ratio under different online duration model. This is because the scheduling algorithm in the simulation can efficiently leverage those rich bandwidth resources. Note that, as the streaming rate increases, the extended online duration models always achieves better streaming quality.

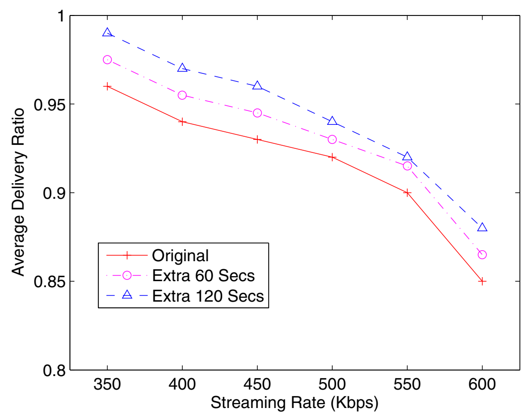

Fig. 4. Comparative average delivery ratio of different online duration models. 10% are 10M LAN users. The rest are DSL/Cable connection nodes.

Towards this end, the comparative simulations among different online duration models demonstrate that the performance in P2P based live media streaming applications can be improved if peers spend more time in the community. This simple but positive result, in essence, validates both the impacts of end users and the need of an effective incentive mechanism to encourage users to stay longer when joining the P2P live streaming systems.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we fight at the front of improving the streaming quality of service in P2P based live media streaming applications. With the practical online duration of end users in hand, we make a comparative simulation study on different online duration models to catch the interplay between the QoS and user behaviors. The experiments demonstrate that a longer-life user online duration, which means a more stable peer community, can benefit the cooperatively peer-pair streaming. We believe that this result will guide the design of further improvements to existing protocols.

In next step, we will focus on the incentive mechanism design to encourage users to spend more time in P2P networks and further integrate it into the practical systems.

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