日本ソフトウェア科学会第 27 回大会 (2010 年度) 講演論文集

A Construction Method for Scalable Peer-Assisted Video-on-Demand Systems

Huijun Li　Takehiro Tokuda

Peer-to-Peer (P2P) technology has become an effective solution to large-scale content distribution. However, in Video-on-Demand (VoD) systems, asynchrony in watching video contents among users makes the cooperation between users difficult, so construction of scalable VoD systems is a big challenge. In this paper,we present a construction method for peer-assited VoD system to address the challenge. The peer-assited VoD system uses P2P-based mesh overlay network. Piece selection and cache management policies are proposed to achieve high peer bandwidth and storage utilization. Thus the server load is alleviated and it can provide VoD service to a large number of users. Simulations have been conducted to demonstrate the effectiveness of our approach.

1 Introduction

Video-on-Demand (VoD) services have been popular services in the Internet. There are many VoD service publishers, such as YouTube [12] and Hulu [10]. Traditional VoD systems rely on content distribution networks (CDNs) to stream videos to users. Based on this infrastructure, when providing VoD services to large user population with high-quality and full-length videos, the cost will increase greatly.

Peer-to-Peer (P2P) technology has become an effective approach to large-scale content distribution. It can provide many kinds of services such as file sharing [9] and live streaming [8]. Recently, P2P technology has also been applied to VoD systems. Using P2P technology to provide VoD service is different from providing file sharing and live streaming services. In P2P file sharing systems, a video can be viewed only after the whole video file is downloaded completely, while in VoD systems users want to start watching the video quickly after they click the "play" button. In P2P live streaming systems, users can only watch the part of video which is being broadcast, while in VoD systems users may watch their favorite videos at any time, which makes the cooperation among users difficult.

In this paper we study the method for construction of scalable peer-assisted VoD systems. The proposed method aims at take full use of peers' upload bandwidth with a limit amount of hard disk cache on each peer.

The rest of the paper is organized as follows. Section 2 discusses related work. Section 3 gives a description of our proposal. Section 4 describes our evaluation methodology. Finally we give a conclusion and discuss the future work in section 5.

2 Related Work

Early P2P VoD systems organize peers into a multicast tree structure. P2VoD [4] organizes peers into multi-layer clusters according to their joining time. Inspired by P2P file sharing and live stream-

---

大規模化可能なピア支援型ビデオオンデマンドシステムの構成法

李 慧君　徳田 雄洋, 東京工業大学情報理工学研究科, Dept. of Computer Science, Tokyo Institute of Technology.

ing systems, mesh-based P2P overlay structure has been adopted by recent P2P VoD systems. BASS [3] and Toast [2] combine BitTorrent [9] downloading with streaming from the server. Network coding is applied in swarming-based P2P VoD system in [1]. Previous work gives insight into P2P-based VoD system design. Some researches [6], [7] concentrate on the VCR interactions in P2P VoD systems. Recently many P2P VoD systems [5] have been deployed, but they still rely heavily on the server.

An important design issue of peer-assisted VoD system is to minimize the server bandwidth cost by utilizing the peers' bandwidth cost. We explore the construction method for scalable peer-assisted VoD systems from two aspects: which content should a peer request and which content should a peer store.

3 System Design

3.1 System architecture

The peer-assisted VoD system has the following major components: (i) a set of servers, as the source of content, stores all the video contents. For simplicity, we treat the servers as a whole. If a peer can not obtain the video content from other peers, it will ask the server to provide the content. (ii) a tracker to keep track of peer arrivals and departures. The tracker maintains a list of active peers in the system. (iii) peers are the users/clients which run the software provided by the VoD service operator. They are installed with protocols to talk to server, tracker and other peers.

The system architecture is shown in Fig. 1:

The peer-assisted VoD system employs mesh-based overlay. When a new peer joins in, it first contacts with the tracker for a peer list. The tracker gives the new peer a subset of peers already in the system. We call this subset of peers *neighbors* of the new peer. Then the new coming peer will make connections with peers on the returned list to exchange information and video data with them.

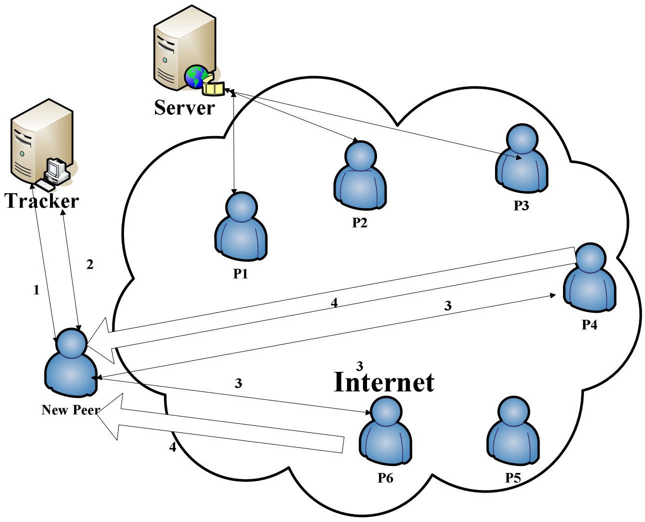

Figure 1 System architecture
1. The new peer sends request to the tracker,
2. The tracker returns a list of peers (*neighbors*),
3. The new peers ask for pieces from *neighbors*,
4. *Neighbors* send pieces of content to new peer.

Users may join the system at any time. After they join the system they will start viewing the video from the beginning to the end. In other words, we assume linear viewing. The video file is divided into a number of pieces, A number of consecutive pieces are grouped into a chunk, which is stored in peer's hard disk cache to meet the needs from other peers.

3.2 Piece Selection

After peer gets a peer list from the tracker, it will send piece requests to peers in the list. Piece selection algorithm determines which pieces to be downloaded first. As the requirements of VoD systems, it is natural to download the piece that is closest to the playback point. But downloading pieces sequentially will reduce the variety of pieces in the system. So we proposed a mixed piece selection algorithm.

In VoD systems the playback point of peers are different. To deal with bandwidth variations and

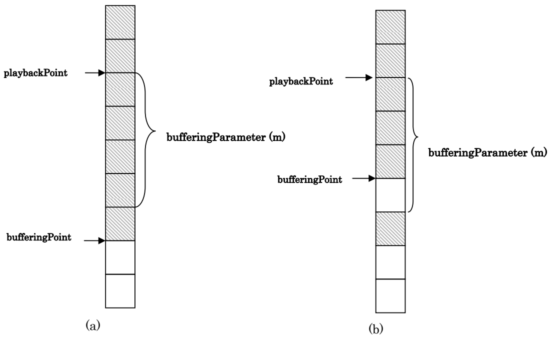

Figure 2 Buffering status
(a) (bufferingPoint-playbackPoint) $\geq$ m
(b) (bufferingPoint-playbackPoint) $\prec$ m

peer churn, peers usually buffer a certain amount of video content beyond their playback point. We describe some notation for peer in the system:

playbackPoint: Peer's current playback position, indexed by the sequence number of the video piece being played.

bufferingPoint: Peer's current buffering position, indexed by the first missing piece beyond current playback point.

bufferingParameter (m): Number of buffered pieces beyond the current playback point.

There are two buffering status as shown in Fig. 2:

The buffering-progress-based piece selection algorithm is described as follows:

If (*bufferingPoint* - *playbackPoint*) is smaller than m, sequential-piece-selection policy is used; otherwise rarest-piece-selection policy is used.

3.3 Cache Management

We assume each peer can provide a limited amount of hard disk to store the video content it is viewing. As the peer's viewing behavior progresses, the size of stored video content become large. Because the size of cache on each peer is limited, it is important to design an appropriate cache management algorithm. The cache management algorithm determines the availability of video pieces in the system. The availability affects server bandwidth costs because peers will download pieces from server if the pieces become unavailable from other peers.

The traditional FIFO (First In First Out) method will replace the early part of the video content, which is not appropriate for peer-assisted VoD systems. Here we propose a popularity-based cache management algorithm. After the limited number of cache on a peer is full, a chunk will be replaced by the new chunk. The popularity of a chunk is expressed by how many times the chunk has been requested by other peers. The least requested chunk will be replaced, so that the chunks requested more can be kept.

4 Evaluation

We develop an event-driven simulator based on OMNeT++[11] to evaluate the proposed method. According to the common assumption that peer download bandwidth is larger than the video bit rate and peer upload bandwidth is bottleneck, the peers are assigned with upload bandwidth 1Mbps. Simulation settings are as follows: There are 500 peers in the simulation. According to measurement data in [9], there are about 250 users at each sampling point. So we think 500 peers is enough in the simulation. The peer arrivals follow a Poisson process with $\lambda = 1/5$. In the simulation we use a video with 120 minutes length. The video bit rate is 512kbps, and each piece size is 64KB. The chunk size is 18.75MB, which is 5 minutes video clip, consisted of 300 pieces. We assume each peer provides a hard disk cache of 10 chunks. The number of neighbors of each peer is 10.

We compare our method with the simple sequential piece selection + FIFO cache management method. According to our simulation, the band-

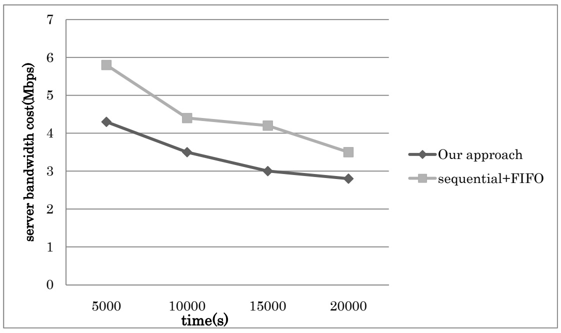

Figure 3 Simulation result

width cost of server is lower than the simple one. Simulation result is shown in Fig. 3:

5 Conclusion and Future Work

We propose a construction method for scalable peer-assisted VoD systems. The method puts emphasis on piece selection and cache management strategies. According to the preliminary simulation result, it is effective in alleviating server's load. At the present stage, we assume the users are watching the same video in the system. We will extend the proposed method to multi-video VoD system. A peer may store multi video contents in its hard disk cache. In the future, we will examine more performance metrics in simulations and explore other methods, for example incentive mechanism for peer-assisted VoD system to promote the cooperation between users in the VoD system.

Acknowledgment The authors would like to thank Associate Professor Toyotaro Suzumura for his helpful discussions and comments.

References

[1] Annapureddy, S. Guha, S. Gkantsidis, C. Gunawardena, D. and Rodriguez, P. R.:Is High-Quality VoD Feasible using P2P Swarming? Proc. 16th International Conference on World Wide Web, ACM, 2007, pp. 903–912.

[2] Choe, Y. R. Schuff, D. L. Dyaberi, J. M. and Pai, V. S. : Improving VoD Server Efficiency with BitTorrent, Proc. 15th International Conference on Multimedia, ACM, 2007, pp. 117–126.

[3] Dana, C. Li, D. Harrison, D. and Chuah, C.-N. : BitTorrent Assisted Streaming System for Video-on-Demand, Proc. 7th International Workshop on Multimedia Signal Processing, IEEE, 2005, pp. 1–4.

[4] Do, T. T. Hua, K. A. and Tantaoui, M. A. : P2VoD:Providing Fault Tolerant Video-on-Demand Streaming in Peer-to-Peer Environment, Proc. 2004 International Conference on Communication, IEEE, 2004, pp. 467–1472.

[5] Huang, Y. Fu, T. Z. J. Chiu, D.-M. Lui, J. C. S. and Huang, C. : Challenges, Design and Analysis of a Large-scale P2P-VoD System, Proc. ACM SIGCOMM 2008 Conference on Data Communication, ACM, 2008, pp. 375–388.

[6] Wang, D and Liu, J. : A Dynamic Skip List-Based Overlay for On-Demand Media Streaming with VCR Interactions, *IEEE Trans. Parallel and Distributed Systems*, Vol. 19, No. 4 (2008), pp. 503–514.

[7] Yiu, K.-W. K. Jin, X. and Chan, S.-H. G. : VMesh : Distributed Segment Storage for Peer-to-Peer Interactive Video Straming, *J. IEEE on Selected Areas in Communications*, Vol. 52, No. 9 (2007), pp. 1717–1730.

[8] Zhang, X. Liu, J. Li, B. and Yum, T.-S. P.:CoolStreaming/DONet:A Data-driven Overlay Network for Peer-to-Peer Live Media Streaming, Proc. 2005 International Conference on Computer Communications, IEEE, 2005, pp. 2102–2111.

[9] http://www.bittorrent.com

[10] http://www.hulu.com

[11] http://www.omnetpp.org

[12] http://www.youtube.com