BEAM: An Efficient Peer to Peer Media Streaming Framework

Darshan Purandare Ratan Guha
School of Electrical Engineering and Computer Science
University of Central Florida, Orlando, FL 32816 USA
{pdarshan, guha}@cs.ucf.edu

Abstract

In this paper, we present a swarm based peer to peer media streaming model. In our approach, nodes that serve the maximum content to their peers have a higher utility to the swarm and become candidates for direct relay of stream from the media server. This reward forms a natural incentive for the nodes to contribute to the swarm. Nodes cluster into small groups, called alliances, for a symbiotic association. Alliance members must exchange pieces to have the complete packet. This policy dissuades non-cooperating members in an alliance from their selfish behavior. We study our model using a simulator and present some initial results.

1. Introduction and Related Work

Peer-to-Peer (p2p) media streaming is an extremely cost effective way to serve the live media content to a large pool of users without the need of an expensive infrastructure. However, timely and in-order delivery of stream packets in such a random swarm environment remains the most important concern. Earlier approaches [1] used application layer multicasting for streaming live media content. However, p2p approaches have become more prevalent because of ease of use and deployment. BASS [2] is a recent p2p streaming technique for Video on Demand (VoD) thats uses a hybrid approach of BitTorrent (BT) and it supplies the swarm with an external media server. However, load on such server increases linearly with the number of users owing to its server centric design and hence does not scale well. BiToS [3] is BT modified approach to VoD using p2p network. Redcarpet [4] is another work which concentrates on providing near VoD using different piece selection algorithms in BT. PRIME [5] is a mesh based p2p streaming approach to live media streaming that focuses on finding the global content delivery pattern to maximize the uplink utilization while maintaining the delivered quality. However, node organization appears to be tree like and organized in different levels rather than a random mesh. Our work mainly focuses on leveraging the randomness of swarm like environments and imposing a few management policies at the node level to reduce the contention of the packet at real time among the nodes. Our model largely works on two most important policies: (i) To arrange nodes in small groups, called *alliances*, for mutual node benefit which in turn helps to save on the reaction time when the nodes contend for streaming packets while maintaining randomness among the alliance members. (ii) To reward the contributing nodes by serving them directly from the media server. It also demands user participation at every stage to leverage the uplink bandwidth of nodes and hence increase the scalability of the system. We call our model as BEAM (Bit strEAMing).

2. BEAM

The main entities involved in a swarm based p2p streaming environment are the nodes, a media server and a tracker. Tracker keeps track of the node details viz. arrival time and IP address. It periodically communicates with the media server for exchanging important system state and information. The server streams the content to some selected number of peers that have higher contribution in terms of content served to other members of the swarm. Tracker computes the rank of the higher contributing nodes and updates the media server. To calculate the rank, we define *Utility Factor* (UF) of the nodes. It is a measure of the node utility to the swarm. Nodes periodically update the tracker with their UF. These contributing nodes, called horses (from English idiom *Horses for Courses*), after receiving the content directly from server, forward it to other peers in the swarm and propagate the content further. Since the horse nodes are periodically computed based on their UF, they need to consistently perform well to remain the horse nodes, else they could be replaced by other well performing nodes. This reward serves as a natural incentive for the nodes to contribute to the swarm. However, real time media streaming and VoD are time and resource constrained. Nodes contend

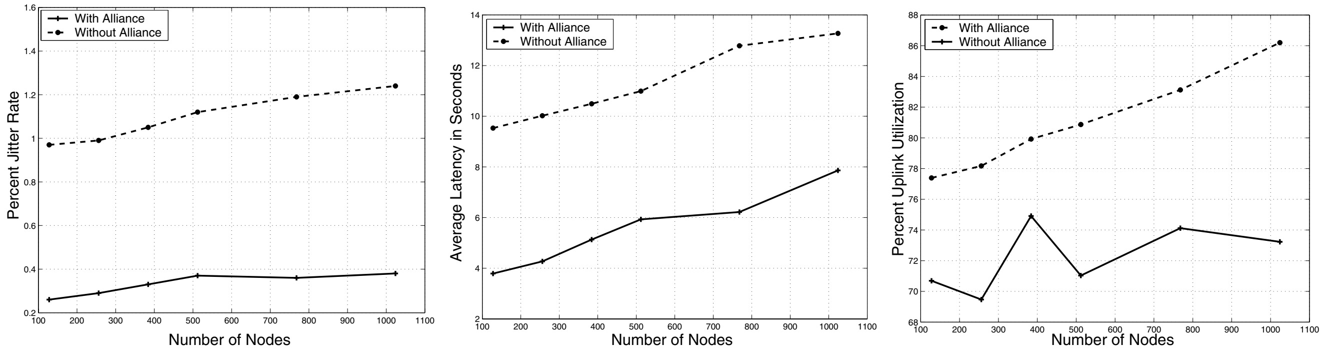

Figure 1. *Evaluative comparison of system with and without alliance formation.*

for the same media content within a short period of time. The need to playback the media and procure the future content necessitates an effective management policy. We introduce the concept of *alliance formation* to counter the above mentioned problem. Nodes cluster into small groups of 4 to 6, called *alliances*, to form a symbiotic association with other peer nodes. Members of an alliance are assumed to have mutual trust and help each other for content distribution. These peer nodes may be chosen based on their mutual utility to each other.

As a new user arrives into the swarm, it contacts the tracker. Tracker issues it a peerlist, typically of 40 nodes. Peerlist helps a node to request initial packet and get bootstrapped. Once it obtains initial packets, it can start creating or joining alliance with other nodes. For mutual benefit, peers that interact more tend to form and join the same alliance. A node uses *announce mechanism* to notify its alliance members the receipt of a new packet. Peers, in turn, request the unavailable packets. Peers exchange the pieces among their alliances. This process dissuades freeriders and improves overall uplink bandwidth utilization. A node can be member of more than one alliance. This facilitates multiple paths for receiving the content. In case of a path failure, it guarantees alternate shortest paths for the content.

3. Simulation Metrics and Results

We consider the following metrics to gauge the efficiency of BEAM, in particular effectiveness of alliance, and quantify them for measurement studies. It includes QoS (average latency and jitter factor), scalability and robustness. Average latency is the time difference of media playback at the server end and the client end. A jitter is unavailability of a packet at its playback time. A system is robust if it withstands node failures, yet maintaining good QoS. We study the above mentioned metrics with the help of a custom simulator.

We present an evaluative comparison of BEAM with a swarm based p2p streaming system without alliance formation in Figure 1. In a simulation run of a media file of duration 1 hour encoded with 512 Kbits/s and an average packet size of 16Kb , BEAM shows an average jitter rate of 0.38%, an average latency of less than 8 seconds in a swarm of 1024 nodes. QoS factors are found to be near optimal for a sizable swarm. BEAM is fair to the contributing nodes, 99.82% users were served with a strictly lower latency than their peers with a lower UF. Upon injecting 50% node failures in the simulation run after 50% time had elapsed, average jitter factor only increased to 1.2%. Uplink bandwidth utilization is 86.2% for nodes from 5 different bandwidth strata. We conclude BEAM is robust and reconfigurable under various node failure rates, however there is a trade off involved in achieving near optimal uplink utilization and maintaining a good QoS, and is attributed to the node heterogeneity. We further intend to study the security issues in such swarm based p2p streaming systems.

References

[1] Y. Chu, S. Rao, S. Seshan and H. Zhang. *A Case for End System Multicast.* IEEE Journal on Selected Areas in Communication (JSAC), Special Issue on Networknig Support for Multicast, Vol 20, No. 8, 2001.

[2] C. Dana, D. Li, D. Harrison, and C.-N. Chuah. *BASS: BitTorrent assisted streaming system for video-on-demand.* In International Workshop on Multimedia Signal Processing (MMSP). IEEE Press, 2005.

[3] A. Vlavionos, M. Iliofotou, and M.Faloutsos. *BiToS: Enhancing BitTorrent for Supporting Streaming Applications.* In IEEE INFOCOM 2006 Global Internet Workshop April 28-29, 2006.

[4] S. Annapureddy, C.Gkantsidis, P. Rodroguez, and L. Massouliea. *Providing Video-on-Demand using Peer-to-Peer Networks.* Microsoft Technical Report MSR-TR-2005-147.

[5] N. Magharei, A. Rasti, D. Stutzbach , R. Rejaiea. *Peer-to-Peer Receiver-driven Mesh-based Streaming.* Proceedings of the ACM SIGCOMM, Poster Session , August 2005.