An Improved Cluster-Based P2P Multicasting Approach

(Work-in-Progress)

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ABSTRACT
In this paper, we describe our work-in-progress end system multicast approach, capacity-aware cluster based multicast (CCM). Cluster overlay is a widely used scalable P2P overlay in which peers are organized into groups and are not aware of the whole system. We address the problem of peer heterogeneity and extend current approaches by providing an ESM approach on cluster overlay able to provide capacity-aware multicast. Our approach works well even when constructing a multicast chain with restricted peer capacities.

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Categories and Subject Descriptors
C.2.4 [**Distributed Systems**]: Distributed applications – *peer-to-peer, cluster-based overlay*; J.7 [**Computers in other systems**]: Real time – *end system multicast*.

General Terms
Algorithms, Management, Performance, Economics, Reliability, Experimentation.

Keywords
P2P, End System Multicast, Cluster Overlay, Capacity-aware.

1. INTRODUCTION
To provide group communication on Internet, IP multicasting and application layer multicasting (ALM) techniques are widely used. Comparing with IP multicasting, ALM, which is to provide data replicating and forwarding between end systems and is also called end system multicasting (ESM), is much easier to be deployed. In essence, there are two major ways in which ESM can be achieved [2, 4]: proxy-based architectures and peer-to-peer architectures. Proxy-based architecture is more appropriate for ESM when having well-established environments with pre-deployed and powerful proxy servers. However, it is not relevant with large-scalable computing environments. Recent research on P2P-based ESM aims at organizing all hosts involved in a multicast group in effective manners so that they become able to multicast in large scale systems, to leverage the total delay and to distribute workload so as to achieve better performances. Cluster-based P2P overlay has been widely studied in the literature. Some challenging problems remain not well addressed in current approaches such as peer heterogeneity in cluster-based P2P ESM. In this paper, we propose a capacity-aware multicast scheme in large-scale and cluster-based P2P overlay. Our approach is able to solve both problems of heterogeneity and load-balance.

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2. RELATED WORK
In structured or semi-structured P2P systems, once peers join in the system, they are organized into a predefined structure called *overlay*. Cluster-based overlay is one of them [3]. Organizes peers in a hierarchy of clusters based on network latency. In each cluster, there is a head (normally are the most powerful and longest online-time peer) to be the manager of the cluster. Heads of clusters' layer L_i construct the peers of layer L_i+1. Several studies [1, 5, 6] have addressed the management of cluster overlay (including peers clustering, peers join and departure, etc.). However, this issue will not be addressed in this paper.

NICE [6] and Zigzag [7] are two ESM systems based on cluster-based overlay.

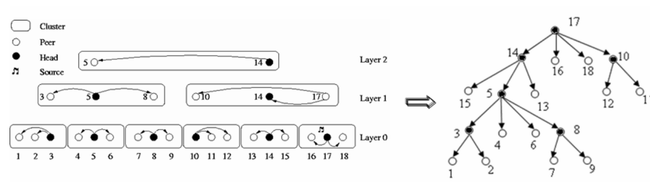

Figure 1. NICE Cluster-based Multicast System.

In NICE (as shown in Figure 1), heads take the responsibility of replicating data to all its cluster mates. Heads work hard to death, at the same time, non-head peers have nothing to do. Zigzag addresses the problem of head-overload identified in NICE by introducing the concept of "associate head" to take over some workload where a head replicates data to its cluster mates and to foreign subordinate at the highest layer L_N. At lower layers, the associate head will take the job of replicating.

Doubling the number of heads can not solve the centralizing-overload problem fundamentally. In the following, we present a balanced multicast approach in cluster overlay by distributing the workload of data replication to all the peers (including heads and non-heads).

3. NEW BALANCED APPROACH

We assume that peers have already joined a cluster overlay where they can at least get information of their cluster mates (other peers in the same cluster) and ancestors (heads in higher clusters).

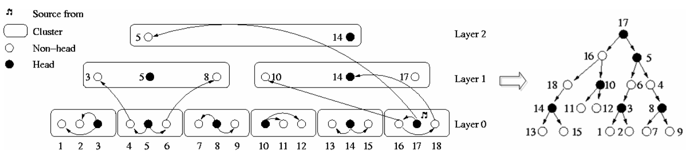

Figure 2. Balanced Cluster-based Multicast System.

In our approach, though heads still play an important role in cluster overlay maintenance, all peers (heads and non-heads) replicate and forward data to corresponding cluster mates and peers in other clusters according to their capacities.

In Figure 2, we show an example of data communication in peers' clusters hierarchy (left part) and the corresponding multicast tree (right part). The heads of clusters are represented as black dot. The capacity of each peer in this example is set to 2, which means that each peer can replicate and forward data to at most 2 other peers. The multicast communication is initiated by the source peer P_{17}. P_{17} replicates data to one of its cluster mates P_{16} at layer L_0, and one of its foreign head P_5 at layer L_2 (which is a peer outside the cluster known by the head). When P_{16} receives the data, it replicates data to one of its foreign heads P_{10} and one cluster mate P_{18}.

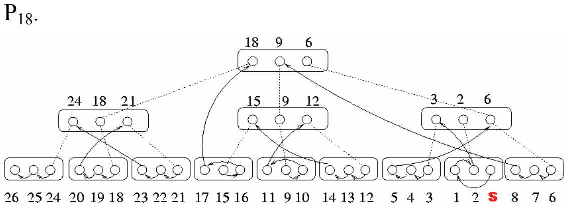

Figure 3. Multicast Chain (capacity of peer equals 1)

Heterogeneous computer are used in Internet, such as mobile and PDA, and etc. Here, *the capacity of a peer is defined as the maximum number of data replicating and forwarding the peer can provide*, which can be calculated according to several parameters such as: computing ability, network link bandwidth, average workload, etc, or can be set by users. Peers with zero capacity are special peers called free-downloading peer which is not addressed in this paper. *The capacity of a cluster is the sum of capacities of all its peers subtracted by the capacity used to replicate data inside the cluster*. The minimum capacity of a cluster is 1 because clusters should be able to replicate and forward data to other clusters.

Next, we address a special case in CCM where capacities of peers are all equal to 1, as figure 3 shows. The multicast data path is a chain. The capacities of all clusters equal 1. For example, the capacity of the cluster in top level is the number of peers minus the number of links inside the cluster (including child-clusters) that is 26-25=1. A peer replicates data to one of its cluster mates preferentially. If all peers inside the cluster have already received the data, the last forwarding peer sends the data to a peer outside the cluster which is known by the head.

In P2P system, peers must also handle problems of peers' departure. As shown in figure 3, when P_{16} leaves, P_{18} and P_{10} loss their data provider. In this case, P_{18} can regain its stream from P_{17}, and P_{10} can get its stream from P_{18}. But if a powerful peer left and the peer is the data provider of many peers, it is time-consuming procedure for all its data receivers to find new providers. In order to relieve this problem, several principles for heads in cluster overlay to pairing providers and receivers.

1, Put powerful peers in front positions in the multicast tree.

2, Monitor the cluster capacity of multicast trees, and keep the number of out-links smaller than cluster capacity.

3, Equalize cluster out-links to peers. In case the departure of powerful peers would not impact too much.

4, Report remaining cluster capacity and streams initiated inside cluster to the head of the super cluster.

5, Relieve heads from data forwarding or at least alleviate data forwarding load.

4. Future work

Various issues will be addressed in the future. Efficient cluster generation is crucial for ESM in the cluster overlay and needs to be tackled. We will also explore how to evaluate peer's capacity dynamically. Moreover, multi-streams and the caches deployment in the cluster overlay are other interesting topics to be studied.

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