

Chapter 13

Peer-to-Peer Network-Based Image Retrieval

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ABSTRACT

Performing Content-Based Image Retrieval (CBIR) in Internet connected databases through Peer-to-Peer (P2P) network (P2P-CBIR) helps to effectively explore the large-scale image database distributed over connected peers. Decentralized unstructured P2P framework is adopted in our system to compromise with the structured one while still reserving flexible routing control when peers join/leave or network fails. The P2P-CBIR search engine is designed to provide multi-instance query with multi-feature types to effectively reduce network traffic while maintaining high retrieval accuracy. In addition, the proposed P2P-CBIR system is also designed in the way to provide scalable retrieval function, which can adaptively control the query scope and progressively refine the accuracy of retrieved results. To reflect the most updated local database characteristics for the P2P-CBIR users, reconfiguring system at each regular interval time can effectively reduce trivial peer routing and retrieval operations due to imprecise configuration. Experiments demonstrated that the average recall rate of the proposed P2P-CBIR with reconfiguration is higher than the one without about 20%, and the latter outperforms previous methods, i.e., firework query model (FQM) and breadth-first search (BFS) about 20% and 120%, respectively, under the same range of TTL values.

INTRODUCTION

Peer to Peer (P2P) networks have been proficiently developed to share files, transferring real-time video streams, and performing CBIR in recent decades. In P2P networks, each connected peer

serves as a server/client simultaneously, which can effectively distribute computation (King et al., 2004) and network traffic among connected peers to provide efficient streaming and CBIR services. P2P networks could be categorized into three network models: centralized (C-P2P), decen-

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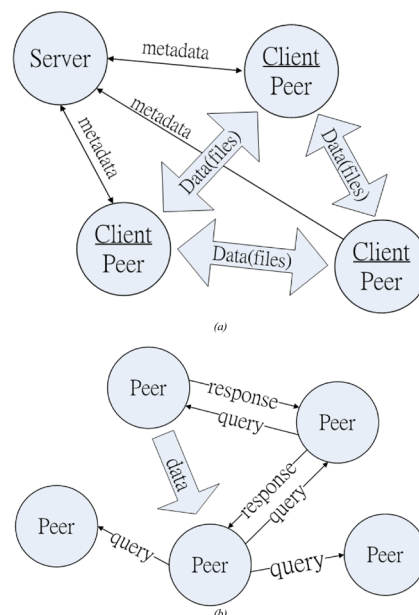
tralized structured (DS-P2P), and decentralized unstructured (DU-P2P). In the C-P2P model as shown in Figure 1(a), such as Napster (Fanning 2007), the query peer must communicate with the central server to access files stored in other peers. It provides fast responses but suffers the single point failure, which can be eliminated by adopting the DS-P2P model, such as the distributed hash table (DHT) (Ratnasamy et al., 2002), which assigns one key for each file and provides strict rules for file placement and object discovery. In this model, each file is represented by one key, and each peer is responsible for some fixed keys. In general, it takes $\log(N_{peer})$ hops to reach the destination file. Figure 1(b) shows that the DU-P2P model, such as Gnutella (Gnutella 2004) and Freenet (Clarke et al., 2000), the location of each file is random, i.e., each peer operates independently to each other. The query message m^Q is propagated by blind flooding, such that it would consume excessive network resources and computation power. The DU-P2P acts as a contrary extreme case of the C-P2P and demonstrates much flexible control capabilities. The DS-P2P compromises between C-P2P and DU-P2P. By comparing the CBIR performances for DS-P2P and DU-P2P, the routing of the latter is much flexible but would suffer traffic flooding due to blind and potential duplicated query processing. However, it is inefficient for the former to update the system when peers join or leave resulted from PC failures or routing change as compared to the latter. Considering the probing diversity for queries and imposing scalable retrieval control on the P2P network, the DU-P2P is adopted since its generalized framework can provide regular operations for CBIR. To solve the potential flooding problem in DU-P2P, we proposed to perform peer clustering to compromise with DS-P2P.

In terms of system configuration, the P2P-CBIR system performs peer clustering to group peers with relevant contents to eliminate excessive routings for efficient retrieval. In general, k -means clustering is better than randomly selecting cluster centroids (Eisenhardt et al., 2006). Methods

which adopt this model include directory node (Inaba et al., 2006), R-tree (Liu et al., 2005), and table of interest (Yang et al., 2003), etc. The directory node manages the peer cluster information to help to propagate the m^Q to peers with relevant contents, denoted as $P_d(Q)$ that stands for the destination peers of Q . The R-tree (Liu et al., 2005) performs image feature clustering and each cluster is managed by several super-peers. In (Yang et al., 2003), results of past queries are recorded to help propagating the m^Q to $P_d(Q)$. In (Li & Wu 2005), each peer stores information of neighbor peers, such as the number of images and connections to other peers, and before propagating a m^Q , it estimates the gain and cost (overlay hops) of all neighbor peers to determine which peer to propagate the message first.

In terms of information retrieval (IR), methods such as breadth-first search (BFS), intelligent search mechanism (ISM), and random-walker searches (RWS) have been developed based on the P2P network (Zeinalipour-Yazti et al., 2004). In

Figure 1. (a) Napster structure, (b) Gnutella structure



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