Chapter 10
A Collaborative Replication Approach for Mobile-P2P Networks

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ABSTRACT
This paper proposes CADRE (Collaborative Allocation and De-allocation of Replicas with Efficiency), which is a dynamic replication scheme for improving the typically low data availability in dedicated and cooperative mobile ad-hoc peer-to-peer (M-P2P) networks. In particular, replica allocation and de-allocation are collaboratively performed in tandem to facilitate effective replication. Such collaboration is facilitated by a hybrid super-peer architecture in which some of the mobile hosts act as the ‘gateway nodes’ (GNs) in a given region. GNs facilitate both search and replication. The main contributions of CADRE are as follows. First, it facilitates the prevention of ‘thrashing’ conditions due to its collaborative replica allocation and de-allocation mechanism. Second, it considers the replication of images at different resolutions to optimize the usage of the generally limited memory space of the mobile hosts (MHs). Third, it addresses fair replica allocation across the MHs. Fourth, it facilitates the optimization of the limited energy resources of MHs during replication. The authors’ performance evaluation demonstrates that CADRE is indeed effective in improving data availability in M-P2P networks with significant reduction in query response times and low communication traffic during replication as compared to a recent existing scheme as well as a baseline approach, which does not consider any replication.

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1 INTRODUCTION

In a Mobile ad-hoc Peer-to-Peer (M-P2P) network, mobile hosts (MHs) interact with each other in a decentralized P2P fashion without using base stations. The proliferation of mobile computing technology (e.g., laptops, PDAs, mobile phones) coupled with the ever-increasing popularity of the Peer-to-Peer (P2P) paradigm (e.g., Kazaa, n.d.) strongly motivate M-P2P network applications. M-P2P applications are essentially aimed at facilitating mobile users in obtaining information on-the-fly from other mobile users in a P2P manner. Such P2P interactions are generally not supported by existing mobile communication infrastructures.

This work focuses on improving the performance (i.e., query response time and data availability) of dedicated and cooperative M-P2P networks by means of a collaborative approach for replica allocation and de-allocation. Some M-P2P application scenarios for dedicated networks follow. Suppose a group of agriculturists\(^1\) are performing studies of crops, crop diseases and soil fertility in a remote agricultural area, where communication infrastructures (e.g., base stations) do not exist. They need to share snapshots (pictures or video-clips) of the crops to determine the progression of diseases in the crops to decide upon the appropriate amounts of fertilizers and pesticides to administer to the crops.

Given the typically large size of such an agricultural area, suppose there is a chief agriculturist, who supervises the working of the agriculturists in a specific region of the area, to facilitate efficient data sharing. Thus, we can visualize the agricultural area as a set of regions, each region having a chief agriculturist, who is in-charge of the agriculturists working in that region. Understandably, agriculturists within the same region may wish to share data among themselves (i.e., local querying) or they may wish to share data with those, who are working in other regions (i.e., remote querying). Each chief agriculturist could keep track of information (e.g., images, video-clips) stored at MHs that are within its region, thereby facilitating local querying. Furthermore, chief agriculturists in different regions of the agricultural area could interact with each other to facilitate remote querying.

In the same vein, a group of archaeologists, who are performing excavations in a remote area of Egypt, may need to share images (e.g., artifacts and ancient maps found), with each other by means of mobile devices because they are working towards the same collaborative goal.

Now suppose agriculturist X in region A requests an image, and obtains a replica of the image (from agriculturists of other regions). After a while, X de-allocates (deletes) this replica, but now another agriculturist Y in region A requests the same image, hence the replica has to be allocated again to region A. Since images are relatively large in size, multiple allocations and de-allocations of the same replica at the same region tax the generally limited bandwidths and energy resources of MHs. This may lead to undesirable ‘thrashing conditions’, where MHs spend more bandwidth and energy on allocating and de-allocating replicas than on answering queries.

Notably, our target applications mainly concern slow-moving objects e.g., agriculturists and archaeologists moving in a remote area. Moreover, M-P2P ephemerality emphasizes the need for queries to be answered in a fast and timely manner, thereby necessitating query deadlines.

Data availability is typically low in M-P2P networks due to frequent network partitioning arising from user movement and/or users switching `off’ their mobile devices. (Data availability is less than 20% even in a wired environment (Saroiu, Gummadi, & Gribbler, 2002)). Hence, several dynamic replication schemes (Hara & Madria, 2006; Huang, Sistla, & Wolfson, 1994; Mondal, Madria, & Kitsuregawa, 2006; Pitoura, 1996; Wolfson, Jajodia, & Huang, 1997) have been proposed for improving data availability in M-P2P networks. However, while these existing
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