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Optimal storage allocation on throwboxes in Mobile Social Networks

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ABSTRACT

In the context of Mobile Social Networks (MSNs), a type of wireless storage device called throwbox has emerged as a promising way to improve the efficiency of data delivery. Recent studies focus on the deployment of throwboxes to maximize data delivery opportunities. However, as a storage device, the storage usage of throwboxes has seldom been addressed by existing work. In this paper, the storage allocation of throwboxes is studied as two specific problems: (1) if throwboxes are fixed at particular places, how to allocate storage to the throwboxes; and (2) if throwboxes are deployable, how to conduct storage allocation in combination with throwbox deployment. Two optimization models are proposed to calculate the optimal storage allocation with a knowledge of the contact history of users. Real trace based simulations demonstrate that the proposed scheme is able to not only decrease data loss on throwboxes but also improve the efficiency of data delivery.

1. Introduction

Mobile Social Networks (MSNs) [1] are composed of mobile users that carry portable devices such as cellphones. As the links among users and the network topology are unstable, MSN can be regarded as a special type of Delay Tolerant Network (DTN) [2], which makes data delivery a challenging issue in MSN. Comparing with traditional path-building based routing approaches such as AODV [3] and DSR [4], *Store-carry-and-forward* strategy based schemes [5–8] are more efficient for data delivery. In these methods, mobile users can act as mobile relays and store data until the next hop is available. Such a strategy may partly overcome the intermittent links of MSN. However, these opportunistic encounter based schemes still have low delivery efficiency.

Many recent studies [9–12] focus on the utilization of *throwboxes* [13] in data delivery. Throwboxes are a type of storage devices equipped at particular places acting as stationary relays. As shown in Fig. 1, with the aid of a throwbox, data can be successfully delivered even if the two users do not encounter each other. In [14], the authors apply throwboxes in the Epidemic Routing protocol [15] and the Two-hop Multicopy Routing protocol [16]. The delivery delay and the resource consumption of the two protocols are both decreased.

Throwboxes are widely studied in recent researches. Some studies investigate throwbox deployment [13,17]. In [17], the social graph among specific locations and mobile users is explored to establish the placement of throwboxes. The work in [13] studies the combination of throwbox deployment and routing to achieve high throughput. Several throwbox-based relay strategies are proposed in [12]. In addition, the work in [18,19] propose an energy-efficiency scheme of throwboxes, in which a hardware and software architecture is proposed. However, as a storage

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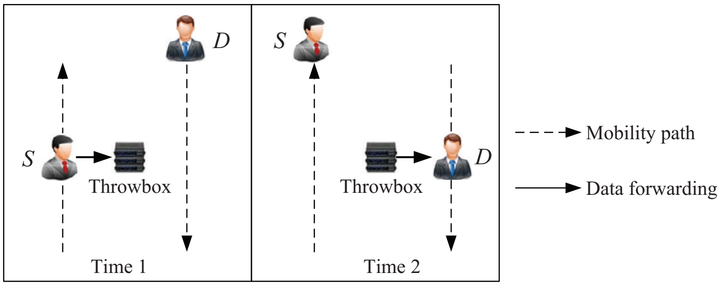

Fig. 1. User S and user D pass a throwbox at different times. User S sends a data to the throwbox firstly. Then, user D can receive the data from the throwbox.

device, the storage usage of throwboxes has been seldom studied.

In this paper, we study the optimal storage allocation of throwboxes. Since the deployment of throwboxes directly determines the usage efficiency of storage, the storage allocation problem can be discussed in the following two specific cases.

(1) *Throwboxes are fixed at particular places:* In this case, storage allocation is conducted individually on the fixed throwboxes.
(2) *Throwboxes are deployable:* Throwboxes are not deployed or can be redeployed. In this case, storage allocation can be conducted in combination with throwbox deployment.

The potential places for deploying throwboxes and storage are called user *Gathering Points* (*GPs*) [10] where a large number of users usually gather. Contact history between users and GPs is explored as a priori knowledge for estimating the storage requirement of each GP, as well as the contact strength between users and GPs. In order to calculate the optimal storage allocation, we propose a Linear Programming (LP) model for the case with fixed throwboxes and a joint optimization model for the case with deployable throwboxes.

To the best of our knowledge, this is the first work to address the optimal storage allocation on throwboxes in combination with throwbox deployment. Comparing with the existing work, the main contributions of this paper can be summarized as follows.

(1) We propose a method to evaluate the contact strength between a mobile user and a place, which fully utilizes the characters of the contacts between the user and the place, including frequency, durations and intervals.
(2) The optimal storage allocation is studied in combination with throwbox deployment. When throwboxes are deployable, both throwbox deployment and storage allocation can be solved using the proposed joint scheme.
(3) A balance between the number of throwboxes and the size of storage is achieved, so that network operators can prepare these two kinds of resources properly and avoid resource wastage.

The remainder of this paper is organized as follows. Section 2 provides a review of related researches on throwboxes. The system model of this paper is presented in Section 3, followed by the estimation of contact strength between users and GPs in Section 4. Section 5 presents the detail of storage allocation. Simulations of the proposed scheme are presented in Section 6. Finally, Section 7 concludes the paper.

2. Related works

The concept of throwbox is first introduced in [13], which defines a throwbox as a stationary relay with limited storage and power. This work addresses throwbox deployment in combination with routing designing. With different levels of knowledge, three throwbox deployment schemes are proposed. For each scheme, three different relay strategies are designed to achieve high throughput. Another work addressing throwbox deployment is [17], where the social graph among specific locations and users is exploited to determine the placement of throwboxes. Multiple metrics, such as betweenness centrality and degree centrality, are used to evaluate the importance of each potential place. Based on different metrics, several deployment schemes are presented. These two studies make excellent contributions to throwbox deployment. Nevertheless, as they both ignore storage allocation in the deployment, effective storage allocation schemes can be hardly realized with these deployment schemes, because the place selected for throwbox deployment may be not proper for storage allocation. Work [18,19] investigate an energy-efficiency scheme of throwboxes, in which a hardware and software architecture is proposed to improve the energy efficiency of throwboxes. However, as a storage device, the storage usage of throwboxes is usually ignored by existing studies.

Throwboxes are widely applied in data delivery methods. Ibrahim et al. [14] add throwboxes into two existing routing protocols, the Epidemic Routing protocol [15] and the Two-hop Multicopy Routing protocol [16] to study the enhancement of performance by using throwboxes. Simulation results show that the data delivery delay and the resource consumption of the two methods are both significantly decreased. In [12], several routing schemes are designed based on throwboxes. The authors classify nodes as source node, destination node, mobile relays and throwboxes and design five relay strategies. These strategies differ from each other only in the restriction of data forwarding among specific types of nodes. In the context of MSN, throwboxes are mainly utilized as a relay at some locations with large social popularity, such as GPs [9–11]. As these places usually