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Rethinking routing information in mobile social networks: Location-based or social-based?

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ABSTRACT

With the rapid development of wireless communication technologies, mobile social networks (MSNs) become more and more popular and have attracted much attention from researchers. In this paper, we address the routing issue in MSNs where a set of social related mobile devices communicate opportunistically and intermittently. Existing routing strategies are mostly based on location information (i.e., geographical coordination and physical distance) and social information (i.e., the number of friends and the strength of social ties). These two kinds of information indeed represent two different levels of human behaviors: the location information is concrete and corresponds to the physical property of human activity; while the social information is logical and represents virtual human interactions. In the context of data routing, a rising question is: does the concrete location information outperform the logical social information in designing routing strategies in MSNs?

To address the question, we devise a comprehensive social-based routing strategy called *Soc* and a general location-based strategy called *Loc*. We provide comprehensive performance comparisons of Soc and Loc together with other social-based and location-based strategies. Our experiment results show that the social-based strategy and the location-based strategy have no significant difference in routing performance: they perform closely in delivery ratio, delay and delivery cost with a slight difference less than 5% in most cases. This indicates that concrete location information is not always necessary to be the key consideration for routing design and logical social information could be potential substitute. Since collecting location information needs dedicated equipment and arguably violates user privacy, our work implies that the proposed social-based routing strategy is safe and effective for MSNs.

1. Introduction

A mobile social network (MSN) is a network where a set of individuals interconnect with each other based on social relationships such as friendships and partnerships [19,26,22]. In this paper, we refer to individuals (or nodes) in MSNs as mobile devices and their social relationships as mutual communications of devices. Such MSNs are considered to be infrastructure-free and self-organized, that is, there exists no communication station and a pair of devices can send and receive message only when they move into each other's communication range. Thus data routing in MSNs relies on the movement of individuals and their encounter opportunities to relay data to the destination.

There are two kinds of information widely used for data routing in MSNs: location information and social information. The location information refers as the geographical related data, includes the geographical coordinates [25], the distance between individuals [16] and etc., which represents the physical property of human activity. The social information is defined as the inferred human relationship from encounter-based graph in this paper. It can be contacts of individuals [18], social centrality [15], social similarity [9] and etc., which represents the logical information of human interactions. Accordingly, routing strategies in MSNs can be divided into two categories: the location-based routing strategies [5,17,16,25] and the social-based routing strategies [1,15,13,9,29].

There are advantages and disadvantages of both kinds of strategies. On the one hand, location-based strategies forward data to the nodes *geographically* closer to the destination, which tend to achieve geographical shortest routing path. An example is shown in Fig. 1, where node S wants to send a message to node D. The lower layer indicates the physical locations of the mobile devices. Based on the measurement of geographical distance, it tends to choose $S \rightarrow A \rightarrow B \rightarrow C \rightarrow D$ as the shortest routing path. However, since encounter opportunity is not taken into account, such routing

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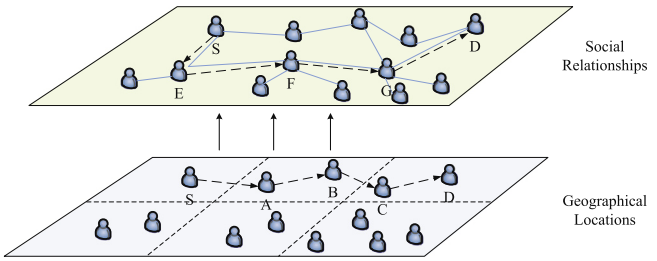

Fig. 1. Data routing in MSNs.

path may not be efficient and the delivery ratio is not guaranteed. On the other hand, the social-based strategies forward data to the nodes more *socially* active. As in the example of Fig. 1, the upper layer indicates the social connections (in solid lines) of nodes. Based on the measurement of their social connections, S tends to forward data via the path $S \rightarrow E \rightarrow F \rightarrow G \rightarrow D$ (since the number of social connections are $S < E < F < G$). Such forwarding strategy seems to enhance the chance of data delivery, but due to unawareness of location, it may also lead to a longer routing path and higher delay.

To the best of our knowledge, there are still lack of comprehensive performance comparisons between the social-based and location-based routing strategies and the following questions remain open. Since the two kinds of strategies require different routing information, do they perform significantly different? Now that physical location information is considered to be highly private in MSNs [21,30], is it worthy to risk incorporating location information for routing decision, or does it exist possible alternative?

To address these questions, we provide comprehensive performance comparisons of the two kinds of routing strategies in this paper. We propose general schemes for social-based and location-based routing strategies called *Soc* and *Loc* accordingly. The Soc scheme integrates social metrics including social degree and social similarity to calculate a comprehensive routing metric. The Loc scheme, on the other hand, uses the geographical information like GPS coordinates and geographical distance to depict the closeness among different nodes, and routes data to nodes which are closer to the destination in geographical aspect.

We conduct extensive experiments to provide fair comparisons of the two kinds of strategies. We first compare the Soc scheme with several existing social-based routing methods. Experiment results show that Soc achieves competitive performance compared to others in many cases. Similarly, we compare Loc with other location-based routing methods. It shows that Loc performs better than or at least as well as the other location-based schemes in various performance metrics. Finally, we carry out the comparison between Soc and Loc, which illustrates that their performance is very similar with a slight difference within 5% in terms of various metrics in most cases.

Based on the analysis, we infer that physical location information and logical social information have no significant difference in routing performance. This indicates that location information is not irreplaceable in data routing. Since collecting user location information needs dedicated equipment and it is considered to violate user privacy, our work implies that the logical social information could be potential substitute for the physical location information in designing data routing strategy for MSNs.

The contribution of this paper is summarized as follows:

- We propose a comprehensive social-based data routing strategy *Soc* for mobile social networks. By convoluting the social centrality and social similarity, *Soc* presents that the routing decision is made dynamically depending on the social properties and encounter frequency of nodes.
- We also devise a representative location-based data routing strategy *Loc* for MSNs. The *Loc* strategy comprehensively represents multiple location-based data routing schemes by embedding the similarity of mobility pattern and geographical distance.
- We conduct a comprehensive comparison between social-based and location-based routing strategies. The comparison suggests that Soc and Loc perform similarly with a slight difference within 5% in terms of various metrics in most cases. The experimental analysis infers that the social information could be potential substitute for the location information in designing data routing strategy for MSNs due to nontrivial collection of location information and arguable violation of privacy for using location information.

The rest of the paper is structured as follows: Section 2 reviews the existing work. Section 3 illustrates the assumption of the paper and provides the overview of social information and location information. The social-based representative scheme Soc is described in Section 4 and the generalized version of location-based scheme Loc is depicted in Section 5. Section 6 evaluates the performance of social-based schemes and location-based schemes. The paper is concluded in Section 7.

2. Related work

Data routing schemes in mobile social networks make forwarding decision according to the social information like social status of a node in the network, or the location information such as the mobility pattern of a node in MSN. Based on the information used for data routing in MSNs, we category the relevant work to social-based and location-based routing strategies in the following.

2.1. Social-based routing strategies

Social-based routing strategies make forwarding decision relying on the social properties of nodes. Bubble Rap [15] considers the data routing in pocket switched network (PSN) which consists of several communities and there are social relationships among users. There are two steps of routing in Bubble Rap. The first step is to forward data to the destination community. It delivers data items from outside of the destination's community according to a node's global social centrality. If a node with higher global social centrality, it will be selected as the relay for data forwarding. Within the destination's community, the forwarding utility is based on a node's local social centrality. The data item will be forwarded to a node with higher local social centrality. SimBet [9] takes the linear combination of social similarity and social centrality as the forwarding utility to construct the data forwarding path. Instead of only considering single social property, the SimBet scheme considers the utility function as the combination of social similarity and social centrality, which measures both the social closeness with destination node and social position of the node in the network. The scheme chooses the node with higher combination value as the relay for data forwarding. A work related to social-based data multicasting is proposed by Gao et al. [13]. It presents multicasting path selection based on social centrality and social community. In the case of single data multicasting, it measures the social centrality, and chooses nodes with the higher value as the successor for data forwarding. In the case of multiple data multicasting, it takes the community structure into consideration. It finds the nodes with destination awareness and forwards the data to the node with highest delivery probability within the community. Then it continues its forwarding by social properties to find the destination. Social feature-based algorithm [29] takes the multi-dimension social properties and chooses the node with most similar social features as the