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Routing protocol based on social characteristics for opportunistic networks

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Abstract

Opportunistic networks are derived from delay tolerant networks, where mobile nodes have no end-to-end connections. Nodes are represented by people, which means that opportunistic networks can be regarded as social networks. Human mobility plays an important role in affecting the performance of forwarding protocols in social networks, furthermore, the trajectory of people's movements are driven by social characteristics. However, current routing protocols rely on simple mobility models, and rarely consider social characteristics. Considering two heterogeneous network models, an social opportunistic networks routing (SONR) was proposed which brings an adapted discrete Markov chain into nodes' mobility model and calculates the transition probability between successive status. Comparison was made between Spray, Wait and Epidemic protocol. Simulation show that SONR can improve performance on delivery ratio, delivery latency and network overhead, meanwhile. SONR approaches the performance of Epidemic routing.

Keywords opportunistic networks, delay tolerant networks, social characteristics, Markov chain, transition probability

1 Introduction

With developments of mobile ad hoc networks (MANET) in recent years, opportunistic network provide methodfor information transmission in disconnected network environment. They make researchers come into notice [1–4]. Opportunistic networks do not need laid communication infrastructure or contemporaneous end-to-end path. The networks use node mobility to set up delay-tolerant routines for communication [5–6]. Opportunistic networks are mainly applied in the circumstance where complete connected networks are impossible to be set up such as network transaction in remote areas, tracking of wild animals, vehicular communications, and portable devices in ad hoc networks [7–8].

Opportunistic networks make it possible to build pocket switched networks (PSNs) since portable devices are widely used. PSNs take advantage of opportunistic dissemination to facilitate people-to-people communication in dynamic and disconnected network environment. However, the major challenge of PSNs is how to design a routing protocol without instant end-to-end path. In parallel, social characteristics presents decisive property in human networks when embedded with routing algorithms, it's considerable to add social factors to routing design. In the previous research, social properties are introduced in designing forwarding algorithms in opportunistic networks which have been discussed in Refs. [9–11]. The inherent concept of creating community, in fact, divides the network nodes into closely related sub-groups [12]. Research on community detection in complex network has proceeded for a long time [13], puts forward several methodologies to detect community structure in centralized [14] or distributed way. In addition, the centrality is also an important indicator of the social networks. In communities, the centrality of some nodes with higher degree implies that nodes may be more popular, therefore, the centrality defines the node property in network [15], and can be assessed by various metrics based on closeness, betweenness and degree, etc.

Zs. Zhang et al [16] evaluate several routing strategies

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in delay tolerant networks (DTN), they use different methods to deal with the problems in complex networks, for example, the node mobility or trajectory of each node. In Ref. [17], the authors proposed Spray and Wait algorithm based on data dissemination, and made improvements for the rising of message delivery ratio by copying messages. In addition, the procedure of message transmission is based on automatic forwarding, which leads to lower computational complexity and processing overhead of the system. However, this algorithm has limitations, firstly, besides adjusting the number of copies, it does not provide any measurements to improve the efficiency of forwarding, secondly, in order to optimize the number of copies, the algorithm has to estimate the network parameters accurately, thirdly, the algorithm can't adjust the design adaptively for the changes of the network topology.

The current algorithms are limited in ~~to~~ ~~take~~ social structures associated with individual nodes and the encounter probability between nodes. To improve performance, new routing algorithms take advantage of social properties to predict encounter probability between nodes in Ref. [10], the author proposed a label algorithm, in which each node is presumed to own a label to inform other nodes of its belonging organization. The label compare the potential relay nodes' labels with destination node's label, and then the data objects are forwarded to the nodes belonged to the community destination resides. In Ref. [9], the rank algorithm, proposed by P.Hui et al, treated node centrality as forwarding metric to transmit data objects in its routing protocol. Each node is presumed to only know its own ranking and ranking of its encounter nodes. In the rank algorithm, data objects are simply forwarded to those nodes that own a higher ranking than the current ones, until the message is expired or the destination is reached.

There are many researchers attempting to build social structure in opportunistic networks from real world human mobility traces. In Ref. [18], based on different community detection algorithms from human mobility traces, the authors proposed visualization of detected community structures. [19] pointed out the mobile devices are able to detect their own community instead of relying on server. Nevertheless, there is still lack of thorough research on how the performance of forwarding algorithmsis impacted by social characteristics hidden in real connectivity traces. This paper aims on addressing these limitations and proposes SONR, a new social-based forwarding algorithm for opportunistic networks that can significantly improve network performance.

The system model is introduced in Sect. 2. We clarify, in Sect. 3, the forwarding strategies and describe the process of the proposed algorithm in detail. Numerical results are presented in Sect. 4 to compare our approach with existing ones. The conclusion is given in Sect. 5.

2 Individual heterogeneous network model

The network model is analyzed from two perspectives. Different mobile nodes are belonged to different communities with different popularities (see Fig. 1).

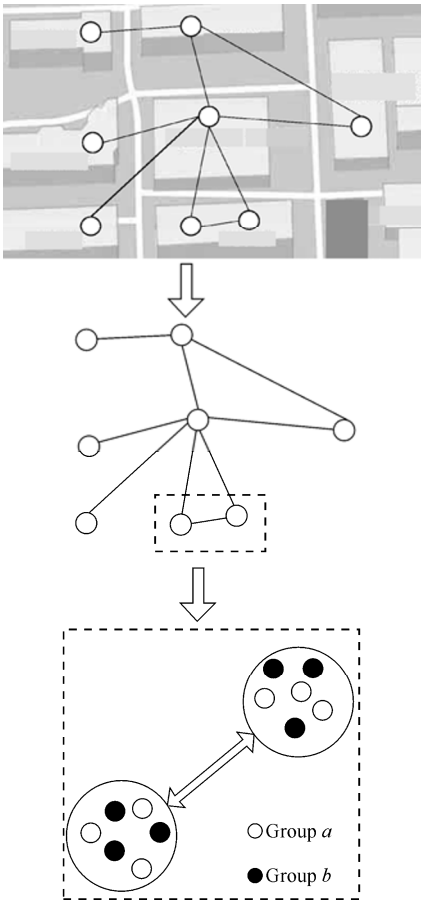

Fig. 1 Individual and spatially heterogeneity in an opportunistic campus network

Seeing in Fig.1, take the environment in school yard for example (say, in University Posts and Telecommunications), students often like place together forming spatial clusters around while rarely move to other clusters in different period of time. Furthermore, for each