ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 1, January 2018

Broadcasting Techniques in Mobile Social Network Based on Geo –Community

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***Abstract*—The issue of data broadcasting in mobile social networks (MSNets) is considered in this paper. Broadcasting data from a superuser to other users in the network is the key objective. The two main challenges are (a) Representation and characterization of user mobility in realistic MSNets; (b) With the knowledge of users' movements, data broadcasting depends actively on the super user route. Based on the geo-community structure of the network a semi-Markov process is employed to model user mobility. The semi-Markov model is used to derive the "dynamic user density" of each geo-community. Different super user route algorithms are provided that wants to either minimize total duration or maximize dissemination ratio. The idea of this work is to study data broadcasting in a realistic MSNet setting. This approach consistently outperforms other existing superuser route design algorithms with extensive trace-driven simulations.**

Keywords*— *Mobile social networks, data dissemination, broadcasting, geography, community.

1. INTRODUCTION

Mobile social users physically interact with each other and reach network service, even in the absence of network infrastructure or end-to-end connectivity such networks are called MOBILE Social Networks (MSNets)[1], [2].More attention has been given to MSNets because of the popularization of smart phones. Intermittent and frequent network connectivity makes data dissemination in MSNets a challenging problem.

The operation of sending data from a source user to all other users in the network is called Broadcasting. Applications of mobile ad hoc networks (MANETs) [3] use broadcasting.Data dissemination in such opportunistic environments makes broadcasting more effective. The existing work in intermittently connected networks always focuses on data unicast [5] or multicast [6]. However, broadcast is more effective for data dissemination. Services from safety applications to traffic managementrely on broadcasting data to the users inside a certain area of interest. Message delivery in Mobile Ad hoc Networks (MANETs) is difficult due to the fact that the network is rarely connected. A key challenge is to find a route that can provide good delivery performance and low end-to-end delay in a disconnected network.

This paper ideally focuses on broadcasting data from a special user to all other users in MSNets. Generally, the special mobile user is called superuser, and the other regular users are called users.Data broadcasting depends mainly on the mobility of the superuser with the knowledge of users' movement. The design of a superuser route has a significant impact on network performance. There are similar works on special user route design, such as Message Ferry or Data MULEs, where they assume that the special users always move with fixed routes to facilitate connectivity among other users, rather than data transmission.

Superuser routes are designed in such a way that there should not be any constraints on the movements of regular users. People sharing similar kind of properties in social network forms a community. Community is always interrelated to geography. For example, PG Scholars working in the same campus form a community, and they always contact each other in the campus. Hence geo-community is proposed, which represents a geography-related community, Based on geo-community, the mobility of the user is characterized and superuser route can be designed to actively broadcast data to mobile social users in the network.

Geo-communities are proposed into MSNets to characterize both geographic and social regularities of user mobility. The user mobility is formulated over geo-communities in MSNets as a semi-Markov model. Geo-centrality is further proposed to measure the user density of each geo-community with a semi-Markov model. Static Route Algorithms (SRA) is proposed considering geo-centrality, that the superuser wants to either minimize total duration of the route (min-T-SRA), or maximize dissemination ratio (max-p-SRA). Greedy Adaptive Route Algorithm (GARA) is further proposed for excluding the overlap of contacting users among the geo-communities.

In this paper, onlyone-hop data broadcasting is considered from the superuser to regular users.The main challenge in data broadcasting is how to design a superuser route to facilitate

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ISSN 2394-3785 (Online)
Available online at www.ijartet.com

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Vol. 5, Special Issue 1, January 2018

databroadcasting most effectively. To solve such a problem, focus should be on answering the following questions:

• What should be the appropriate metric for measuring the dynamicuser density of geo-communities?

• Given the dynamic user density of each geo-community, how should the superuser decide which geo-communitiescan stay, and for how long, respectively?

2. OVERVIEW

Mobile users in MSNets usually move around severalwell-visited locations instead of moving randomly. This shows that people usually belongto several communities, and contact others with similarhobbies, occupations, or social functions. For example,graduate students working in the same office interactmore frequently with each other. The further detection will be such contact preferenceis also usually correlated to geography information based on the community concept. Mostly contacts among officemates mostly happen to meet in theoffice. Such a geography-related community is defined as geo-community.

MSNets have some geo-communitiesof higher user density, and where the superuser thereforehas a much better chance of encountering regularusers than elsewhere. Examples of such geo-communitiesinclude public transportation and shopping centers inurban environments, or conference rooms and cafeteriasin office buildings, etc. Therefore, geo-centrality is propsed, a geography-related centrality metric, intoMSNets to measure the user density of geo-communities.Such a metric will be further used in the superuser route design.

Generally users in MSNets always move around severalwellvisited geo-communities, a Markov process is employed to model user mobility in the network. Each user's steady-state probability distribution is computed over geocommunities by analyzing the Markov model. Geo-centrality is further proposed to measure each geo-community's dynamic user density. If the whole network is composed of a certain number of geocommunities, the challenge of superuser route design will be how the superuser chooses geo-communities,and allocate waiting times accordingly.

3. ARCHITECTURE DESIGN

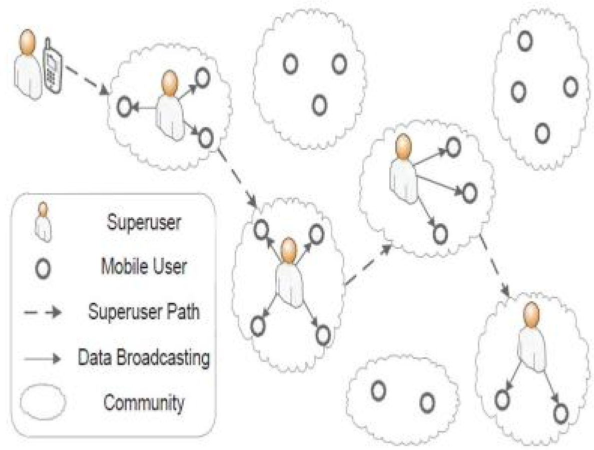

Fig. 1. Geo - Community based Data Broadcast Scheme in MSNets

The architecture shows how the super user broadcast data among the geo communities. The big picture is considered in the following scenario: When a sales man advertise his products to on-campus customers (e.g. faculty,staffs, and students). The salesman has to physically move around thecampus to transmit advertisements via his smartphone tousers. He is trying to decide his route, aiming to broadcastthe ads to mobile users as soon as possible.In data broadcast scheme, the users in MSNets areclassified into two categories, (a) Regular users: Users that move based on their social lives. These users arepotential data receivers from the superuser. The movements ofthe users are not controllable;.
(b) Super User: A single, special user calledsuperuser (e.g. the salesman) that aims to broadcast data toregular users in the network.

The following two cases are considered:

(1) The superuser aims to minimizethe total duration of route T under the constraint of a certaindissemination ratio, which corresponds to time-sensitivesuperuser. For example, the salesman tries to use less time toadvertise the product to a certain number of people;

(2) Thesuperuser aims to maximize the dissemination ratio p beforea certain deadline, which corresponds to dissemination-ratiosensitivesuperuser. In this case, the salesman tries to advertisethe product to more people within working time.

In both cases, the superuser route design scheme follows a utility-based approach. The superuser route comprises some geo-communities and the corresponding waiting times. Supposethat the whole network is composed of a certain

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
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numberof geo-communities, and the superuser can immediatelytransmit data to all the users within the geo-community wherethe superuser is stopping. The utility ui of geo-Communityi describes its potential contribution to the superuser's datadissemination. From a statistic perspective, the number ofusers to whom the superuser transmits data at geo-Communityi does not decrease with increasing ti. This indicates thesuperuser's waiting time at geo-Community i.

4. GEO - COMMUNITY

Clustering of users that are "tightly" linked to each other is defined as community. Members of a community usually share interesting properties, such as common hobbies, social functions, and occupations. On campus, graduate students working in the same office interact more frequently with each other; members affiliating with the same team, such as football or swimming, have such heavy interactions.

This is based on the quantities that guide human mobility. People generally move within a set of geo-communities, i.e. locations loosely shared among people, following speed, pause time and choice rules whose distribution is obtained by the statistical analysis; similarly, inside a geo-community, people move according to a Lévy walk. A methodology to derive social relationships from traces, by representing the system (node, geocommunity) as a bipartite graph whose projections on nodes indicate the strength of the relationships amongst nodes. Finally, simulation results are presented to show how the model correctly reproduces all the statistics of some real trace datasets through a simple setting of environment parameters. [4] discussed about a method, This scheme investigates a traffic-light-based intelligent routing strategy for the satellite network, which can adjust the pre-calculated route according to the real-time congestion status of the satellite constellation. In a satellite, a traffic light is deployed at each direction to indicate the congestion situation, and is set to a relevant color, by considering both the queue occupancy rate at a direction and the total queue occupancy rate of the next hop. The existing scheme uses TLR based routing mechanism based on two concepts are DVTR Dynamic Virtual Topology Routing (DVTR) and Virtual Node (VN). In DVTR, the system period is divided into a series of time intervals. On-off operations of ISLs are supposed to be performed only at the beginning of each interval and the whole topology keeps unchanged during each interval. But it has delay due to waiting stage at buffer. So, this method introduces an effective multi-hop scheduling routing scheme that considers the mobility of nodes which are clustered in one group is confined within a specified area, and multiple groups move uniformly across the network.

Interests might relate to geography in human society.Officemates contact each other in the office; Volleyballlovers play volleyball together in gyms. Thus forming a correlation between community and geography. The geo-community shows its efficiency in modeling user mobility in MSNets.

Normally users in MSNets affiliates to several different communities, and thenthey periodically act as the different roles, respectively. A user usually contacts other users who have at least onecommon interest with him/her at the according geo-locations.Therefore, geography-related community, geocommunity is considered to characterize the stable-member structure ofa geo-location in MSNets. For simplicity, assume thatone geo-location corresponds to a geo-community, and consider the sojourn time of a participant spent at a geocommunityto be the time interval of his/her two consecutivecontacts with different geo-locations, the former of which isthe corresponding geo-community. Later, the geo-communityshows its efficiency in modeling user mobility in MSNets.

A single user can be a mutual member of several different communities (people have varying roles in society). However, consider that a user only shows one membership at any single time in this paper. The user can change geo-community affiliation over time, and assume he/she does not spend any time on the transition between geo-communities.

5. GEO - CENTRALITY

The method which measures the extent, to whicha node lies on the paths linking other nodes, is currently widely used called Betweenness' centrality. Freeman's measure is used in social-based data forwarding[5]. Certainly, betweenness is not sufficient to analyticallyrepresent the probabilities for a geo-community to contactmobile users in the network. Inspired by [6],geo-centrality is proposed, a centrality metric of the geo-community, intoMSNets:where C_i (t_i)indicates the average probability that a randomlychosen user in the network is contacted by geo-Community$i$ within time t_i. The unit time focus on thediscrete time system . A user being contacted bya geo-community indicates that the user affiliates with thatcommunity.

6. SUPERUSER ROUTE ALGORITHMS

A. *STATIC ROUTE ALGORITHM (SRA)*

The total duration T of the superuser route has two components:

(a) Waiting time T_w: The sum of waiting times at the chosen geo-communities.

(b) Traveling Time T_t: Thetotal time that the superuser spends traveling between geocommunities.

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The total route time $T = T_w + T_t$.

Assuming that T_w contributes to the superuser's data dissemination,the superuser route design algorithm can be broken into twosubproblems: finding a good set of geo-communities andtheir corresponding waiting times, and ordering these geocommunitiestogether to form a tour.

B. GREEDY ADAPATIVE ROUTE ALGORITHM (GARA)

Greedy Adaptive Route Algorithm is further proposed because the superuser does not need to disseminate data to the same users more than once.

If the superuser has already deliveredthe data to a certain user at one community then thecontribution from that user to the other associated communities should be excluded.

Greedy Adaptive Route Algorithm (GARA) faces the dynamic centrality of geo-communities. GARA can overcome the overlap among geo-communities in the network by facing non-contacted users.

The algorithm shows that the GARA aims to maximize the sum of centrality withinthe total duration of superuser route. the travel cost of moving to the othergeo-community is less than the total utility gain, the superuser should move; otherwise, the superuser would be better to stay at the current geo-community. In contrast to SRA, GARA can overcome the overlap among geo-communities in the network by facing non-contacted users each step, but the trade-off is introducing more computational overhead.

7. EXPERIMENTAL RESULT

A. EVALUATION OF PERFORMANCE RATE

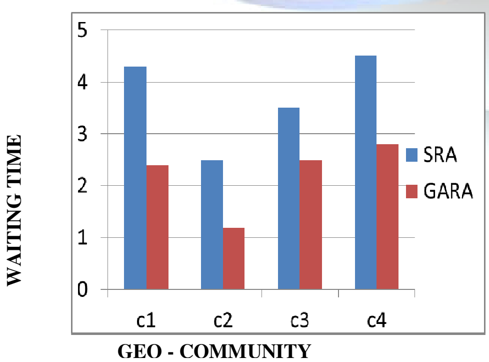

Fig.2. Evaluation of Performance Rate

The graph shown in Figure 2 plots the waiting time for different geo communities at two different algorithms. The C1, C2, C3, C4 denotes the different geo communities. The waiting time in the communities in GARA is reduced as it can overcome the overlap among geo-communities in the network by facing non-contacted users. Thisshows that GARA performs better than SRA.

B.Table for evaluating performance rate which includes the waiting time of each community at different algorithm

Community	SRA	GARA
c1	4.3	2.4
c2	2.5	1.2
c3	3.5	2.5
c4	4.5	2.8

The comparison of SRA and GARA perform significantly better than any other MF-based schemes, with higher dissemination ratios, lower transmission delays, and less superuser overhead. The main reasons are balancing the traveling time and waiting time. In addition, invest waiting time at geo-communities that are more advantageous in terms of increasing the contact probability with the mobile users. GARA takes advantage of updating geo-centrality metrics in terms of non-contacted users

Schemes (SRA and GARA) are considered with the followingtwo Message-Ferry based routing schemes [8], [12] for timesensitive(min-T) and dissemination-ratio-sensitive (max-p)superusers, respectively.

Message Ferry moves with Restricted Random Waypoint model (MF-RRWP): The ferry moves according tothe random way-point mobility model, with the restrictionthat the way-points are only chosen from the center ofeach geo-community. At each way-point, the ferry pausesfor exponentially distributed time with a mean of 15minutes.

Message Ferry moves along ordered set of waypoints (MF-ORWP): The ferry orders the center of each geo-community (way-points) to form a shortestpossibletour using the Concorde Traveling Salesman(TSP) solver [19]. The ferry traverses the ordered set ofway-points repeatedly.

The following two metrics are focused,which are key characteristics in data dissemination of MSNets:

- *Dissemination ratio*: the ratio of the number of deliveredusers to the total number of users in the network.
- *Average cost*: the traveling distance of the superuser. Note the superuser is not limited in powersupply, but still aim to maximize the energy efficiency.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 1, January 2018

8. FUTURE WORK

There is recent work which focuses on proposing routing schemes to achieve comparable performance as Epidemic routing, but with a lower cost measured by the number of relays needed for forwarding.They have proposed communicationmodels where special mobile nodes (Message Ferry [8], [9] and Data MULEs [10], etc.) facilitate the network connectivity. However, these models always assume the special nodes move with fixed routes.

The data dissemination scheme exploits the social characteristics of mobile networks without any online collaboration between the superuser and regular users in the network. The focus is on a different application (data broadcasting from the superuser to regular users); superuser also can extend to work as a "data carrier" between regular users. As such, it strengthens the research of both mobility-assisted routing schemes, and even the foundations in the area of intermittently connected networks.

9. CONCLUSION

In this paper, one-hop data broadcasting is studied from a single superuser to other users in MSNets. The main idea behinds this paper is exploring both geographic and social properties of users mobility to facilitate data dissemination on purpose. The geographic and social regularities of user's mobility from both theoretical and experimental perspectives are explored. Based on the exploited characterization, a semi-Markov process is introduced for modeling user's mobility.

The proposed superuser route comprises several geo-communities and the according waiting times, which are both calculated carefully based on the semi-Markov model. Extensive trace-driven simulation results show that the data broadcast schemes perform significantly better than other existing schemes.

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