Social DTN Routing

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ABSTRACT

Delay-tolerant network architectures exploit mobile devices carried by users to enable new networked applications. Efficiently routing information through these DTNs faces new challenges such as mobility and the dynamic nature of the network. Previous work has looked at using encountered nodes to build a social network for routing. In this work we construct routing tables from users' self-reported social networks. Initial experiments indicate that this significantly reduces the delivery cost of transmitting messages through a DTN.

1. INTRODUCTION

Delay-tolerant networks (DTNs) are intermittently connected networks where applications must tolerate delays beyond conventional IP forwarding delays [5]. DTNs may be useful for various scenarios including information propagation during disasters, bulk data distribution in urban areas and network connectivity in rural areas.

A fundamental issue in DTNs is how to effectively and efficiently route information. Since nodes may be mobile, static routing tables are inappropriate. When a source sends a message it is likely that the destination node (and even many of the intermediate nodes) is known to the source, and so researchers have explored the use of this social network information for building DTN routing tables. By analysing the encounters between nodes, it may be possible to optimise routing by forwarding messages to frequently-encountered nodes. At the same time, the use of these social network data may enable new social applications.

In order to build social networks, data such as encounters must be collected, so that the social network topology can be discovered. This can delay DTN bootstrapping and reduce effectiveness, as well as potentially increasing the costs of delivering messages. Since many applications involve sending to a known destination node (within the sender's existing social network), it may be simpler to generate the DTN routing table from a user's declared social network, rather than one detected through encounters.

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A recent study [3] that looked at these *self-reported social networks* (SRSNs) and *detected social networks* (DSNs) found the two social networks to be similar for conference attendees. Social scientists, however, have found that self-reported and detected social networks may differ [1].

In this work we are interested in two questions: i) Are DSNs and SRSNs similar? ii) If they are not similar, how does this affect routing in DTNs?

In order to study this we conducted an encounter-tracking experiment. 25 participants carried a single IEEE 802.15.4 sensor (the *t-mote invent* mote) for a total of 79 days. The motes recorded sensor encounters, where an encounter was said to be the detection of another mote within its radio range ($\sim 16m$). These encounters were then uploaded by the participants via Linux basestations that bridged the sensors to the Internet. Participants volunteered their social network information from the popular site *Facebook*[1], from which we derived the participants' SRSNs [2].

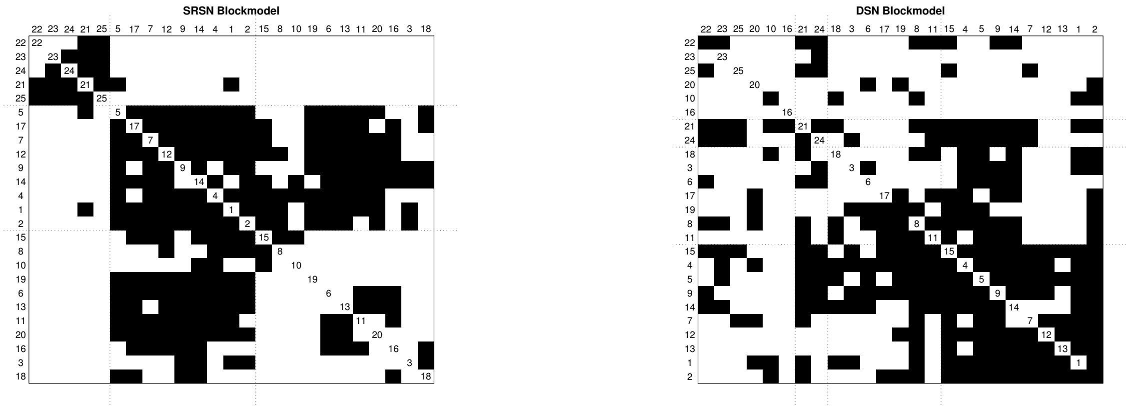
2. SOCIAL NETWORK COMPARISON

In order to determine whether the SRSNs and DSNs are similar, we employ a technique frequently used by social scientists: *role equivalence*.

Role equivalence studies clustering among the nodes. Two actors i and j are *role equivalent* if the collection of ways in which i relates to other actors is the same as the collection of ways in which j relates to other actors [4].

Figure 1(a) and Figure 1(b) show that on average, nodes in the DSN have a greater number of ties than in the SRSN. The roles are less well defined in the DSN, since the block-model does not show as obvious divisions as in the SRSN. The SRSN roles seem to form more blocky structures with similar relations to each other, and with clear boundaries. In the DSN, however, divisions seem to be distinguished by number of ties to the centre of the network. This implies that

[1] http://www.facebook.com/



(a) Blockmodel for the SRSN. There are three clearly-defined roles within the social network.

(b) Blockmodel for the DSN. There are four weakly-defined roles.

Figure 1: Blockmodels of the SRSN and DSN. Dotted lines indicate role divisions.

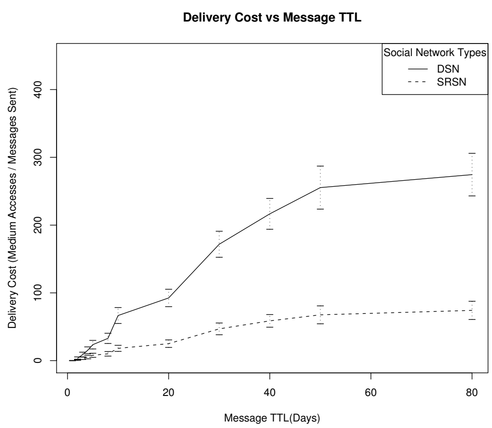


Figure 2: Comparison of SRSN and DSN delivery cost. Dotted error bars show one standard deviation.

in the SRSN there are some key nodes that bridge structural holes in the social network and allow routing between members of the different roles. The DSN, with its greater number of ties, is less reliant on a small number of key nodes.

3. ROUTING EVALUATION

To analyse the effects of SRSNs and DSNs on DTN routing performance, we used the two social networks as inputs to a simulated DTN.

We observe similar trends for both DSN and SRSN in terms of delivery ratio ($MessagesDelivered/MessagesSent$), with the SRSN's delivery ratios around 6% lower. Figure 2 shows the delivery costs ($MediumAccesses/MessagesSent$) for the SRSN and DSN simulations. We observe that messages are sent at around a third of the cost when using the SRSN, with the largest difference for any TTL being 84.93 medium accesses per message sent.

4. CONCLUSIONS AND FUTURE WORK

This work demonstrates that it is possible that SRSNs can provide a viable means to bootstrap a DTN. Further work needs to be carried out to see if DSNs, SRSNs or a hybrid of the two is optimal for routing. Our current work includes more in-depth simulations of DTNs in an urban environment. We simulate message-passing using both DSNs and SRSNs for the routing table, along with other common message-passing algorithms in a variety of different application scenarios, to obtain a comprehensive comparison of relative performance.

In the future we intend to: conduct larger-scale experiments using different devices and scenarios; explore how SRSNs and DSNs can be used together for routing; explore how to provide functionality to applications to tune the use of SRSNs within a DTN scenario; and explore how SRSNs can help in specific application areas.

5. REFERENCES

[1] H. R. Bernard et al. Informant accuracy in social-network data V. an experimental attempt to predict actual communication from recall data. *Social Science Research*, 11(1):30–66, Mar. 1982.

[2] G. Bigwood et al. Exploiting self-reported social networks for routing in ubiquitous computing environments. In *Proc. IEEE SAUCE*, Avignon, France, Oct. 2008.

[3] A. Mtibaa et al. Are you moved by your social network application? In *Proc. ACM SIGCOMM WOSN*, Seattle, WA, USA, Aug. 2008.

[4] S. Wasserman. *Social network analysis : methods and applications*. Cambridge University Press, 1997.

[5] Z. Zhang. Routing in intermittently connected mobile ad hoc networks and delay tolerant networks: Overview and challenges. *IEEE Communications Surveys and Tutorials*, 8(1):24–37, Jan. 2006.