Social Roles for Opportunistic Forwarding

Greg Bigwood, Supervisor: Tristan Henderson {gjb,tristan}@cs.st-andrews.ac.uk
School of Computer Science, University of St Andrews, UK

University of St Andrews

Overview

1. Introduction

Previous work has looked at using encounter-based social network data for opportunistic routing. It is unclear how fairly these schemes distribute the forwarding of messages.
In this work we investigate this and look at the potential of classifying nodes using "social roles" to find nodes with equivalent connections that can be used for forwarding.

2. Problem

Opportunistic networks frequently use small battery-powered devices. Current schemes use indicators from the structure of the network and topology history to identify nodes best suited for forwarding. Since energy consumption is an important factor, there may be a trade off between node lifetime and the need for nodes to forward messages in order for the network to be useful.
If there is a particular subset of nodes being frequently asked to do a large share of the forwarding, then this has the potential to balkanise the network and reduce network performance.

3. Thesis Statement

Current opportunistic forwarding schemes do not lead to a fair allocation of nodes messaging resources.
By exploiting the social structure of opportunistic nodes in an opportunistic network, we can build forwarding schemes that are both efficient and fair.

4. Contributions

i) Demonstrating that self-reported social networks can be used for efficient message forwarding [1].
ii) Showing that existing schemes for opportunistic routing are unfair to network users. Existing schemes use calculations of utility and ranking that may cause specific subsets of nodes to be overloaded due to being repeatedly selected by the routing mechanism to forward messages.
iii) Developing a new routing scheme that uses social information for message forwarding.

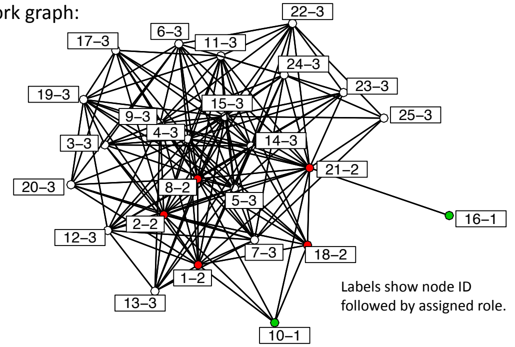
Current work

5. Social Roles for Forwarding

In society, we are members of various roles. Similarly in an opportunistic network, passing on messages to nodes performing a similar role may provide useful alternate routes, or constrain message flooding.

6. Regular Equivalence for Role Division

Computing the regular equivalence of a graph is a social science technique for constructing "a partition of nodes into classes such that nodes of the same class are surrounded by the same classes of nodes"[2]. All nodes of a role are connected to nodes in the same roles as those connected to by all other members of their role.
In order to partition the nodes, the network must be initially partitioned according to some selection criteria. In our experiments this was done using betweenness centrality. The role assignments are computed using the Kanellakis-Smolka algorithm[3]. We analysed our SASSY dataset[1] and are left with three roles below we can see how these roles apply to the network graph:



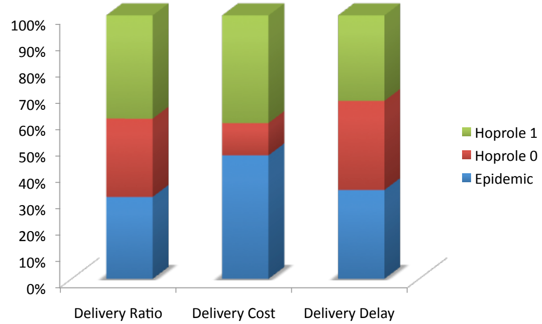
Labels show node ID followed by assigned role.

7. Evaluation

We have performed a preliminary experiment to demonstrate the usefulness of roles. We have created a simple forwarding algorithm called HopRole. Nodes pass a message if the encountered node is within a given range (number of hops) of the sender in the role-connectivity graph.
This scheme with a range of 0 and 1 was compared against epidemic routing by using the SASSY dataset to perform a trace driven simulation of nodes passing messages to one another.

8. Results

We observe that all three schemes have a similar delivery ratio (MessagesDelivered/MessagesSent). The difference in delivery ratio and cost (MediumAccesses/MessagesSent) between the Epidemic and HopRole range 1 schemes is not significant ($p=0.89$). The Epidemic and HopRole range 0 schemes are significantly different ($p<0.01$).
However this ratio is still comparatively good, and the delivery cost for the HopRole range 0 scheme is around a quarter of the cost of Epidemic routing. Below we can see the difference in magnitude of the Delivery Ratio, Cost and Delay.



9. Future Work

We will perform a comparison of existing opportunistic routing schemes, Epidemic routing and our own scheme based on the role analysis described above.
We will compare fairness of the schemes with respect to the maximum cost of message sending. Fairness is challenging to define in the domain of opportunistic routing. Existing fairness metrics may be inappropriate for this network scenario, and a new metric may need to be developed.
We hope to show that role-based schemes distribute the message sending and do not unfairly rely on a small subset of nodes. We will investigate whether a role based scheme can be used to increase the lifetime of nodes frequently used for routing, while still offering similar performance to existing protocols.

Funding
This work is supported by an EPSRC Doctoral Training Grant.

Bibliography
[1] G. Bigwood et al. Exploiting self-reported social networks for routing in ubiquitous computing environments. In Proc. IEEESAUCE, Avignon, France, Oct. 2008.
[2] S. Borgatti. Two algorithms for computing regular equivalence. SocialNetworks,15(4):361-376 December 1993
[3] P.C. Kanellakis and S.A. Smolka. CCS expressions, finite state processes, and three problems of equivalence. In Proc. PODC '83,pages 228-240, NewYork, NY, USA, 1983. ACM