A Comparison of Opportunistic Connection Datasets

Pedro Vieira, Department of Informatics/Centro Algoritmi, School of Engineering, University of Minho, Braga, Portugal
António Costa, Department of Informatics/Centro Algoritmi, School of Engineering, University of Minho, Braga, Portugal
Joaquim Macedo, Department of Informatics/Centro Algoritmi, School of Engineering, University of Minho, Braga, Portugal

ABSTRACT

Opportunistic networking differs from conventional architectures in the lack of existing network infrastructure, which can cause intermittent connectivity or increased communication delay between nodes. From a message routing perspective, solving these problems require a different set of techniques than those used in more traditional network schemes. Forwarding algorithms in these scenarios aim to improve performance metrics such as message delivery ratio and message delay time, while trying to keep the number of message copies small. A common approach used for testing the performance of opportunistic protocols relies on existing opportunistic contact traces. These datasets are widely available on the Internet, and provide a convenient way of simulating realistic usage scenarios. As such, studying the contact patterns between nodes can lead to useful observations to take into account in future experiments. This paper presents the results of a study on four different datasets. First, the authors describe the main characteristics of each trace. Then, they propose a graphical representation of the contact behavior for each pair of nodes. Further analysis of the results in terms of connectivity distribution among nodes reveals that contacts follow a roughly lognormal distribution and that there is a small group of nodes in each set which is seemingly much more popular than the rest. Finally, the authors introduce a temporal analysis that was made over the duration of each collection experiment. It was noticeable that individual nodes have repetitive contact patterns over time, apart from some observed cyclic variation over time (namely on weekends). By modeling the data traces as time-varying graphs, a performance decrease was observed with the absence of the most popular nodes.

Keywords: Connectivity Distribution, Datasets, Forwarding Algorithms, Network Infrastructure, Opportunistic Networking

INTRODUCTION

Opportunistic networks are usually characterized by the lack of conventional network infrastructure. As such, end-to-end paths between two nodes may not be always available, while also being prone to increased delay and error rates during data transfer, among other challenges. These problems motivate the need to design routing algorithms without guarantees of continuous connectivity, since traditional forwarding proposals do not usually take these constraints into account.

DOI: 10.4018/jdst.2013070103
Several opportunistic routing protocols use context information (i.e., information that a node can acquire of its surrounding environment) in order to determine which of the available neighbors has the best chance of delivering a message to a destination node. For example, the PRoPHET protocol (Lindgren, Doria, & Schelén, 2003) uses the past contact history of a node to predict future connection opportunities, while other approaches explore social relationships between nodes in the network, for example. In recent years, this area has been subject of extensive research among the academic community, with a great number of proposals being made in regards to routing protocols and data dissemination strategies (Chen, Yu, Sun, Chen, & Chu, 2006; Ramanathan, Hansen, Basu, Rosales-Hain, & Krishnan, 2007; Boldrini, Conti, Jacobini, & Passarella, 2007).

The performance of a routing protocol is an extremely important issue in these environments, as suggested by the challenges mentioned above. Some of the most important metrics in this subject include message delivery ratio, delay and overhead.

One of the most popular tools to test the performance of opportunistic routing algorithms is the use of existing contact datasets, which consist of a record of all of the contacts made between the participants, during a data collection experiment. This information is then used to design more efficient forwarding schemes, based on real usage scenarios.

Contact traces are available for widely different scenarios, ranging from groups of university students, to bus systems in a city, among others. Nevertheless, several questions arise when comparing different datasets. Do the traces have any similar statistical characteristics? Are the contact patterns sufficiently varied between individual participants? Would it be interesting to collect other types of information? Some of these concerns can be considered while planning future dataset collection experiments.

In order to answer some of these questions, we apply a methodology consisting of statistical analysis regarding different subjects, such as data distribution, correlation between different metrics, and temporal analysis. We also present visual representations of the datasets in question, which can be used to summarize the interactions among the nodes in the network. The remainder of this article is organized as follows. The next section describes some articles which use different strategies for opportunistic dataset comparison and visualization. Next, we present a description of the different datasets used on this work. Then we present visual representations of each node’s contact patterns. Then we explore the statistical distribution of the data. Following these, we provide an analysis of the data over the duration of each experiment. The experiments are represented as time-varying graphs and message forwarding simulations are used to find the critical nodes in the network. Finally, we present our conclusions on the work that was made, in addition to proposing future work on this subject.

This article is an extended version of the paper presented at the EIDWT-2012 conference (Vieira, Costa, & Macedo, 2012). The additional contributions presented are include a series of simulations in order to evaluate the performance of a static graph model in comparison to the ONE simulator, using different routing schemes and network parameters.

**RELATED WORK**

Several different approaches have been made with regards to opportunistic dataset analysis and visualization. Belblidia et al. (2010) propose the surround indicator metric, which describes the spatial dimension of a contact in a wireless network; in other words, it indicates the density of nearby nodes in a given network. This metric could be used in conjunction with the more widely used temporal dimension metric as information for opportunistic routing protocols.

Xu, Yang, Li, and Chan (2009) present a social community detection strategy for opportunistic datasets. This algorithm groups the nodes in different communities (or clusters), based on the duration and frequency of contacts a node has with others. Community informa-
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