

Chapter 18

Routing in Opportunistic Networks

Hoang Anh Nguyen

University of Applied Sciences (SUPSI), Switzerland

Silvia Giordano

University of Applied Sciences (SUPSI), Switzerland

ABSTRACT

In Opportunistic Networks (OppNets), mobile devices transmit messages by exploiting the direct contacts, without the need of an end-to-end infrastructure. Disconnections of nodes and high churn rates are normal features of opportunistic networks. Hence, routing is one of the main challenges in this environment. In this article, we provide a survey of the main routing approaches in OppNets and classify them into three classes: context-oblivious, mobility-based, and social context-aware routing. We emphasize the role of context information in forwarding data in OppNets, and evaluate the relative performance of the three routing techniques. Finally, we present how context-based information is used to route data in a specific subclass of OppNets: Sensor Actor Networks (SANETs).

INTRODUCTION

In the last decade, mobile ad hoc networking has been suggested as a technology for realizing the ubiquitous computing vision. However, after more than ten years of research in this field, this promising technology has not yet entered the mass market. One of the main reasons for this is the lack of a pragmatic approach to the design of in-

frastructure-less multi-hop ad hoc networks (Conti et al., 2007: The Theory). In current networks, the network layer has become the interface (and thus the bottleneck) between a growing multitude of applications and an increasing number of technologies. In terms of mobile ad hoc networks, this has resulted in the exponential grow of complexity at the network layer, which has further complicated practical realization. Opportunistic networking tries to simplify this aspect by removing the assumption of physical end-to-end connectivity

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while providing connectivity opportunities to pervasive devices when no direct access to the Internet is available. Pervasive devices, equipped with different wireless networking technologies, are frequently out of range from a network but are in the range of other networked devices, and sometimes cross areas where some type of connectivity is available (e.g. Wi-Fi hotspots). Thus, they can opportunistically exploit their mobility and contacts for data delivery (Conti et al., 2007: The Reality).

The elimination of the need to build paths drastically simplifies the routing in opportunistic networks; however, challenges remain that are distinct from those of conventional network routing methods. A routing scheme in OppNets has to provide data with some reliability¹ (ideally with full reliability) even when the network connectivity is intermittent or when an end-to-end path is temporally nonexistent. Moreover, since “contacts” in an opportunistic network may appear arbitrarily without prior information, neither scheduling routing nor mobile relay approaches can be applied. In such environments, flooding-based routing protocols appeared for some time to be popular design choice. However, this approach tends to be very costly in terms of traffic overhead and energy consumption. Routing performance improves when knowledge regarding the expected topology, the behavior of the participants, and the information about the participants themselves in the networks can be exploited: that is, the context information of the networks.

Context information can cover various ranges, depending on the specific routing protocols. It could be the workplace, home address, profession, and email address, the mobility pattern of nodes, or the communities that the nodes belong to, and so on. All information that aids in making decisions to route messages is context information. For example, to identify those hops best suited for communication towards the eventual destination, the home address of a user is a valuable piece of context information.

In the following section, we provide a brief description of the primary routing approaches in OppNets available in the literature, from “naïve” approaches to “intelligent” ones. Specifically, we emphasize the role of context information as well as social aspects in routing messages, where the classification of routing approaches is based on the amount of context information used as given in (Conti et al, 2008). Based on the context information exploited we classify routing in OppNets into three classes: context-oblivious, mobility-based and social context-aware protocols. Finally, we present the context-based routing protocols in Sensor Actor Networks (SANETs).

Context-Oblivious Routing

Flooding-based routing algorithms belong to the context-oblivious routing group, from “blindly” flooding techniques to controlled flooding solutions. In flooding techniques, a source node sends out a request packet on its entire outgoing links. Each node receives a request packet and forwards the packet on its entire outgoing links except the one corresponding to the incoming link on which the packet arrives. Each request packet may reach the destination node along a different route at a different time. The advantage of flooding-based routing is its simplicity in finding a route², in particular, a minimum delay ratio for a connection request because it doesn’t require any global information about network topology, or any context information. However, flooding causes a huge number of control packets in control channels, which can result in network congestion. Moreover, this kind of technique floods all the nodes in the network, and is thus very costly in terms of energy consumption and memory. Network performance is particularly important in OppNets because of the device constraints.

One way to address this problem is to use a hop counter in the header of each packet and decrement it at each hop; when the counter of a packet reaches zero, the packet is discarded.

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