Chapter 13
A Distributed Monitoring Framework for Opportunistic Communication Systems:
An Experimental Approach

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ABSTRACT

Opportunistic communication systems aim at producing and sharing digital resources by means of localized wireless data exchanges among mobile nodes. The design and evaluation of systems able to exploit this emerging communication paradigm is a challenging problem. This paper presents the authors' experience in developing U-Hopper, a middleware running over widely diffused mobile handsets and supporting the development of context-aware services based on opportunistic communications. The authors present the design of the platform, and describe the distributed monitoring framework that was set up in order to monitor and dynamically reconfigure it at run time. The paper concludes with an experimental evaluation of the framework, showing its practical utilization when monitoring an operational opportunistic communication system.

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1. INTRODUCTION

The proliferation of mobile technologies such as mobile phones, gaming consoles and MP3 players, equipped with short-range wireless communication technologies (e.g., Bluetooth and WiFi) has encouraged the development of applications that allow users to produce, access and share digital resources in a wide number of everyday occasions without relying on a fixed telecommunication infrastructure. The communication paradigm behind these application scenarios is referred as "opportunistic communications" (Pelusi et al., 2006), and is based on the possibility of exchanging data whenever in mutual communication range. The applications behind this communication paradigm have addressed the possibility for users to access data from certain locations (location-based) or to share contents with other users in proximity (mobile peer-to-peer). Examples include mobile social networking (Aka-Aki), where users exploit opportunistic communications to share information, distributed computing scenarios (Tan et al., 2007), where the opportunistic replication of data is used to, e.g., recovery data in case of a device failure, or Delay Tolerant Networks (DTNs) (Fall, 2003), where the nodes of network act as data carriers in order to let messages reach the intended destinations.

In this work we focus on mobile social computing. The importance of these application scenarios is mainly determined by two factors. On the one hand, it is a direct consequence of the widespread diffusion of mobile devices (e.g., smartphones or PDAs). On the other, such devices are constantly increasing their computing, communication and storage power. Several mobile phones are in fact equipped with Bluetooth and Wi-Fi technologies, which are directly accessible for programmers through freely available and easy-to-use APIs. Furthermore, mobile phones are now capable of intensive processing operations and of storing and processing large amounts of data in their internal memory. This is significantly changing the use that people make of mobile phones: originally conceived for making calls, they are becoming nowadays platforms for entertainment, for running data and communication intensive mobile applications. This has led to creative and innovative application scenarios, mobile social computing being one of the most popular ones.

Opportunistic communication systems have been deeply investigated from a theoretical viewpoint. Such studies explored the many tradeoffs existing between the performance of the system, and the resources allocated for running it (Zhang et al., 2007). Typically, the performance of an opportunistic system (e.g., end-to-end delay) is inversely proportional to the resources utilized for running the system (e.g., number of copies introduced for each message): the more copies are generated for each message, the faster it will reach the intended destination. Congestion is generally not an issue, since we are dealing mostly with sparse scenarios, where nodes are assumed to be isolated most of the time.

Most of the research in opportunistic networking has been devoted to the definition of forwarding mechanisms capable of optimally exploiting such trade off. Conversely, limited work has been done in the literature to study the many challenges related to the design, engineering and operation of such systems.

Following these considerations, we have developed a User-centric Heterogeneous Opportunistic Middleware (Create-Net, 2008), which is a middleware platform running over any Java-enabled smartphone and leveraging Bluetooth connectivity for exchanging data. Such platform provides all the necessary programming abstractions for developing opportunistic mobile services, and transparently handles all the necessary operations that are needed in order to dynamically program data gathering tasks.

In this paper, we present an overview of the U-Hopper platform and describe our experience in developing, evaluating and testing opportunistic mobile applications running over commercially

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