Chapter XXI
Context-Aware P2P Over Opportunistic Networks

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ABSTRACT

Recently, the popularity of p2p computing paradigm has been increasing, especially in the mobile environments, due to the large use of mobile devices as tools to generate and share content among users. Several works have been proposed in ad hoc networks literature to optimize legacy p2p systems over a mobile environment, mainly relying on the necessity of a stable path between pairs of nodes wishing to communicate. However, in the last few years, resources limitations and high mobility of users have introduced a new networking paradigm characterized by intermittent connectivity and frequent partitioning: the opportunistic networks. In such a dynamic environment, where systems must exploit all communication opportunities to enable the users to get in touch and exchange data, the authors propose a novel definition of mobile p2p, which exploits context information to enhance distributed services. In addition, they present a Context-aware opportunistic File Sharing application as a practical example of an optimized p2p service over opportunistic networks.

INTRODUCTION

In the last few years mobile p2p computing is increasingly emerging as an important paradigm for building next generation distributed mobile applications. The main motivation is the increasing use of mobile devices as tools to generate and share content among users according to the
Web 2.0 model. Until now, this paradigm has been supported by the legacy client/server model (e.g., through web sites such as YouTube). In a pervasive mobile environment, the p2p paradigm is conceptually closer (with respect to the client/server paradigm) to Web 2.0 content generation and sharing models. In p2p systems users directly communicate with each other without any intermediate entity such as a server. They can join and leave dynamically equally sharing the load of communication and data management. Unfortunately, p2p systems in mobile environments are not (yet) as successful as the legacy p2p systems for the wired Internet are. This is essentially due to the difficulties of running efficient p2p systems in resource-scarce and possibly challenged networking environments, which is the typical case of mobile pervasive environments. However, there is no reason not to foresee that p2p system will play a fundamental role to support data sharing in mobile environments as well, as – in principle – they represent a very efficient and natural solution.

Recently a lot of studies on p2p over self-organizing ad hoc networks have been conducted providing optimized solutions for mobile users (see (Conti, Delmastro, & Turi, 2007) as an example) but they are essentially based on the assumption that there always exists a stable path between pairs of nodes wishing to communicate. Actually, while it’s foreseeable that users’ devices be able to communicate wirelessly with each other, it’s not realistic to envision a single, well-connected, ad hoc network including all devices. A pervasive network made up of a large number of mobile devices is intrinsically disconnected. Due to nodes’ mobility, clouds of connected devices appear, disappear, and re-configure dynamically. Some of these clouds can include devices connected to the legacy Internet (e.g., Wi-Fi Access Points), while some others can be (temporarily) disconnected from the rest of the network. This scenario can be supported by the new communication paradigm called opportunistic networking (Pelusi, Passarella, & Conti, 2006). It fits well the behavior of mobile users who need to exchange data while they are moving even in areas without the Internet coverage. In this case nodes must be enabled to communicate even if a route connecting them never exists. Mobile nodes are not supposed to possess or acquire any knowledge about the network topology, which instead is necessary in traditional routing protocols for mobile ad hoc networks (MANETs).

In opportunistic networks routes are built dynamically, hop by hop, while data flows towards the destination(s). In this way any possible node can opportunistically be used as next hop, provided its probability to bring the message closer to the final destination is sufficiently high. In this scenario nodes must exploit all the available opportunities to get in touch and communicate. In this type of networks the topological information about the network states is often unreliable and not precise. Therefore, data-centric communication paradigms should be preferred with respect to conventional topology-based paradigms. Furthermore, as the network is very dynamic and possibly unstable, context information should be exploited to complement the inaccurate knowledge provided by topological information alone. This makes an outstanding case for the use of context-aware p2p systems in opportunistic networks, as p2p systems are one of the most natural ways of supporting data-centric communication. Available systems designed for ad hoc networks are not directly applicable in such an environment, and network protocols and services must be enhanced to exploit all possible opportunities to deliver messages on the network. However, characteristics of p2p systems for MANETs must be considered as a basis for designing data-centric services for opportunistic networks.

For this reason in this chapter, before analyzing current solutions for p2p over opportunistic networks, we review the most popular p2p systems for mobile ad hoc networks in the background section. Then, we investigate how it is possible