Chapter XVI
Mobile P2P in Cellular Networks: Architecture and Performance

Kurt Tutschku
University of Vienna, Austria
Andreas Berl
University of Passau, Germany
Tobias Hossfeld
University of Würzburg, Germany
Hermann de Meer
University of Passau, Germany

ABSTRACT

The telecommunication industry has recently seen two areas with very high growth rates: cellular networks, for example, GSM (Global System for Mobile Communications) or UMTS (Universal Mobile Telecommunications System), and P2P (Peer-to-Peer) file-sharing applications. A combination of both might be highly attractive: a) for attracting new users; and b) for exploiting the potential of cellular broadband technologies. From a system’s perspective, architectures and performance figures of cellular mobile network applications and services that have edge-based intelligence (e.g., P2P applications) are, to the best of the authors’ knowledge, less researched and many questions remain open. This chapter presents the design of MP2P (Mobile P2P) applications for cellular mobile networks by using the example of a MP2P content-distribution application. First, the incompatibilities between the P2P paradigm and properties of cellular mobile networks are identified. Then, a design methodology for MP2P applications for cellular mobile networks is proposed. The proposed method is based on a functional analysis of the two basic P2P functions, resource mediation and resource access control. The result is a hybrid P2P content-distribution architecture, which is enhanced by different operator-controlled infrastructure.
elements. The suggested architecture does not only overcome incompatibilities between P2P and cellular mobile communication systems, it also meets the functional needs and performance requirements of future P2P applications in cellular environments, while still largely preserves the user characteristics and efficiency of P2P systems. Finally, the performance enhancements by the architecture for the two basic P2P functions are investigated by comprehensive simulative and analytical performance evaluations.

**INTRODUCTION**

The telecommunication industry has recently seen two major areas with very high growth rates. First, the GSM (Global System for Mobile Communications) system has reached two billion users in 2006 and still shows an annual growth rate of more than 10%. Second, P2P (Peer-to-Peer) file-sharing applications have surpassed Web surfing by up to one order of magnitude in terms of data volume. Thus, a combination of cellular mobile networks and controllable P2P content distribution would be highly attractive for the attraction of new users and for exploiting the potential of broadband wireless technologies like UMTS (Universal Mobile Telecommunications System).

A first experience of cellular mobile networks and of P2P systems might imply that the concepts fit well. Both systems have features like point-to-point or group-oriented communication and permit the roaming of users. At closer look, however, the architectures of both systems differ tremendously. Thus, their architectures and requirements make a combination of both systems difficult.

In this chapter, we first identify the incompatibilities between cellular mobile systems and P2P systems. Then, we propose a new design methodology for MP2P (Mobile P2P) applications for cellular mobile networks. The suggested method is based on a functional analysis of the two basic P2P functions, resource mediation and resource access control. The result is a controllable, hybrid P2P content-distribution architecture. The controllability feature is obtained by applying three different operator-controlled P2P infrastructure elements. The suggested architecture does not only overcome incompatibilities between P2P and cellular mobile communication systems, it also largely preserves the usability characteristics and efficiency of P2P systems. Finally, the performance enhancements for the two basic P2P functions by the infrastructure elements are investigated by comprehensive simulative and analytical performance evaluations.

Since P2P overlays mainly operate on application layer, cross-layer design and radio resource management mechanisms are not the focus of this chapter.

**INCOMPATIBILITIES BETWEEN CELLULAR MOBILE NETWORKS AND P2P NETWORKS**

In general, cellular mobile networks and P2P networks are both communication systems which enable users to directly exchange information. However, incompatibilities arise between the concepts since they implement their capabilities on different layers. To identify the design challenges of MP2P applications, the key characteristics of cellular mobile networks and P2P systems need to be compared. First, a brief review of the features of cellular networks is given, then an example of a P2P application is described, and afterwards incompatibilities are discussed.

**Cellular Mobile Networks**

In cellular mobile networks, the wireless nodes communicate via dedicated elements such as base stations or switches. Hence, such networks
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