Chapter VIII
Cooperation Strategies for P2P Content Distribution in Cellular Mobile Networks: Considering Mobility and Heterogeneity

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ABSTRACT

The performance of P2P content distribution in cellular networks depends highly on the cooperation and coordination of heterogeneous and often selfish mobile users. The major challenges are the identification of problems arising specifically in cellular mobile networks and the development of new cooperation strategies to overcome these problems. In the coherent previous chapter, the authors focused on the selfishness of users in such heterogeneous environments. This discussion is now extended by emphasizing the impact of mobility and vertical handover between different wireless access technologies. An abstract mobility model is required to allow the performance evaluation in feasible computational time. As a result, the performance in today’s and future cellular networks is predicted and new approaches to master heterogeneity in cellular networks are derived.

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INTRODUCTION

The cooperation strategies applied in popular P2P content distribution networks (CDN) such as eDonkey or BitTorrent, rely on the fundamental P2P assumption that all peers are equal. In cellular networks, however, the peers differ significantly in their characteristics, e.g. their access system and bandwidth which might change over time or their on-line behavior, thus introducing heterogeneity and even selfishness in the peer community. In the previous chapter “Cooperation Strategies for P2P Content Distribution in Cellular Mobile Networks: Considering Selfishness and Heterogeneity”, we discussed the impact of heterogeneity resulting into selfishness of users. Hence, the P2P assumption of equal peers is not valid any more. In this chapter, we concentrate on the dynamics and heterogeneity in cellular mobile networks which is further increased by the mobility of users.

Although most P2P CDNs utilize the benefits of multi-source downloads, the various platforms differ significantly in the actual implementation of the cooperation algorithms. In particular, the peer selection as well as the chunk selection mechanisms lead to different system behaviors and performance results. The detailed performance of the strategies is further determined by the actual peer characteristics and the peer behavior. The peer characteristic includes, among others the available upload and download bandwidth, as well as the number of parallel upload and download connections. The mobility of a user makes these peer characteristics change over time. Thus, the performance depends considerably on the heterogeneity. The peer behavior is mainly described by churn, i.e. the switching of a user between offline and online state, and by the willingness of a user to participate in the CDN. A user may behave selfish and tries to minimize the upload of data or he may redistribute the data in an altruistic way. In the context of cellular mobile networks, churn and selfish behavior appear even more distinctive, e.g. to save battery resources or scarce and expensive uplink capacities, resulting in the last chunk problem.

Additional challenges and influence factors on the performance of the system arise in a heterogeneous, wireless cellular network. We consider a beyond third generation (B3G) network with different infrastructure-based radio access technologies, in particular UMTS and WLAN. Due to the user mobility, vertical handovers (VHO) between the different wireless access technologies are required which may result in transmission delays and IP address changes of the switching peer. We investigate whether it is recommended to use mechanisms like Mobile IP in the context of P2P-based content distribution in cellular environments, since such mechanisms also introduce additional delays. Another important phenomenon occurring with vertical handovers is the abrupt change of available bandwidth, e.g., from a fast WLAN connection to a rather slow UMTS connection.

There are several possibilities to improve the performance of content distribution in cellular networks. Those are: a) particular architecture concepts introducing special entities like caches for storing contents or crawlers for locating sources, e.g. (Oberender et al., 2005); b) the optimization of parameters, like the size of chunks, as done by (Hoßfeld, Tutschku & Schlosser, 2005b); c) incentives to motivate the users to share files and to contribute to the system; and d) cooperation strategies for the coordination among peers. From these possibilities, we will focus on the cooperation strategies in this chapter. The goal is: i) to describe how to a model a P2P content distribution system with multi-source download in a cellular wireless environment; ii) to identify the fundamental problems of typical cooperation strategies; iii) to investigate the impact of user behavior and heterogeneity, in particular mobility and VHO; and iv) to propose solutions to overcome the derived problems.
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