Chapter 11
Mathematical Optimization Models for WLAN Planning

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Abstract Wireless Local Area Networks (WLANs) based on the IEEE 802.11 standard family are used widely for wireless broadband Internet access. The performance aspects of WLANs range from deployment cost, coverage, capacity, interference, and data throughput to efficiency of radio resource utilization. In this chapter, we summarize some recent advances in applying mathematical optimization models for solving planning problems arising in placing access points (APs) and assigning channels in WLANs. For AP location, we present an optimization model aimed at maximizing the average user throughput. For channel assignment, we present two modeling approaches that use different performance metrics. We also discuss integrated models for joint optimization of AP location and channel assignment. We report computational experiments with real-life data, and show the advantages of mathematical optimization in WLAN planning.
Key words: integer linear programming, performance, optimization, wireless local area networks, WLAN

11.1 Introduction

WLAN (Wireless Local Area Network, also WiFi) is a technology for providing wireless broadband Internet access. Due to their low cost and ease of use, WLANs are widely deployed. The network layout and its configuration determine the performance of a WLAN; important performance indicators are deployment cost, coverage, capacity, interference, data throughput, and efficiency of radio resource utilization. At present, WLANs are often installed using rules of thumb; this calls for quantitative and systematic methods that can outperform manual approaches. This chapter presents mathematical optimization approaches to the problems of locating access points (APs) and assigning a channel to each of them. We show how mathematical models can capture the essential features of the technology and provide superior network designs.

Most aspects of WLAN optimization resemble problems studied in mobile cellular network planning. The AP positioning problem is akin to base station positioning and coverage planning in cellular networks. Due to the smaller coverage area of WLANs, however, the number of installed APs is smaller, and the signal propagation characteristics are different. Moreover, WLANs are mainly intended for providing broadband access to users that are rather stationary. Channel assignment for minimizing interference is needed in WLAN just as, for instance, in GSM (see Section 1.5.5.1). The number of channels is, however, much smaller, and access to the medium is controlled by a contention mechanism on each channel. The impact of this mechanism on network performance is paramount, and requires tailored modeling approaches.

We present several optimization models for the planning phase of deploying WLAN. The models can use both measurements and prediction-based data. As data are collected prior to solving the models, optimization can be performed using centralized computation. We optimize AP location using a facility location model in which the average single-user throughput is maximized. Two modeling approaches are considered for channel assignment: overlap graphs and contention sets. With overlap graphs, each pair of APs is assigned a weight proportional to the area in which the received signal strengths of the two APs are above some thresholds. Channel assignment has the objective of minimizing the total weighted overlap of APs on the same and adjacent channels. Two integer-linear programming models for minimum-overlap channel assignment are discussed in the chapter. For each user, the contention set comprises all other users potentially contending for medium access with the user. The modeling approach resulting from the concept uses a performance metric, called network efficiency, that reflects the average probability of successful access to the medium. Using contention sets, the goal is to maximize the network efficiency metric. Because the contention sets carry information on