11  TELECOMMUNICATIONS
NETWORK DESIGN

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Abstract: Telecommunications networks are fundamental in any telecommunications system. The network has to meet a number of criteria for the performance to be satisfactory. Hence, when designing the network, one may pose a number of optimization problems whose solutions give networks that are, in some sense, optimally designed. As the networks have become increasingly complex, the aid of optimization techniques has also become increasingly important. This is a vast area, and this chapter considers an overview of the issues that arise as well as a number of specific optimization models and problems. Often the problems may be formulated as mixed-integer linear programs. Due to problem size and problem structure, in many cases specially tailored solution techniques need to be used in order to solve, or approximately solve, the problems.

Keywords: Telecommunications optimization, network design, mixed-integer linear programming.

11.1  INTRODUCTION

Telecommunications network design is about creating a blueprint for a network. A network design is a plan for how the network should look like so that the involved parties—users, operators, regulators, etc.—will be happy with its performance and cost. Creating a network design is about choosing network structures, allocating re-
sources, and configuring high-level parameters. It depends on the capabilities of the networking technologies, it needs a fair level of detail (but not too much since it is usually based on uncertain forecasts), and the results have to be carefully judged based on several contradicting merits.

Telecommunications networks are very complex today, in essence because they have to meet a wide range of requirements. Heterogeneous services and applications that coexist in the same network, mobility, interworking with a large number of other networks (including legacy networks), and deregulation are just a few factors that have driven complexity up. As a consequence, network design complexity has also been increased. The number of design options and possible design solutions are enormous.

The standard approach for handling the complexities of network design is to divide into subtasks and restrict possibilities, but even the subtasks can be very difficult decision problems. Many of the critical tasks relate to a practical, technical, and quantifiable problems in network design. Some examples are topology design, dimensioning (sizing/loading), configuration, routing, location of functionality, and resource allocation. Many of these problems can be naturally, and fruitfully, cast as optimization problems.

This chapter presents an overview of telecommunications network design from an optimization point-of-view, i.e., the focus is on discussing current problems in telecommunications network design where optimization models and algorithms are applicable and useful as tools. Business oriented aspects of network design, such as deciding on networking technology, and choosing targeted customers and services to offer, are not covered. Neither are technical problems that have no immediate optimization formulation (e.g., designing addressing plans).

The exposition is not complete, neither from a telecommunications network design perspective nor from an optimization application point of view. Network design in telecommunications encompasses many more aspects than what is covered here. There exists an extensive body of literature on the subject. The application of optimization to these problems also has a long history that is not described or surveyed in any detail. Nevertheless, it is our hope that this chapter can serve as a guide to the general network design issues.

11.2 BACKGROUND

To understand how optimization can be applied to telecommunications network design we begin by looking at the who, why, and how of network design: who is interested in doing a network design, why is it interesting, and what is the overall procedure.

Throughout this chapter, telecommunications network design is considered as a planning and configuration problem for a network administrator, which is someone, who is running, or planning to run, a telecommunications network. The network administrator can be a public operator, e.g., fixed telephony and mobile operators or Internet Service Providers (ISP). It can also be a corporation or larger company with a private network that connects its branch offices with each other and with external networks. There are also network administrators that are providers to other network administrators, e.g., access providers and leased line operators.