Chapter 13
Scheduling Healthcare Systems: Theory and Applications

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ABSTRACT

This chapter offers a series of scheduling techniques and their applications in healthcare settings. Healthcare administrators, physicians, and other professionals can use such techniques to achieve their operational goals when resources are limited. Implementing scheduling techniques in healthcare is difficult. Healthcare systems are complex, and the scheduler must be able to connect the scheduling theory with suitable algorithms for implementation. The chapter covers a wide spectrum of scheduling models, from single server and deterministic models to the more difficult ones, those which consider several servers and stochastic variables. A strong emphasis is placed on the practical aspects of scheduling techniques in healthcare.

INTRODUCTION

Scheduling plays a crucial role in healthcare organizations. The pressure to reduce costs has an impact on the quality of service. Healthcare schedulers must find a line between reducing cost and caring for people. Application of scheduling techniques in healthcare can reduce costs and improve the quality of medical treatments.

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Healthcare systems are complex because of their complicated design, multifaceted objective functions, and stochastic nature. Consider an emergency department at a hospital. There are several ambulances, emergency technicians, nurses, and doctors. Patients arrive and wait in several service areas: triage, waiting room, emergency room, beds, X-ray machines, and laboratory stations. All these "server stations" differ with respect to their operational characteristics, such as processing capacity, processing times, and operational

goals. The system becomes even more complex when considering that upon arrival, patients may go through several stations which often are determined dynamically as patients move from one station to another. In this complex scheduling system, the primary goal is to provide high quality treatment. This goal, however, must be achieved while costs of patients' care are kept as low as possible.

In addition, there are difficult questions of medical scheduling ethics. For example, should the physician schedule an untested and expensive treatment or a more traditional and less expensive one? Should a doctor see his patients according to the First Come First Served (FCFS) rule or Shortest Case First (SCF) heuristic? The FCFS rule provides an equal waiting time for patients and is a known to be "a fair" scheduling heuristic. On the other side, the SCF heuristic may seem "unfair" to patients but it may significantly increase utilization of doctors, nurses, and other resources of the healthcare clinic.

Another challenge of healthcare scheduling is that healthcare systems have a high degree of patient contact and are difficult to control and rationalize. For example, patients arrive randomly and as such they can always make an input to, or cause a disruption in, the healthcare service. Besides patient arrivals, treatment times are often random in nature. Consider the oncology department in the same hospital. Planning and scheduling radiotherapy treatments seems to be an uncomplicated task for the scheduler. A patient will typically visit the treatment center several times a week for a given number of consecutive weeks as described in his or her treatment plan. The goal of such a patient scheduling system is to ensure the delivery of the right treatment at the right time while maximizing the utilization of equipment and other resources. However, this is not a simple task because treatment time for each patient is random. Under such environment, it is difficult to minimize waiting times for patients, idle times for equipment, or overtime for nurses and technicians.

In general, the implementation of operations research models and scheduling techniques in real life problems is difficult. Such a challenge is related to the scheduler's inability to connect a theoretical model with an appropriate approach for implementation. There are two main objectives of the chapter: (a) describe a series of scheduling models in healthcare organizations, and (b) provide practical solutions and algorithms which can be used by healthcare practitioners to achieve their operational goals.

The next section of the chapter will describe a framework of scheduling models in the healthcare industry. According to this framework every scheduling model in healthcare has two dimensions: number of treatment stations and nature of scheduling problems. A scheduling environment may involve one or many servers (stations) and the nature of the problem may be deterministic or stochastic. If the processing times of treatments and patient arrivals can be ascertained with certainty, then the model represents a deterministic scheduling problem. Those models where the processing and arrival times are considered as random variables represent stochastic scheduling problems.

The chapter continues with detailed investigations of a series of scheduling situations according to the above framework. For each case, scheduling theory is consulted and the most practical possible solution is offered. The suggested algorithm for each case can be extended to similar scheduling situations which belong to the same scheduling category, that is, the same number of stations and the same problem type. The chapter concludes with a summary of assumptions used in the models and with a discussion of implementation issues of the offered heuristics.