

ABSTRACT

This research is concerned with the modelling and analysis of appointment scheduling systems in hospitals. A typical hospital is considered as an integrated service unit consisting of a number of interacting departments (outpatient, inpatient, emergency, pathology, radiology etc.). Among various services provided in a hospital, arrivals of patients are scheduled mainly for the consultation services, investigation and treatment procedure (such as magnetic resonance imaging (MRI), computed tomography (CT) scan, and dialysis), and also for surgical services. The focus of this research endeavour is mainly the improvement of appointment systems prevalent in consultation and investigation facilities in a hospital. Appointment scheduling plays a key role in improving the operational performance and efficiency of a hospital system as well as the satisfaction of the patients. By controlling the arrival process of patients, idle times of patients and physicians as well as congestion in the system can be significantly reduced. As a result the waiting times of patients are reduced and the utilization of the hospital facility improves.

An appointment scheduling system may be evaluated in terms of certain performance metrics, such as the waiting times of different classes of scheduled as well as unscheduled patients and the idle time, overtime and utilization of the facility. Various factors may affect the performance of an appointment system; these include both environmental and the decision factors. While the environmental factors include no-shows and unpunctuality of scheduled patients, service time distribution and variability, presence of walk-ins and emergency arrivals, the decision factors mainly include capacity planning-related decisions and selection of scheduling rules. The goal of appointment scheduling is to find a trade-off between the efficiency of service providers (e.g., maximizing the utilization or minimizing the overtime and idle time of resources, such as physicians, imaging machines and operating rooms, etc.) and satisfaction of patients (e.g., minimizing waiting times, etc.).

Any appointment system, in general, is a queueing system with scheduled arrivals. The performance of such a system may be evaluated either through queueing theoretic models or through simulation of the patient flows. For evaluating the scheduling rules governing an appointment system, performance of the corresponding appointment queueing system needs to be evaluated.

This thesis focuses on some of the rarely addressed issues in the context of hospital appointment scheduling research. Specifically, appointment systems with multiple classes of patients (non-

homogeneous in terms of several characteristics), different patterns of arrival of walk-ins and emergency patients and combination appointments (appointments for more than one facility on the same visit) are taken into consideration. In specific terms, the objectives of the research are: (i) to select appropriate sequencing and appointment rules for appointment systems with multiple classes of patients, (ii) to measure and evaluate the effects of decision and environmental factors on the performance of an appointment system, and (iii) to develop a scheduling methodology for combination appointments for patients requiring services from multiple facilities on the same visit.

Owing to the complexities in patient flows due to multiple classes of patients, unpunctuality and no-shows of scheduled patients and presence of walk-ins and emergency arrivals, discrete-event simulation is used to analyse different scheduling rules. In order to parameterize the simulation models, data related to the arrival patterns, punctuality and no-shows of patients and service times in the facility were collected through direct observations and reference to past records of a multi-speciality hospital located in eastern India. It is found that classifying the patients and using appropriate sequencing rules may significantly improve the performance of an appointment system.

The specific contributions of the research are: (i) development of an improved methodology for appointment scheduling with the consideration of a set of non-restrictive assumptions, (ii) insights and practical guidelines for appointment scheduling in hospital facilities serving multi-class patients, and (iii) development of a unique methodology for scheduling combination appointments for a patient requiring services from multiple facilities in the same visit. The methodologies as developed are generic in nature, and hence, are applicable to appointment scheduling systems of other service organizations as well.

Keywords: Appointment scheduling systems, Hospital patient flows, Patient flow modelling, Radiology department, Queueing theory, Discrete-event simulation, Design of experiments, Multiple classes of patients, Combination appointments