Chapter 15
A General Simulation Modelling Framework for Train Timetabling Problem

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ABSTRACT

One of the most important problems encountered and needed to be solved in railway systems is train timetabling (scheduling) problem. This is the problem of determining a feasible timetable for sets of trains which does not violate track capacities and additionally satisfies some operational constraints of the railway system. In this chapter, a feasible timetable generator framework for stochastic simulation modelling is introduced. The objective is to obtain a feasible train timetable for all trains in the railway system, which includes train arrival and departure times at all visited stations and calculated average train travel time. Although this chapter focuses on train timetabling (scheduling) problem, the developed general framework can also be used for train dispatching (rescheduling) problem if the model can be fed by the real-time data. Since, the developed simulation model includes stochastic events, and it can easily cope with the disturbances that occur in the railway systems, it can be used for dispatching.

INTRODUCTION

Management of railway systems is an important issue of transport systems. One of the important problems in management of railway systems is the train timetabling (scheduling) problem. This is the problem of determining a timetable for sets of trains that does not violate track capacities and satisfy some operational constraints of the railway system. Several variations of the problem can be considered, mainly depending on the objective function to be optimized, decision variables, constraints and complexity of the studied railway network. Several names have been given to the problem widely using three-word phrases:

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beginning with Train / Railway
going on with Timetabling / Scheduling / Dispatching / Rescheduling / Planning / Pathing
and ending with Problem

words with a few exceptions.

A general most common train timetabling problem in the literature considers a single track linking two major stations with a number of intermediate stations in between (Caprara et al., 2002). It is assumed that $S = \{1, \ldots, s\}$ represents the set of stations, numbered according to the order in which they appear along the rail line. In particular, 1 and $s$ denote the initial and final stations, respectively. Analogously, it is assumed that $T = \{1, \ldots, t\}$ denotes the set of trains which are candidate to be run in a given time horizon. For each train $j \in T$, a starting station $f_j$ and an ending station $l_j$ ($l_j > f_j$) are given. Let $S_j = \{f_j, \ldots, l_j\} \subseteq S$ be the ordered set of stations visited by train $j$. A timetable defines, for each train $j \in T$, the arrival and departure times for the stations $f_j, f_j+1, \ldots l_j-1, l_j$. The running time of train $j$ in the timetable is the time elapsed between origin station and destination station of the train (Caprara et al., 2002). This general problem can be more sophisticated by adding some real life behaviour of railway systems or relaxing some assumptions made related with the railway system under consideration.

The problem has been studied by researchers and so far many efforts have been spent on it. In early years, due to the limitations of computers’ abilities and the complexity of the problem, the problem was relaxed by unrealistic assumptions and generally deterministic models were studied. Depending on the increasing computer capabilities more realistic models were developed. Although simulation for modelling has been used in some articles, none of them includes a comprehensive framework. This has been the main motivation for the authors to develop a feasible timetable generator simulation modelling framework.

In this chapter, a feasible timetable generator framework for stochastic simulation modelling is developed for obtaining a feasible train timetable for all trains in a railway system. This framework includes train arrival and departure times for all stations visited by each train and calculated average train travel time. A general stochastic simulation modelling framework is developed and explained step by step in order to guide to researchers who aim to develop a simulation model of railway transportation systems. By using this framework all the railway systems can be modelled with only problem and infrastructure specific modifications and feasible solutions are easily obtained. In order to avoid a deadlock, a general blockage preventive algorithm is also developed and embedded into the simulation model.

In next section the literature on the problem is given. After that, the simulation modelling framework is demonstrated in detail on a hypothetic problem. Next, the obtained results are discussed. Concluding remarks and future work directions are exhibited in the last parts of the chapter.

BACKGROUND

The studies on the train timetabling problem aim at achieving a train timetable with arrival and departure times of all trains at the visited stations in the system. These studies generally begin with a planned infeasible initial (draft) timetable with many conflicts needed to be solved. After these conflicts are solved a feasible train timetable is composed, and the train operating authority runs the trains according to the feasible timetable.
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