40.302: Advanced Topics in Optimization Project case study- Freight Terminal Management in Railways

Selin Damla Ahipasaoglu
Raja Gopalakrishnan

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1 Introduction

On a large railway network, freight trains transport goods between various origin-destination (O-D) pairs. Owing to the large volumes of cargo carried in a freight train (the heaviest freight train carried over 100,000 tonnes in 650+ wagons and was over 7 km long!!!), they are loaded and unloaded at specialized terminals with material handling facilities. These specialized terminals, referred to as freight terminals, are geographically spread out across the rail network. A freight train consists of a number of wagons and hauled by a locomotive(s).To simplify our problem, we assume that the freight terminals are categorized as terminals where only one of the activities of loading or unloading operations take place but not both. We also assume that all the wagons on each freight trains carry the same commodity (called unit trains in railway parlance).

The freight terminals can be managed by a single entity (usually the operator managing the railway network) or by agencies which are different from the train operator.

2 Description of a freight terminal

A schematic diagram of freight terminal is shown in figure 2. Every freight terminal has a set of platforms where trains are handled for loading or unloading operations. In our figure, D-1 is the destination freight terminal where trains are unloaded. Depending on the commodity in a train, only a subset of the platforms can accommodate the train. E.g, a train carrying petroleum products can be handled only on a platform where decanting (pipes, valves) and fire-fighting facilities are available alongside. While for certain other commodities, the train can be handled on one of the many compatible platforms, albeit with different unloading times depending on the material handling infrastructure available on the platform. In figure 2, train T-1 can be handled on both Platform-1 and

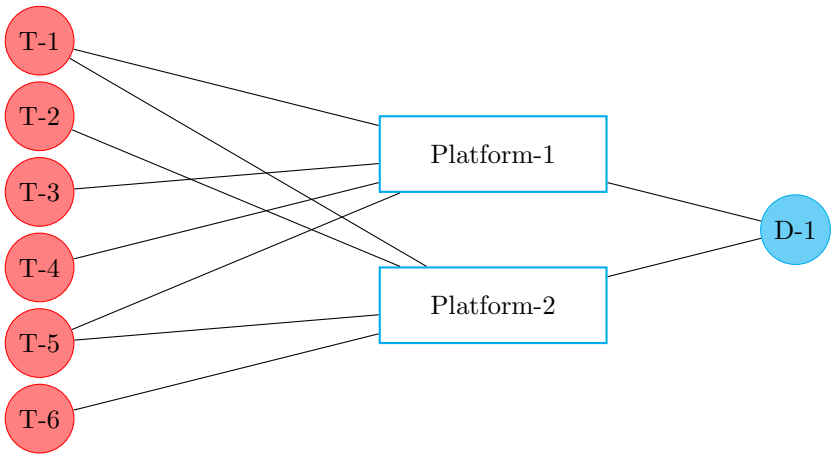

Figure 1: Schematic representation of a freight terminal

Platform-2, while train T-2 can be handled only on Platform-2. In the figure shown, T-1 $\cdots$ T-6 depict the freight trains destined for terminal D-1. The amount of cargo that can be carried in wagon will depend on the commodity loaded in it and also the wagon type. Therefore, the volume of cargo that is loaded/unloaded from a freight train determine the loading/unloading times.

We assume that each platform in a freight terminal can accommodate a complete train,i.e, we do not have to break the freight train into smaller parts to fit into a siding. Also, a single platform cannot accommodate two freight trains simultaneously. Until the loading or unloading operations for a train is completed on a platform, the next train cannot be placed for processing. Trains which are waiting for placement in one of the loading/unloading platform in the freight terminal can wait in parking tracks. The number of parking tracks in a freight terminal is finite.

3 The scheduling problem

The problem on hand is to find an optimal sequence of scheduling the trains on the platforms in the freight terminal. Freight terminal D-1 has two platforms, viz., Platform-1 and Platform-2. A total of 47 trains are destined for D-1. The platform(s) on which a given train can be handled (TrainPlatformCompatibility) as well as the respective processing times(UldgtimePlatform) are given in the data set. The expected time of arrival (from the current time) of the trains is given in the column ETAHours.

4 Instructions

1. You are permitted to submit the project as a group consisting of not more than 3 students.
2. Formulate the above problem as a scheduling problem using notation discussed in class.
3. Discuss and describe the objective function in the problem formulation.
4. You may code the solution to the problem in CPLEX, VBA or Python.
5. For groups working on the railway freight terminal problem [1]:
   (a) Give a demonstration of the solution for the data set supplied in the lab on **04/04/2017**.
   (b) Extend the the problem and incorporate constraints which you consider realistic. You may consider incorporating one or more of the following:
   - Uncertainty in problem parameters
   - More than one commodity in each train
   - Larger number of platforms at the freight terminal
   - Parking capacity constraint at the freight terminal
   - Time windows for unloading of trains and/or unloading at platforms
   - Due dates, deadlines for unloading of trains.
   - Release time as a variable instead of a parameter.
   - Optimize with multiple objectives
   - Fairness as an objective
6. Each group will make a 15 minute presentation of their project of not more than 15 slides explaining the problem formulation, methodology and results. Slides should be visually engaging and creative.

[1] **Remark** : You have the option to choose another project which should follow similar steps or a research topic. Discuss your project topic with Gopal & Selin by **Lab 2**. You still need to demonstrate a working AMPL code by **04/04/2017**.