# Study Based on the Assignment Optimization of Freight Train Scheduling

**Xing SU[1], Meijiao CUI[1], Shuangliang TIAN[1], Sili WANG[2]**

[1]*Computer science and Information Engineering Institute*

[2]*China Minorities Information Technology Institute*

*Northwest University for Nationalities, Gansu, Lanzhou,* 730030

*E-mail: liujianhuasjz@163.com*

**Abstract:** Truck decompiling work is the key to optimize the assignment in the marshalling yard, and a reasonable solution for scheduling programs can enhance the efficiency of grouping. This paper sets down a corresponding program for the direction of its distribution, aiming at the different case of the train, primarily according to the disorganization character of the arriving train. Through establishing 0-1 Integer Programming model and using the Traversal Algorithm to solve the serial disorganization number matrix on the basis of different levels, it can achieve the grouping of the same direction vehicles.

**Keywords:** assignment optimization; 0-1 integer programming; traversal algorithm

## 1. Introduction

The scientificity and rationality of the Freight Train Scheduling impact the rate of operation for railway equipment and the transport's efficiency[1]. Zhen Zhou North Railway Station takes the task of domestic freight train marshalling scheduling for the west-east and north-south two main railway lines, and it is the vital communication line which is linking up north and south and connecting west and east, known as the railway "heart". The railway management department hopes the work of marshalling scheduling is quick and efficient. The key indicator of measuring the efficiency of marshalling scheduling is "median time"[2]—the average time for each train from the time when it enters into the receiving-arriving yard to the time when it is marshaled to a new train and gets into receiving-starting yard, which is the average time for each train to transit at the station. All operational links of train marshalling are set classes, fixed time, certain one to operate, automatic control processes. Generally, the newly organized trains are bound for the same direction and ranked according to the priority order from far to near, and trains with the same destination are connected. Usually, there is a specific pre-reporting system about the information related to the freight trains, but the exact information is ascertained when they arrive to the station[3].

## 2. Model Assumption and Symbol Description

According to the actual operation, we can see that locomotives push the trains to be disintegrated to the line of hump from the receiving-arriving yard and carry on the disintegration of operation while the trains are moving slowly and after disintegrated the trains run to marshalling yard by inertia (no power). Each train (one or several units in the same direction) need about 10 minutes from the receiving-arriving yard to the assembly in marshalling yard through the disintegration in hump; it takes 5 minutes to pull a train from marshalling yard to the departure yard. The trains without being shunted (trains which needn't be marshaled, including the special trains) need 15 minutes to enter the departure yard directly after making a necessary technology treatment in the forwarding yard. From uplink (downlink) marshalling yard via forwarding yard to downlink (uplink) departure yard need almost 20 minutes once. The marshalling scheduling regulation stipulates that each heavy train is less than 80T (including dead weight of 20T), generally requires the grass weight of every train under 4800T, and the total length under 70 sets.

### 2.1 Model Assumptions

1) Supposing the weight of all the heavy trains is 80T.

2) All the trains are considered to arrive at the station on time, and there is no late phenomenon.

3) Don't consider the loading and unloading operations in the loading yard, namely "when" doesn't contain the time for train to marshal.

4) Trains will be sent out promptly after entering into the forwarding yard and departure yard, irrespective of the waiting time in the forwarding yard and departure yard in model solution [4].

5) Trains that are already in the receiving-arriving yard at zero time are considered as fictitious arrival train; those trains also belong to the trains for departure after the completion of train marshalling.

6) Ignore the time delayed by the trains in the departure yard and forwarding yard during the leaving time, that is, this part of time is not included in median time[5].

## 2.2 Symbol Description

$t_i$ : The marshalling time for the $i$ train during marshalling a train destined for the same direction.

$q_i$ : The $i$ period.

$H_{ij}$ : The number of trains at the $j$ point about the $i$ disintegrated train

$U_{ij}^t$ : The number of trains at the $j$ point about the $i$ disintegrated train after marshaled by the $t$ number of runs

$X_i^k$ : Whether the train No. $i$ in traffic mix is marshaled in system $k$ , $k$ can be 0 or 1,separately standing for two marshalling systems in marshalling yard[6].

$Y_j^k$ : Whether train $j$ after marshaled is sent out in the receiving-starting yard of system $k$ .

$Q$ : The set of all the trains in the receiving-starting yard of marshalling yard, including the fictitious arrival trains.

$R$ : The set of all the marshalling yard.

$P$ : The set of all the arrival sites.

# 3. Model Building and Solving

## 3.1 Problem Analysis

The main work of marshalling yard is to decompile the arrival trains. Organizing the trains to be disintegrated rationally and marshalling the trains is the marshalling yard's key work, and the optimization for the whole marshalling process and compiling procedures is the core content of the entire marshalling system. The key of dealing with the work of train classification is to build up the related optimization model, requiring satisfying the marshalling control procedure and the task index requirement of each period, namely, every heavy train is less than 80T (including the dead weight 20T), generally require the gross weight of each train no more than 4800T, the overall length at most 70 sets; and the condition that the trains can't stay at arriving field more than two periods of time and the median time is less than 8 hours.

We are doing research about median time of how many trains can be decompiled during different periods in uplink and downlink, the elements which make influence on median time are as follows: how long the trains stay in the receiving-arriving yard, how long it takes to decompile and marshal the trains, and the time for transferring—time from receiving-arriving yard to marshalling yard, time from receiving-arriving yard, time from marshalling yard to departure yard via forwarding yard and time to forward from marshalling yard to departure yard[7]. According to the model assumption, the fact has a great variability, so the trains' marshalling time is not counted in median time. And we just take the arriving time of the latest marshaled train as the completion's time for marshalling. The known transit time are 10 minutes,15 minutes,20 minutes and 5 minutes respectively, we can know from all the time aspect, no matter the trains enter into the departure yard after marshaled or directly, it both takes 15minutes on average, so we need not count in the solving process, and for the trains entered into departure yard via forwarding yard, we can only count the time difference of all the trains in the process of forwarding, namely the total number of trains entered into departure yard via forwarding yard with the same schedule multiplied by 15mins.

## 3.2 Basic Model

According to the problem analysis, we can build some planning models like 0-1

$$\begin{cases} \min \quad \sum_{i\in Q}\sum_{j\in P} t_i U_{ij} \\ s.t. \quad \sum_{j\in P} U_{ij} \le 70 \\ \sum_{j\in P} U_{ij}^{weight} \times 80 + \sum_{j\in P} U_{ij}^{light} \times 20 \le 4800 \\ \sum_{i\in Q}\sum_{j\in P} U_{ij} = \sum_{i\in Q}\sum_{j\in P} H_{ij} \\ \sum_{k\in\{0,1\}} X_i^k = 1 \quad i \in Q \\ \sum_{k\in\{0,1\}} Y_j^k = 1 \quad j \in R \\ t_i \le 8 \qquad i = 1, 2, \cdots \\ U_{ij} \in Z^+ \end{cases}$$

Then, we can get the calculation formula of different shifts for median time.

$$\frac{\sum_{i\in Q}\sum_{j\in P} t_i U_{ij} + u_t \times \frac{1}{4}}{\sum_{i\in Q}\sum_{j\in P} t_i U_{ij} + u_i} + \frac{1}{4}$$

## 3.3 Algorithm

We have already known the train marshalling process is as Figure1. So we can write down the corresponding algorithm by the marshalling process. At the same time, in order to generalize the model, we use binary tree depth-first traversal to design its algorithm [8], the detail is as follows:

The first step: Disintegrate the trains in the receiving-arriving yard based on the principle as FIFO, and then utilize the station restriction to make the train enter the corresponding compiling station line, according to the known vehicle.

The second step: Choose any one or any group of trains as the first marshalling unit according to disintegration serial number matrix, and define the first one as the first element and the last one as the last element

The third step: Read the elements in disintegration matrix based on the order of row first.

The fourth step: Judge whether it can connect, if it can not, return to the third step, if it can, enter into the next

The fifth step: Judge whether it meets the constraint condition, if it does, enter to the next, if it doesn't, enter into the seventh step.

The sixth step: Connect the connectable trains, make the connected marshaled unit to be the new one, and change its first element or the last element, and enter into the next.

The seventh step: Judge whether the connected marshalling unit has connection space and short waiting time, if it is, return to the third step; otherwise, marshal is finished, and the marshalling unit at present is the final marshalling train.

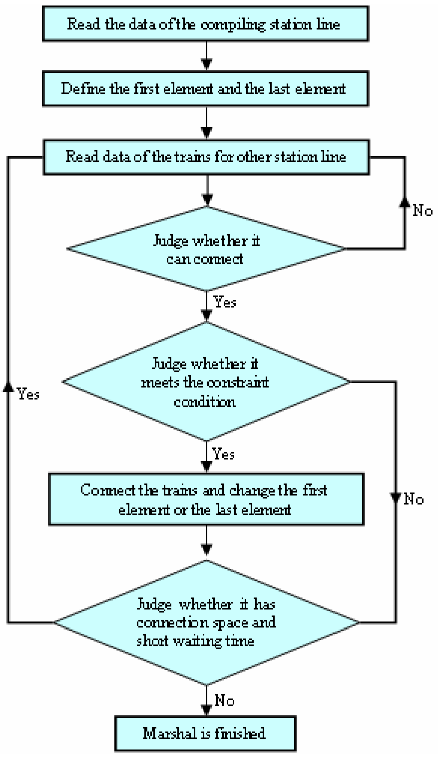


**Figure 1. Train marshalling program at marshalling station**

### 3.4 The Resolution of Model

Program the corresponding MATLAB program by the model and algorithm, and get the feasible marshalling scheme using the data given in results C of the fifth China mathematical modeling contest for postgraduates. According to the calculation formula, the average median time of each shift is shown in Table 1.

**Table 1. The "median time" schedule for each shift in uplink and downlink. (Unit: hour)**

| Line / Number | Uplink | Downlink |
|---|---|---|
| Night shift | 1.008 | 0.946 |
| Day shift | 0.599 | 0.629 |

## 4. Conclusion

This paper designs a 0-1 integer line programming and traversal algorithm in order to achieve the assignment optimization of freight train scheduling automatically and fleetly. Then it aims at the six problems which must be resolved in the introduction and reveals the internal organizational disciplinarian of the trains in the compiling station. As the problems are static, it belongs to medium and long-term operation schedule for the general case. In this situation, the model reduces the median time of each shift especially, and fully considers the influence for freight trains made by number of marshal, content of marshal, time for connecting and assembly's site. And it gives each problem a practical marshalling strategy, including procedure for decompiling, number of orbits, number of trains, assembly's procedure, consists of new trains. Finally, we can compute each median time.

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