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Study on Development of Train Running Diagram Optimization

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Abstract

This article from a whole new perspective on existing studies was classified, from the specific issues addressed by starting on two key issues of recent train scheduling plan: train running diagram and train operation adjustment. Solutions, basic ideas and researches are discussed in detail. Among them, the train working diagram is divided into single and double lane sections and Passenger Train Running Diagram. And the train operation adjustment includes the real-time adjustment, the service of train insert and the conflict prediction. This paper introduces automatic train operation dispatching system in scheduling applications, and discusses the train scheduling problems and the future direction of development.

Keywords

Train Running Diagram, Train Operation Adjustment, Train Scheduling

1. Introduction

Nowadays, all the countries are vigorously developing railway construction, increasing train speed, and the density is increasing, so more complex railway network in railway operations process and many new problems have emerged. Therefore, it is necessary to summarize the latest progress in the research on train operation scheduling in order to more clearly show for the development of train scheduling situation.

1.1. Train Running Diagram

Train Running Diagram of train operation is mainly based on business requirements and train timetable historical data on pre-scheduled. Nowadays the trains are running faster and faster; therefore track time is getting shorter by the finite number of steps; so determining a viable and effective operation scheme becomes more important. Currently the train running diagram research is mainly divided into two aspects, single and double lane sections, which two aspects of train running diagram represent the main direction of the research.

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1.2. Single and Double Track Sections of the Running Diagram

The primarily of railways operating lines can be divided into single-track railway, double-track railway, but there are three and four track railways. Therefore, a single and double track section of the train running diagram is a focus of the study. Single-track railway has only one main line of the railway, in the same interval or occlusion of the same area, at the same time allowing only one train running. Double-track section of the railway line has two main lines which are divided into uplink and downlink. Under normal circumstances, up and down trains are driven in the uplink and downlink line, respectively.

It establishes the train operation diagram optimization model for a single track section and designs a freight train plan optimization method [1]. Operation diagram phased optimization methods can effectively reduce the solution space and the complexity of the algorithm. To shortest the total running time in a single train route, you can use a lower bound for the Quadratic Assignment Problem based upon a semidefinite relaxation and a cutting planes approach to reducing the solution space, and use branch and bound method to obtain a feasible schedule [2]. For the two-lane you need to change the Way Traffic blocking situations, and design different time periods between stations based on Way Traffic Lanes switching method [3]. This method can improve the transport capacity of the line and driving safety by using Automatic Block for two passenger trains which are running in both sides of single line. This method can improve passenger and freight train running through the section of line capacity [4]. Currently, most train operation diagrams are prepared separately for a single and a double-lane; it is designed simultaneously in a single one. The flexible application of double track line train working diagram algorithm is of important significance.

1.3. Passenger Running Diagram

Since 1964, Japan built the world's first 1210 kilometers per hour high-speed passenger line, the French, German, Spanish, Italian, South Korea and China Taiwan and other countries and other regions have built high-speed passenger line, the speed from 210 km to 270 km, 300 km, 350 km range. As countries develop passenger line construction, Passenger Train Working Diagram received widespread attention.

Literature [5] Passenger train speed combined with high mixed passenger trains run at different speeds and other characteristics of Passenger train diagram compilation principles and processes, plan alternate run line shop run chart preparation and holidays elaborated. According to traffic on weekdays and holidays passenger travel different actual situation, the passenger line utilization plan is divided into weekdays and holiday's utilization plan utilization plan is working diagram PDL a big research focus. Literature [6] through analysis of the EMU Passenger various application methods, developed a Passenger EMU cyclical utilization plan. Literature [7] Passenger trains on China's type and grade, run chart cycle, run chart basic parameters and laying plans to run sequence diagram compilation principles such as are described, put forward China Passenger traffic-intensive sector map for cyclical operation mode. Literature [8] for Dedicated Passenger Lines moment, stop programs relatively fixed in each period, punctuality rate, running time is cyclical characteristics, combined with China's passenger line running lines of the actual situation is proposed based on the periodic collation train operation diagram model. Passenger periodically run is actually an approximate cycle mode; the actual situation should develop a combination of cyclical and non-cyclical run chart pattern. Literature [9] Passenger Railway from the actual situation, is designed based on improved genetic algorithm Passenger train diagram optimization strategy proposed train diagram shop zoned layered overlay model. Literature [10] Passenger train operation diagram for the basic model and type of preparation, preparation principles, key technologies and related measures such as the preparation of the main problems were analyzed. At present, China's Passenger Train Working Diagram of the theory and methods is to learn from the existing single lane preparing train diagram theory and calculation method, a new set of operating characteristics meet the PDL preparation theory worthy of further study. A single Passenger train diagram model and algorithm development to full-scale passenger special line network, as well as the Passenger train diagram model and existing common across the line train operation diagram models combined with great research value and application value.

2. Train Operation Adjustment

Program schedule limitations is that even if the schedule to find the optimal solution, trains running frequently occurring disturbances can also make planning difficult schedule strictly enforced, then you need to adjust the running status of the train. Train Operation Adjustment refers to the process in train operation in a variety of

disturbances under the influence of the actual train running off a predetermined value, the train runs through the timely adjustment of status, making it as far as possible plans to run. Train Operation Adjustment is scheduled trains running research priorities, causing widespread concern in academic circles. According to the actual situation and for different railway perturbation approach, Train Operation Adjustment research into real-time adjustment of train operation, the train into the (canceled) service, conflict predicted three parts.

2.1. Trains Running Real-Time Adjustment

Currently, the majority of train operation adjustment is offline methods, real-time method is relatively small. Real-time adjustment of train operation is increasing with the increased complexity of the railway network and the development of computer technology. For the transport of heavy task, the line through the high capacity of the line, the transport of small fluctuations are likely to affect a wide range of normal operation of the train. Therefore, the train runs real-time adjustment problems of great significance and practical value. Literature [11] proposed a railway crossing train running real-time scheduling programming model by model integration into decision support system; operators can make use of the model proposed solutions to change the order of train routes and to avoid conflicts of train operation and delays. Literature [12] for a fixed or moving block signaling system of large-scale railway network, presents an advanced traffic management system (Traffic Management System, TMS). TMS includes two real-time models: model train dispatching and line speed programming model. The former alternative based graph model to provide solutions to resolve the conflict; latter by changing the speed of trains running to execute the former resulting adjustment program. TMS can prevent and bring real-time constraints interfere with parking and reduce train delays, improve the efficiency of train operation. Literature [13] according to the principles of train operation adjustment and basic methods, the design of double track section to adjust the mathematical model of train operation and use three Swarms Cooperative Particle Swarm Optimization to solve and improve the model solution fast, the train run real-time decision support played a very good role adjustment.

Train detection system needs to have a high real-time, in order to keep abreast of the train dispatcher train each part of the state information, and timely adjustment of train operation plan, to achieve real-time scheduling train. To this end, the literature [14] uses a real-time performance better train detection system as the application of RTLinux operating system, through the RTLinux real-time system is divided into parts and non-real-time part to achieve the system's operation, to ensure the system in real time. Literature [15] considered a safe distance between the train and the train speed between front and rear adjacent coordination, design time block model, using iterative algorithm to obtain real-time adjustment of train operation solutions. Literature [16] for high-speed trains running system parameters and external resistance is unknown, an adaptive control method to achieve high accuracy and speed of train position tracking control. Literature [17] event-based control technology applied to the inter-station subway train operation control, the establishment of a mechanical model of the subway train, which according to the distance of the train trains running in real-time adjustments. Position and speed of the train accurate detection approach can predict in advance potential conflicts and make real-time solution to achieve real-time adjustment of train operation.

Train running programs on real-time adjustments to avoid or reduce the train running off with a predetermined value. To achieve real-time adjustment of train operation is an important prerequisite to be able to train the system in a timely manner all dynamic information feedback to the train dispatcher, therefore, to improve the real-time train detection systems and train position, speed, high-precision tracking control has important research value.

2.2. Train Inserts (Cancel) Service

Since the transport industry competition intensifies, especially aviation and road transport continues to grow and improve the competitiveness of rail transport is the best way to provide different train services, so that the train service diversification, to meet different needs. Meanwhile, with the train service between operators increased competition, the train insert and cancel the service has become very popular, as train dispatcher facing important issues. Therefore, for the train to insert or cancel service modeling and analysis, rational planning of train running status, is of great practical significance. Literature [18] for passenger and freight trains running on the same lines, passenger train running schedule unchangeable situation, study how to insert additional lines freight trains, single line proposed integer linear programming model, using a pull-based Lagrangian heuristic slack variables,

the goal is to ensure close freight train running time program schedule, based on the insertion of additional freight train as much as possible, while the newly inserted Construction freight train schedule. Literature [19] for rail operators need to provide rail lines to third parties caused by the train into the case, to discuss how to increase the train services that SATS (Scheduling Additional Train Services) problem. SATS as it will have limited time window, fixed operation and maintenance services, etc. constraints of the train scheduling problem is proposed based train disjunctive graph model building algorithm and simulated annealing optimization algorithm, by changing the time window constraints and fixed operations, etc. conditions, to coordinate the various needs of the customer or operator. Insert the train service can ensure that a given train run by drawing on the basis of possible insert more train services, improve the utilization of the railway line. And insert train service conversely, if a train service is not at its scheduled within the time required, it may be canceled or replaced by another train service, this time in the SATS mechanisms need to include cancellation mechanism.

2.3. Conflict Predictions

Forecasts of future events and results will be studied and evaluated. By train running forecast may encounter interference that may occur in advance of the line conflict problem solving, and thus to adjust train running programs to train as much as possible on plans to run.

Literature [15] through precise monitoring train position and speed of the train running forecast potential conflicts in advance of conflict resolution, real-time adjustments to achieve the purpose of train operation. Literature [20] proposed a distributed concurrent design support conflict detection methods, the train bogie design conflicts were detected. This conflict detection method is developed for the design level, cannot meet the requirements of real-time collision detection, and can at any time to design a method for detecting the conflict have significant research value. Literature [21] according to the mechanism of train running conflict will conflict into four categories; high-speed trains running on Conflict Management Research were reviewed.

Train detection system in real time and precision as well as a well-run conflict detection method can better train dispatcher during the operation of the train may encounter conflicts forecast to develop conflict resolution in advance for train operation providing real-time adjustment options. Most real-time adjustment of train operation conflict prediction is using this idea. Conflict prediction and real-time adjustment in various researches, in some cases, the former embodiment can be provided for the latter option.

3. Automatic Train Control System

Trains run manual scheduling process is complicated, inefficient. Without the aid of artificial scheduling automatic scheduling support system in the case, the main virtue of past experience to operate. Experienced dispatchers can predict changes in train schedules and develop adjustment plan, so that timely remedial action. In order to improve the efficiency of train operation manual scheduling literature [22] designed an automated scheduling system, through the coordination of train speed to resolve the conflict. Literature [15] is that this automatic scheduling system improvements, has done in real-time focus on. Author of two fixed speed and variable-speed train operation system are analyzed and discussed, with an emphasis on speed train dispatching system modeling analysis. Literature [23] of the train operation adjustment and adjustment program automatically generates a detailed analysis, the model based on multi-agent scheduling system solutions focused and fit wire section dedicated intelligent dispatching system. Literature [24] by analyzing the process of adjustment of train operation plan, the development of technology-based business process management system automatically adjusts the train operation plan. Automatic Train Control System is a decision support system, and its development is not intended to replace the train dispatcher, but as the railway network scheduling system is a key component to the train dispatcher to provide appropriate decisions for their choice and make the best scheduling scheme. Real-time decision support systems need to cooperate with each other and the train dispatcher, the train running program arrangements. Experienced train dispatcher decision support system by means of which came from the programs offered, you can quickly and efficiently determine the emergency response measures to improve the efficiency of train operation schedule.

4. Conclusions

In this paper, the research progress train scheduling for a more comprehensive overview of the existing research into the train scheduling train working diagram, train operation adjustment and automatic scheduling system was

carried out, in accordance with the problem of the train working diagram and train operation adjustment was classified elaborately. Even after decades of development, the train operation scheduling research has made a lot of achievements, but for some issues still relatively small study, it is worth further study, such as:

1) Applies to both single and dual zone scheduling model are relatively rare; the flexibility to adapt to a single two-lane section of the scheduling algorithm has high research value.

2) Train run real-time adjustment process is used to train the dynamic parameters; dynamic parameters need to improve the monitoring of train running accuracy and reduce monitoring data errors and improve the accuracy of real-time adjustment solutions.

3) Automatic Train Control System as a decision support system that can solve the train running manual scheduling inefficiencies is to achieve automation of railway traffic dispatching key. Automatic Train Control System to improve timeliness and intelligence is a major research direction.

4) Of May, November and spring holidays such as traffic surge peak holiday train operation in case of scheduling problems has been the focus of academic attention, but effective scheduling scheme is still relatively small. Ensure that the original program schedule train running time on the basis of close, as much as possible into the additional passenger trains, the effective solution to solve this problem, but further research is needed characteristics of holidays and the corresponding train traffic into service scheduler algorithms.

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