Ahmedabad University

MAT277 - Probability & Stochastic Processes

Winter 23'

S2 : Literature Review

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Work : 1

Title :

Train Rescheduling With Stochastic Recovery Time: A New Track-Backup Approach

URL :

https://ieeexplore.ieee.org/abstract/document/6734674

Summary :

Train rescheduling is a critical decision-making process in railway administration. It seeks to reduce the negative consequences of disruptions through real-time traffic management. The two key issues are determining how to construct the dynamic and complicated rescheduling problem as an optimization model and obtaining a suitable solution within a limited time frame. This study tackles the complexities of these two difficulties and presents a novel time and cost-efficient strategy in the MIP model while taking into account the older approach in MIP as well as other models. The research offers a new track-backup rescheduling (TBR) technique that optimally assigns each impacted train a backup track based on the estimated

recovery time, the original timetable, and track shifting cost, with a focus on the stochastic capacity recovery durations of blocked tracks. Then, we use a mixed integer programming (MIP) model to generate a conflict-free schedule that minimizes the delay cost as well as the projected track shifting cost. A greedy algorithm is used to rank trains and reschedule arrival and departure times, and then a MIP algorithm is used to find the best track backup method. But the highlight of the paper is the TBR model.

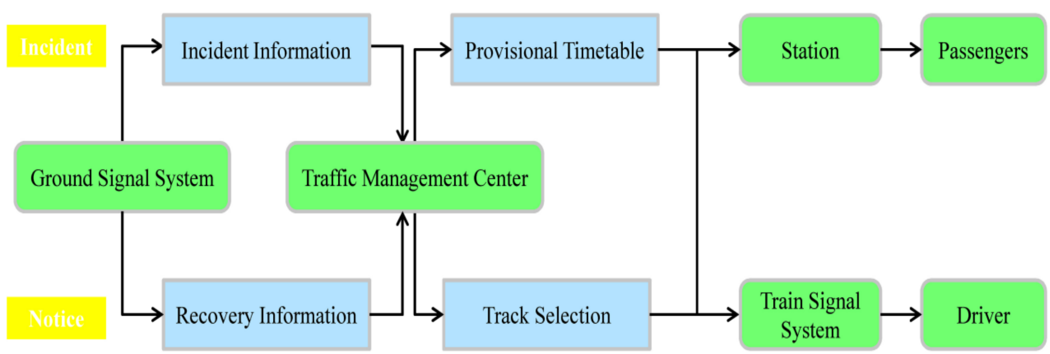


Fig. 3. Flow chart for the TBR approach.

TBR Approach: It is a method used in train scheduling to optimize the utilization of available resources and improve the overall efficiency of the railway network. The TBR approach involves the real-time adjustment of train schedules based on the actual running times, delays, and other operational constraints. This allows the train operator to quickly adapt to changing conditions and minimize the impact of disruptions on the network. The TBR approach is typically supported by advanced scheduling and dispatching software, which allows for real-time monitoring and decision-making. The TBR approach in train rescheduling assigns backup tracks for trains in case of a blocked track at a station. The real-time traffic management system generates a provisional timetable based on incident information from the ground signal system and assigns a backup track to each affected train. A notice time is calculated for each affected train and the ground signal system reports to the traffic management center whether the blocked track has recovered by the notice time. If it has recovered, the originally scheduled track will be kept, otherwise, the backup track will be used and the passengers will be informed of the change. The advantage of TBR is that it can minimize the inconvenience to passengers and reduce the track-changing cost by using the recovered track if possible. The core of TBR is modeling and solving the conflict-free timetable. Compared to other approaches, TBR allows changes on tracks, providing more flexibility in rescheduling and reducing delay time and cost.

Work : 2

Title :

Railway scheduling and optimization by proposing a multi-agent-based approach through Petri-net model

URL :

https://link.springer.com/article/10.1007/s43674-022-00039-7

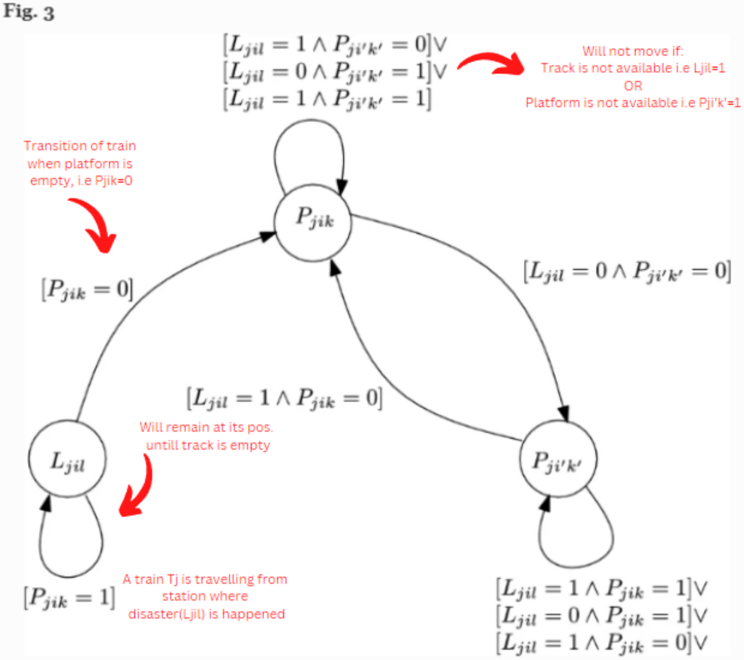
Summary :

A coloured Petri-net model is a mathematical tool for modeling complex systems that will be utilized to tackle the challenge of dynamic railway scheduling.

The railway system is modeled as a Markov Decision Process (MDP) to address the uncertainty of the railway network during disasters. The MDP consists of a set of world states (W) and a transition function (Ψ). The set of world states represents the state of train agents in the railway network under disturbances, and the transition function maps each action to constraint(s) of the Distributed Constraint Optimization Problem (DCOP) to move from one state to another.

The disaster handling and rescheduling model for railway systems in case of platform or track blockages refers to three situations: retiming, reordering, and rerouting. Retiming involves delaying or stopping trains at the station or on the track. Reordering involves adjusting the departure sequence of trains at the station based on priority. Rerouting involves rescheduling trains to an alternative path.

Fig. 3



MDP representation with set of states and transition functions.

Full size image

Further, we are considering a scenario where a train Tj is approaching station Si, and the station has faced some disaster. There are two cases discussed in this scenario; the first, if the station has a free platform and the priority of the incoming train Tj is the highest amongst all trains, then the system can allow Tj to reach Si if all the necessary resources are available. If this condition is not met, Tj will stop at the station until recovery or another alternative path becomes available. And second if the scenario does not conform to the first case, Tj stops on its current track and occupies it. The scenario is represented using a Petri-Net model, and the behavior of the Petri-Net is analyzed using reachability graph analysis and state equation analysis. The state equation holds if the marking M is reachable from the initial marking M0 through a transition sequence σ.

Work : 3

Title :

Modeling and Solving Real-Time Train Rescheduling Problems in Railway Bottleneck Sections

URL :

https://ieeexplore.ieee.org/abstract/document/7004862?casa_token=AHCHwvnZf1kAAAAA:7YYZ48nV92cEW761nnDO1H9ZnZOYy4ugY1euxo4zA1zApWtBC-skIgJdxTy3XXk-Qe6_JIgvT7A

Summary :

Researchers have suggested a methodical approach for managing the real-time traffic of trains around bottleneck sections. Trains must be rescheduled in an ideal way to reduce overall delays because the allowance times and buffer times added to the original timetable are insufficient to absorb train delays brought on by perturbations of a single train.

A mixed integer programming problem is proposed in the paper, known as the Junction rescheduling model (JRM). Its primary goal is to reduce the weighted average delay (WAD), which determines how closely the trains passing through the two portals at either end of bottleneck sections comply with the rescheduled timetable in relation to the nominal timetable. WAD can be minimized by optimizing the two variables i.e., $d^{*}_{r,e}$,which denotes the route setting decision and $t^{p*}_{i_{r,e}}$, which denotes the arrival time of the train at each portal (Here, r is the route taken by a train and e denotes an event when one train passes the junction area)

An optimized algorithm based on improved differential evolution (DE) algorithms is developed to solve the proposed problem. A typical DE algorithm includes Mutation, Crossover, and Selection to solve the problem. However, these stochastic processes cannot ensure that the parameters(specifically $t^{p}_{i_{r,e}}$) can meet all the constraints of JRM. As a result, the algorithm incorporates an innovation known as the "modification" operation, mainly based on the greedy rules of stochastic processes. The improved algorithm is termed the DE_JRM algorithm. The processes involved in the operation are:

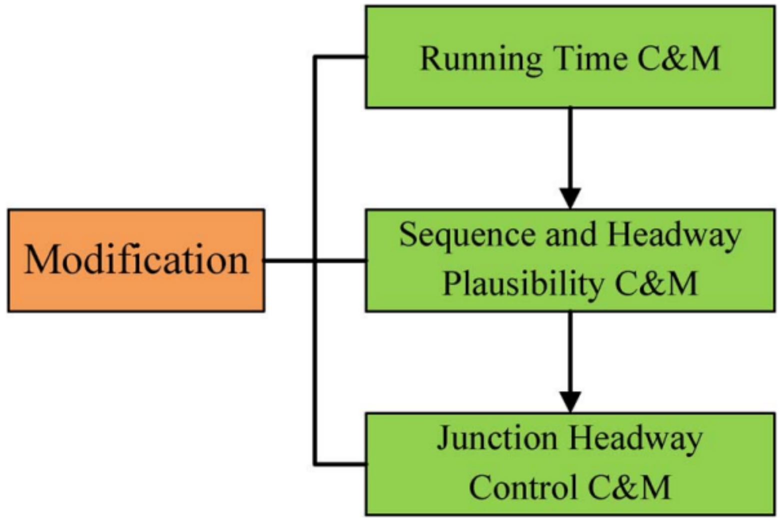


Fig. 4. Processes in modification operation.

(C&M-Check & Modification)

The algorithm converges when the WAD reaches its minimum value to meet the optimal requirements. Researchers evaluated the optimized algorithm using Monte Carlo methodology by undertaking a case study of the Thameslink route in London.