An Algorithm for Rescheduling Freight Train Locomotives and Drivers

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Freight trains operate over long distances through different areas; making them susceptible to large-scale disorder caused by transport disturbances in particular regions. In such situations, timetables are adjusted by delaying or cancelling trains as necessary, which requires the rescheduling of locomotives and the reassignment of drivers to trains. Figure 1 shows an example of timetable adjustment in which three trains are delayed by about three hours at the departure of Station U and one is cancelled. The red line in the figure shows the duty of a particular driver, and demonstrates that he/she will miss the next train to drive. The rescheduling process has so far been entrusted to manual work by the dispatchers in charge, and there is a need to speed up rescheduling in response to disruptions and to reduce the related staff workload.

To this end, we have developed an algorithm to reschedule locomotives followed by related rescheduling of drivers in situations where timetables need to be adjusted. In locomotive rescheduling, many conditions need to be taken into account, such as the traction power and available area of locomotives. Above all, each locomotive must be inspected in every 72 or 96 hours depending on its type. This algorithm provides a solution that satisfies all these constraints while minimizing the number of locomotives whose schedules are changed or the number of urgent locomotive inspections to be carried out. Figure 2 illustrates a rescheduling plan in which two locomotives are delayed in their arrival at Station B. Locomotive ‘a’ replaces ‘b’ to haul the train from B to A and from A to B. Locomotives ‘c’ and ‘d’ exchange duties, but ‘d’ has an urgent inspection at Station D because there is no maintenance center in the direction of the trains that ‘d’ will subsequently pull.

The driver-rescheduling algorithm considers not only physical constraints (such as the time required for drivers to prepare for the newly assigned leg) but also practical constraints (such as sections where only specific drivers are qualified to operate trains and amounts of overtime work). Figure 3 shows an example of a driver rescheduling solution. The driver whose scheduled train is cancelled moves to his/her destination by deadheading. Our algorithm tries to minimize the number of drivers whose duties are changed, the amount of overtime work required of drivers and several other criteria depending on the settings of the associated parameters.

Algorithms for locomotives and drivers are common; both are based on network representation of problems and formulation as integer programming problems, and are solved using the column generation technique. Integer programming was considered to take a long time to reach a solution, but our temporal relaxation approach to the related problems as well as multi-thread computing, in addition to recent advances in computers and algorithms in the field, allow resolution within an acceptable amount of time. Computational experiments based on real data obtained from the highest-frequency freight train operation area in Japan showed that a three-day goal for locomotive scheduling recovery can be solved in 70 seconds using a personal computer. A rescheduling plan for over 100 drivers can be obtained in about 10 seconds.

In future studies, we plan to investigate the rescheduling of rolling stock for passenger trains in disrupted situations where the operation frequency is high and the splitting and combination of rolling stock arises often.

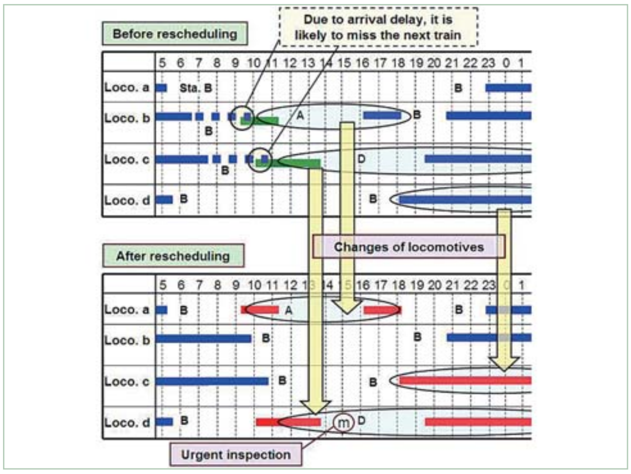

Fig. 2 A locomotive rescheduling plan

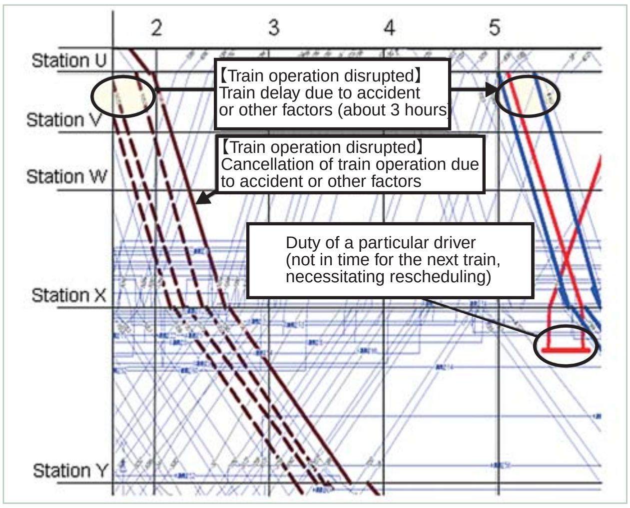

Fig. 1 A disrupted train operation situation

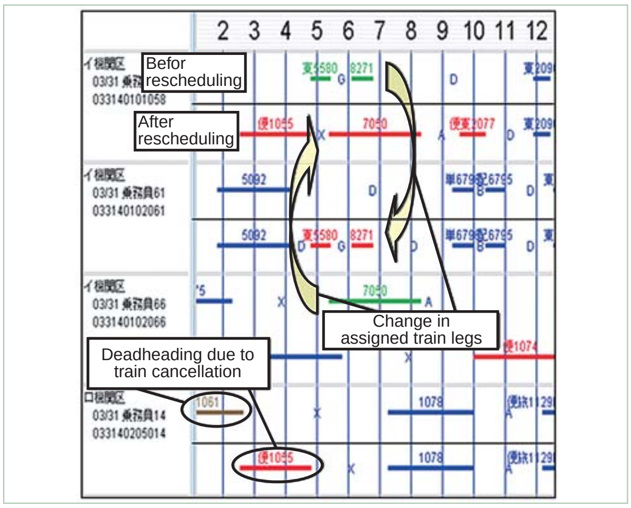

Fig. 3 A driver rescheduling plan