# A New Algorithm for Train Rescheduling Using Rescheduling Patterns

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If train services are disrupted, they can be brought back to normal in a number of ways, including canceling train runs, turning trains back, altering departure sequence, or using different tracks. All such schedule modifications are called train rescheduling. Train rescheduling plans are prepared by train dispatchers.

We recently developed an algorithm for computerized train rescheduling planning, and tested it on an actual track section. The tests confirmed that our algorithm can be used for practical train rescheduling.

At present, train dispatchers prepare train rescheduling plans on the basis of experience and intuition. However, train rescheduling involves a number of difficulties, including:

- The rescheduling of many trains may not be possible within the short period of time permitted.
- Judgment criteria are not always the same—they depend to a considerable extent on existing circumstances, which vary from case to case.
- Some considerations are difficult to quantify.

Computer-based support for train rescheduling would greatly lighten the burden placed on train dispatchers.

Since train rescheduling is an extensive operation involving different departments within the railway company, it is necessary to clearly identify each issue. For the general configuration of our train rescheduling system, we devised the framework shown in Fig. 1. The framework divides the entire system into subsystems (the figure also represents, in chart form, the relationships between subsystems). Our new algorithm is based on this framework.

Over the last few years, railway operators in Japan are increasingly using train rescheduling patterns. These patterns incorporate rescheduling techniques which are customarily adopted by some train dispatchers, and are expressed in such a way that they can be understood by other train dispatchers as well. Since train rescheduling patterns incorporate train dispatchers' knowledge (which includes knowledge of the railway operator's management policy, recommended counter-measures when dealing with unexpected phenomena, and conditions unique to specific locations), the patterns can be used to prepare a practical train rescheduling plan.

The algorithm we developed is composed of Rescheduling Pattern Description Language R (to permit the computer system to learn train rescheduling patterns), and R-Interpreter (which interprets and applies the train rescheduling patterns). R-Interpreter operations are shown in Fig. 2. R-Interpreter allows for speedy preparation of a train rescheduling plan that reflects the knowledge of train dispatchers.

However, simply applying train rescheduling patterns is not enough to formulate a practical rescheduling plan. This is because so many different situations call for train rescheduling that relevant train rescheduling patterns are not always available for a specific situation. Indeed, there are trains for which no existing train rescheduling patterns are applicable. We therefore adopted a two-stage system configuration: (i) train rescheduling patterns are used to create a general image of the train rescheduling plan (indicating decisions regarding major services to be cancelled, and timetable alterations to accommodate the cancellations), and (ii) a scheduling algorithm is used to decide matters for which the rescheduling patterns cannot be applied. This has made it possible for a computerized system to automatically prepare a practical train rescheduling plan. By conducting experiments using actual train schedule data, we confirmed that our algorithm is effective (see Fig. 3).

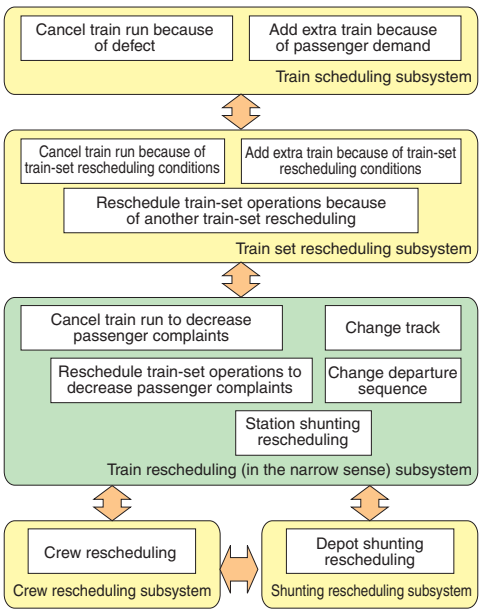


**Figure 1.** Framework of train-rescheduling system

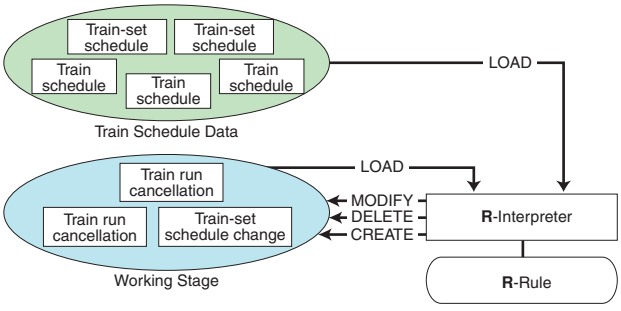


**Figure 2.** Operations of R-interpreter

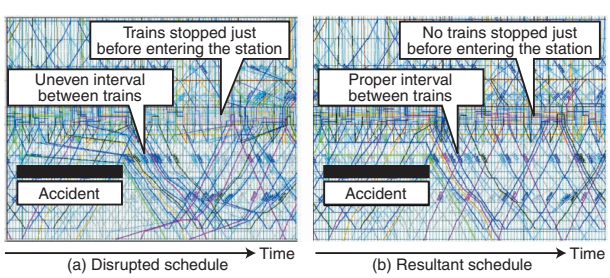


**Figure 3.** Disrupted schedule and Resultant schedule