Development of the Shunting Planning Support System

Shunting planning of the vehicle depots is a complicated job that must take into account many conditions such as facility-related constraints and rolling stock pooling based on the order of exiting the depot. Current planning mainly by manual work takes much time and is far from easy to master. We have thus developed a prototype shunting planning support system to support shunting planning at vehicle depots, and we have carried out functional tests at the Narashino Transport Depot.

Vehicle depots carry out systematic inspections and cleaning on a daily work schedule in the period between when cars enter and exit the depots. Shunting planning is the plan for track changing and pooling of cars in the depot for inspections and cleaning. In that planning, shunting planners have to consider many constraints to plan track changing routes and pooling of each train set, and they repeat total coordination and adjustment to avoid such track changing routes and pooling tracks being in conflict with each other. Those constraints include selection of pooling locations of cars that takes into account the order of track changing of cars to the tracks available for the required work (the washing track equipped with water supply and drainage for washing, the inspection track equipped with rooftop check facilities and an underfloor check pit for inspection and repair etc.) and the order of cars for exiting the depot. At present, the planning is almost fully dependent on manual work, so planning requires much time and skill. Furthermore, when the cars to enter or exit the depot are changed in incidences such as transport disruption, the plan must be changed immediately and flexibly in a short time. In light of that situation, we have developed a prototype shunting planning support system and carried out functional tests on that with an aim of improving efficiency of shunting planning and supporting sudden rescheduling.

1 Introduction
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2 System Overview

2.1 Developed Functions
We have developed functions that met the following specs.
- Automatic shunting planning function considering constraint conditions of the depot based on the depot's entry/exit schedule and in-depot work schedule (inspection and repair, cleaning etc.)
- A system that can immediately make change to and cancelling of in-depot work in case of sudden entry to and exit from the depot due to transport disruption, and that can accept manual amendments of the plan in human final decision.

For the purpose of system development, we have chosen the Narashino Transport Depot as the model depot.

2.2 System Function
2.2.1 Basic Data Management Function
This is a function of importing and outputting of basic information such as the information inherent to the depot and constraint conditions in shunting planning.

2.2.2 Basic Shunting Planning Function
This is a function for automatic planning of the basic in-depot work schedule (basic shunting plan), based on the basic information at the train timetable revision (transport timetable, track facility information, work details and basic operation information) and the transport information such as entry/exit information. In that function, we can select between the “minimum track changes” mode and the “minimum deviation” mode. In the former mode, the system makes the shunting plan with the minimum number of track changes, and in the latter mode, the system makes the shunting plan with the least deviation from the basic shunting plan before the timetable revision. The system also has a rescheduling function, where the system adjusts the total plan after manual adjustment of a part of the machine-made plan.

2.2.3 Basic Operation Change Function
This is a function for importing the timetable revision information in IROS (Integrated Railway Operation System) and checking and changing the scheduling and allocation according to each scheduling number on the display of the scheduling list for working days and holidays. With this function, we can also add information such as the persons in charge of entry/exit and specific comments along with entry patterns.

2.2.4 Daily Shunting Planning Function
This is a function for automatic planning of the in-depot work timetable of the designated day (daily shunting plan) based on the basic information (transport timetable, information of equipment per track, work details etc.) and the daily scheduling information. As with the basic shunting planning function, we can select between the “minimum track changes” mode and the “minimum deviation” mode. The daily shunting planning with this function includes the daily shunting planning function to make the shunting plan of the next
3.1 Interactive Plan Adjusting Function

The system has a program where planners can, in an interactive manner, manually repeat the process to add partial adjustments to the draft plan that is automatically made with the shunting planning function (Fig. 2).

3.2 Constraint Logic Program

A shunting plan shows the work for a train set in the depot from entry to exit in the order of implementation. That work includes not only the work related to inspections and cleaning of cars, but also any move to a specific track with a specific purpose such as pooling, pulling out, entry and exit, along with any track occupation for a certain period of time. In some cases, there is more than one track that can be used for the designated work. Thus, it is necessary to strictly determine the routes and occupation period for each train set with consideration paid to the constraint conditions of the depot (Table 1). Since solving this problem in a brute force manner takes a huge amount of time (combinatorial explosion), we have adopted a constraint logic program for the shunting planning support system as a technology to efficiently find the answer while controlling the possibility of combinatorial explosion.

A feature of the constraint logic program that we use for this system is the search approach where we dynamically narrow down only possible answers. That enables the system to meet a wide range of conditions and to relatively easily add and cancel the constraint conditions (Fig. 3).

3.3 Program Structure of Planning Engine

The planning engine is an independent program component that provides functions for shunting planning. GUI, data management, form outputting and other system components use that engine via an interface (Fig. 4).
3.4 Common Application of the Planning Engine

Vehicle depots have different in-depot layouts, equipment placement and constraint conditions for planning. By making an external database of such information, we have developed an architecture that allows flexible setting and changing to meet the actual layout of each depot that uses this system. Furthermore, we have adopted a constraint logic program for the engine at the planning core to make the system applicable common to any vehicle depot. That is done for the purpose of securing versatility (Fig. 5).

4 Functional Check Results

We developed a prototype shunting planning support system in fiscal 2008, and we carried out a basic functional check for that in the Narashino Transport Depot of the Chiba branch from December 2008 to March 2009. The planning results demonstrated that the system could successfully prepare the basic shunting plan and the daily shunting plan, both of which met all constraint conditions. We further confirmed that manual amendment of the draft plan automatically prepared by the system functioned as the planner intended.

[Test items]

- Basic shunting planning function
  To be able to prepare basic shunting plans at each timetable revision and accept manual amendment
- Daily shunting planning function
  To be able to prepare the shunting plan of the day designated for work and accept manual amendment
- Form output function
  To be able to output basic shunting plans and daily shunting plans as forms for the entry order table and the exit card
- Comparison and verification of the shunting plan by the system and that by a planner

5 Conclusion

The basic function checks carried out on the prototype shunting planning support system clarified the following issues that need to be handled in the future.

(1) Problems in user-friendliness due to much entry work
(2) Incorporation of human judgment criteria based on the know-how of each depot

We were able to confirm, however, that the basic functions and processing method of shunting planning work correctly. That proved the effectiveness of the system.

Reference: