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GUI-based interactive railway planning systems

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Abstract

Central Japan Railway Company (JR Central) operates 300 super bullet trains on the Shinkansen line as well as about 2,000 conventional passenger trains on conventional lines daily. In the past, train operation planning was only possible by using highly skilled professionals. In particular, developing train diagrams and simulations for scheduling of cars and crews was highly dependent on those professional skills and painstaking paper-and-pencil work. Digital Japan, requested by JR Central, has laid a system foundation for JR Central's Computer Aided Railway Planning & Operation Systems. Up to today, standard train running has been measured systematically for data input that is incorporated into the Computer Aided Train Diagram System. This system, in turn, provides basic data for other systems, such as Timetabling, Car Management, and Crew Scheduling. Use of these systems is facilitated by an easy-to-use, interactive GUI that helps planning professionals simulate and produce optimized scheduling. This paper will introduce the basic concept for the total system, provide background information, and will particularly focus on the Crew Scheduling System which is equipped with Artificial Intelligence for checking Union rules and work regulations. The paper will finally look at further technological advancement for the future.

1 Introduction

Railway operation in Japan is renowned throughout the world for its punctuality and efficiency. Central Japan Railway Company (JR Central) has provided a variety of railway services to passengers as customer needs become diversified.

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Along with the super bullet trains (known as Shinkansen), JR Central has a number of limited express and high speed trains in addition to ordinary trains on 12 conventional lines that cover a total of more than 1,400 kilometers. Reserved trains for parties and seasonally operated special trains add further complexity to the planning and management of mass transit transportation.

In the past, the planning and management work was performed manually by extraordinary "artisans" whose know-how was said to be hard to systematize. A majority of work was achieved by using calculators and colored pencils on paper, and the work took many months to simulate a complete schedule and to include all the complexity.

However, it became increasingly difficult to meet diversified customer needs and to deal with rapidly growing traffic volumes by planning and managing manually. It was then decided to overcome this inefficiency by introducing computerized planning and operation systems based on the experiences accumulated for years within JR Central. Digital Japan proposed a GUI based, interactive approach to serve the needs of those professionals who required their "own" tools to use in their work. The essence of their needs can be summarized in the following:

The system must provide

- support functions for flexible simulation.
- multi-levels of information (via windows) available at the one time.

Once operated, the systems also reduced significantly the amount of manual operations and enhanced quality throughout the processes. A great deal of work has been achieved and is now in operation.

2 Overview for Railway Planning & Operation Systems

Figure 1 illustrates the overview of the total system. The descriptions of some of the system components are as follows:

Standard Train Running System:

The system gathers the data that indicates the minimum running time between stations and the minimum interval time between trains. The data is used for developing train diagrams and driver manuals.

Train Diagram System:

This particular system employed 2 minutes scale to work on the train diagram. On the basis of Standard Train Running System, it shows types of train, arrival and departure time of trains, and then the system automatically creates train diagrams. The system also provides copying, editing, enlarging facilities, and these are used by the planner to produce their optimal solution. All these operations are performed interactively through Motif-based GUI windows. The

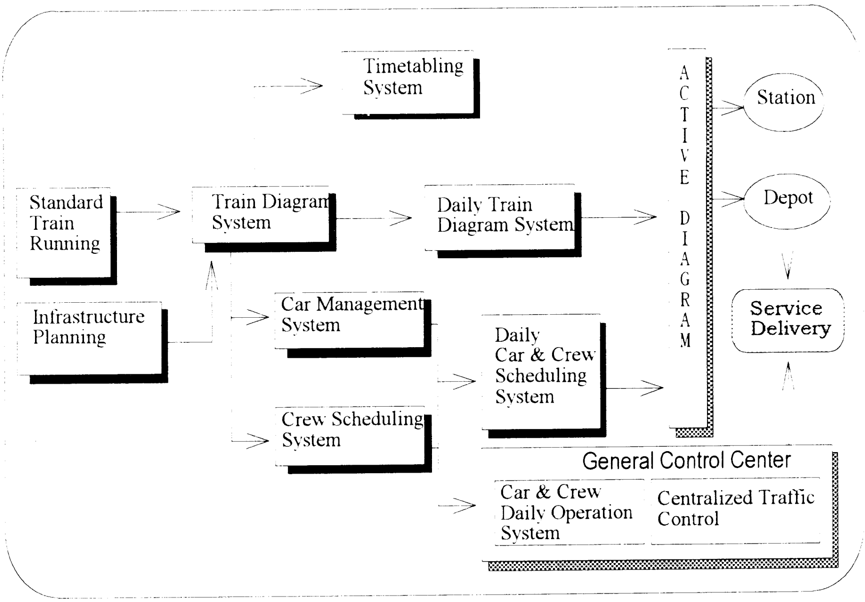

Figure 1: Overview of Computer Aided Railway Planning & Operation Systems

system also has various types of printout functions. Figure 2 & 3 are examples

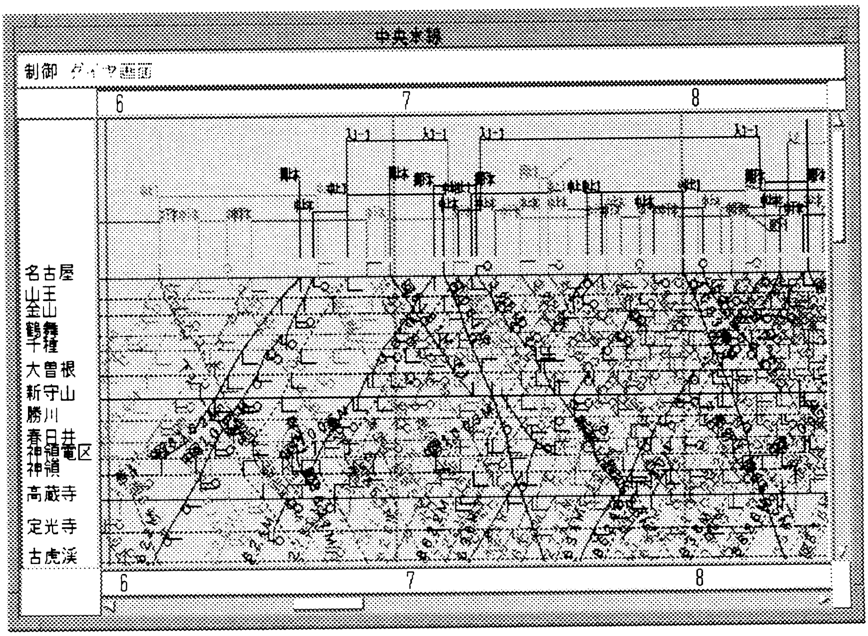

Figure 2: Example of Computerized Train Diagram

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of train diagram developed by the system.

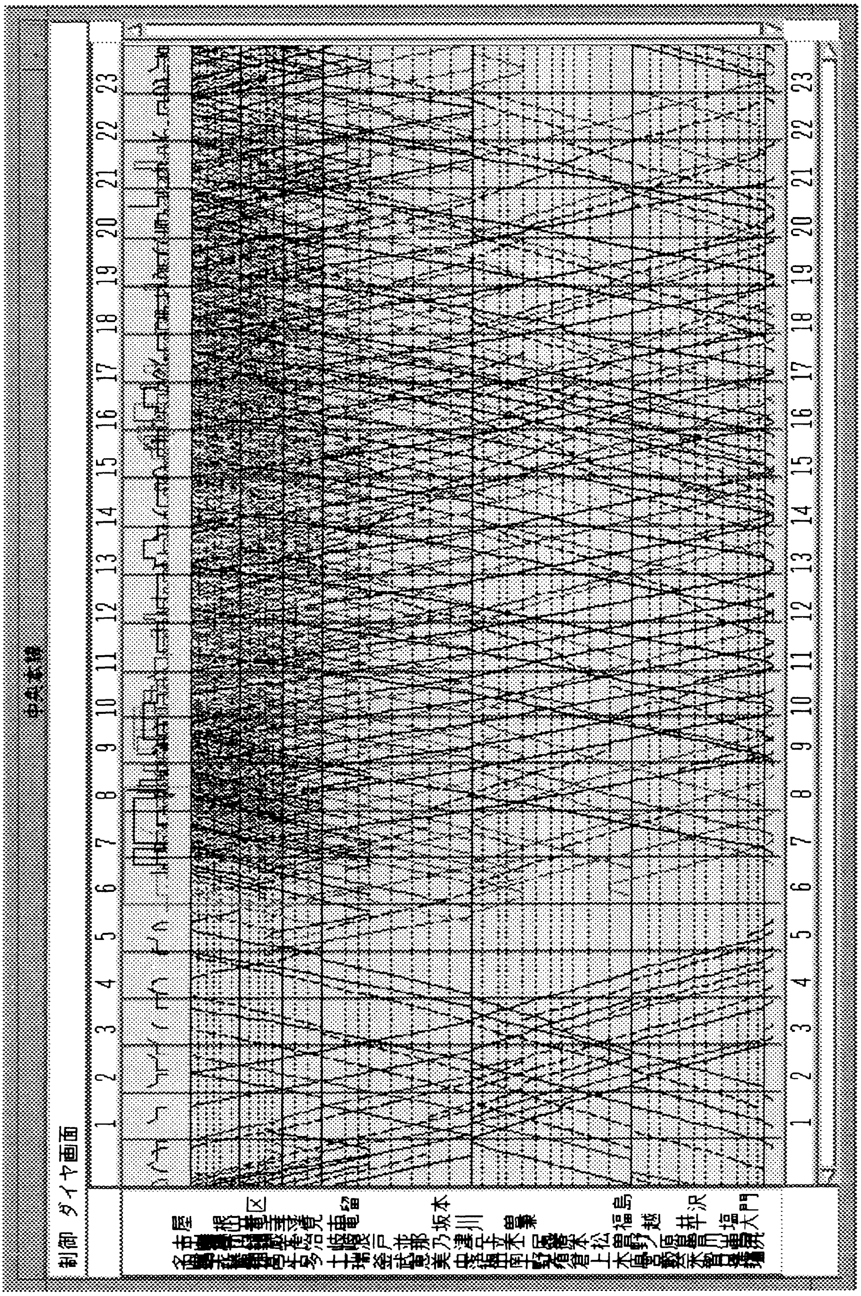

Figure 3: Example of Computerized Train Diagram

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Timetabling System:
Producing timetables for passengers at stations used to involve considerable working time and printing cost, especially when the train diagrams were revised. This system reduced the cost down to one fifth.

Car Management System:
Utilizing the data from the Train Diagram System, this system provides the working environment for planning car management. The diagram is first presented on the screen which can be divided across two workstations to get a large view of the diagram. A planner will, then, interact with the workstations to construct the most effective car rosters. Other schedules, such as, car inspection and cleaning, and facility data for car stock depots, are also produced.

Crew Scheduling System:
The details are discussed in Section 4.

3 Architecture

Hardware:
Figure 4 illustrates the total hardware systems consisting of workstations and servers that are integrated largely on OpenVMS/DECnet, with the PCs, Macintosh and Electrostatic color plotter (CalComp X2020) connected to the Ethernet.

Software:
The components of software depend on the equipment, but the basic structure can be described as below.
1) OS: OpenVMS
2) Network System: DECnet & Pathworks, TCP/IP
3) Window System: Motif
4) Database: VAX Rdb
5) Graphic Tools: GKS
6) Language: C

4 Crew Scheduling System

Overview:
The Crew Scheduling System is one of the key components in the total planning systems. It is similar to scheduling vehicles, but differs in that the system must take human aspects (restrictions) into account. The data from the Car Management System is loaded onto the system first, then a planner will select trains and assign to depots. Train services are operated using multi-day schedules and crews will change at specified points (relief points). The crew

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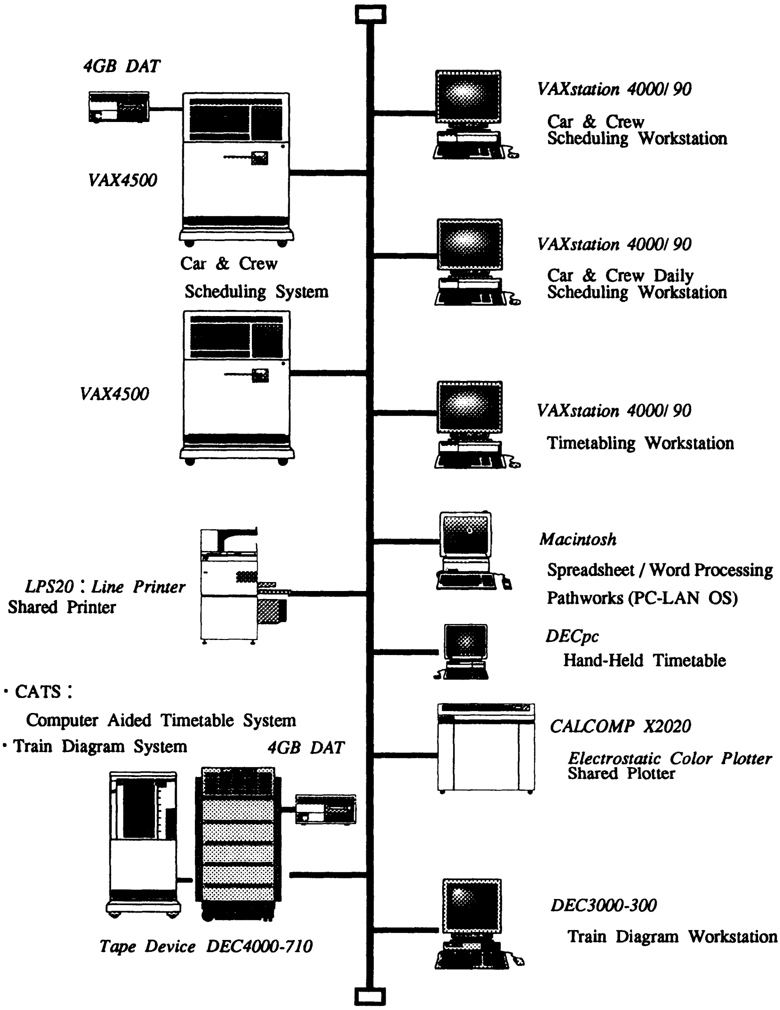

Figure 4: Hardware System

scheduling work is performed based on weekday vehicle schedules, with certain trains deleted for weekend schedules. The crew consists of drivers and guards.

During planning, the crew schedule can be checked against work regulations and Union rules. Due to the complexity of these regulations and agreements, a knowledge database system has been implemented and the system assists error correction of work rule breakage by providing an explanatory message.

There are three basic components in this system : (1) displaying information, (2) editing and simulating information, and (3) printing out information (Figure 5).

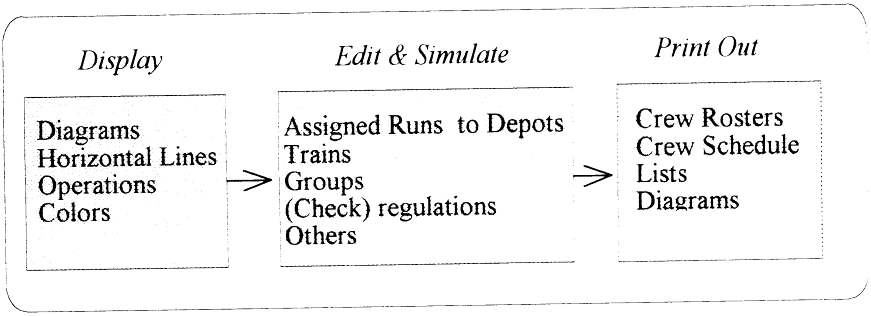

Figure 5: Basic Components

Key Features of Crew Scheduling System:

Advanced features are embedded in the system to help planners to produce crew schedules and crew rosters. Some of these features are described below.

Resizing and Magnification: Because the diagram is drawn based on a 2 minutes scale, the screen view is extremely complex (Figure 6). However, to make the work easier, the whole screen can be zoomed in and out by selecting the area using a mouse. A planner may want a large view of the diagram or may want a certain area to work on. When selecting a train line to connect or to delete, a small window called a "magnifier" will appear if the mouse button is depressed for 3 seconds. The most recently selected train line is highlighted by use of color.

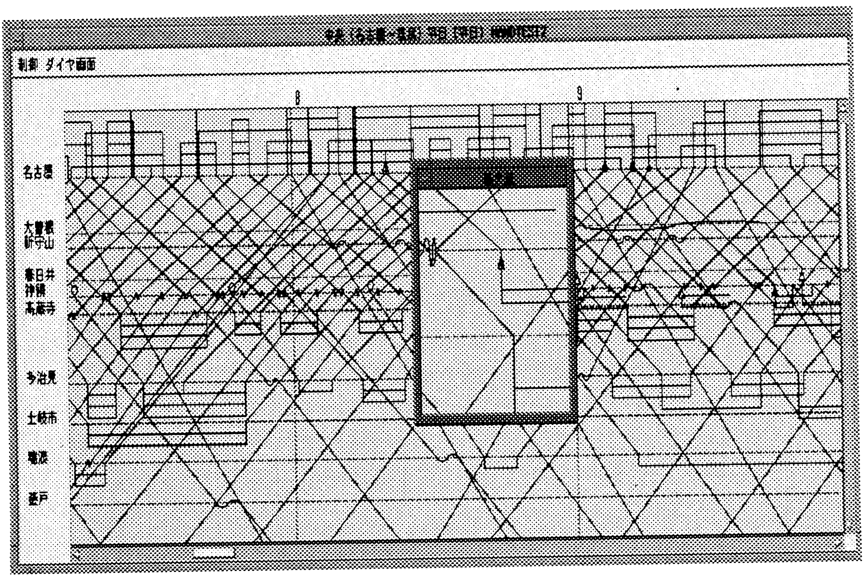

Figure 6: Example of Diagram to Select Trains to Assign to Crews

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Editing & Simulating: There are a number of window based commands in this system to edit and simulate. Once trains are assigned to depots, individual train crews will be constructed on the basis of the number of crews in each depot. Since train services are operated using multi-day schedules, a number of groups are then produced, with individual crew being changed at relief points. When individual trains are constructed, the crew kilos and hours are automatically calculated and displayed on another window (Figure 7).

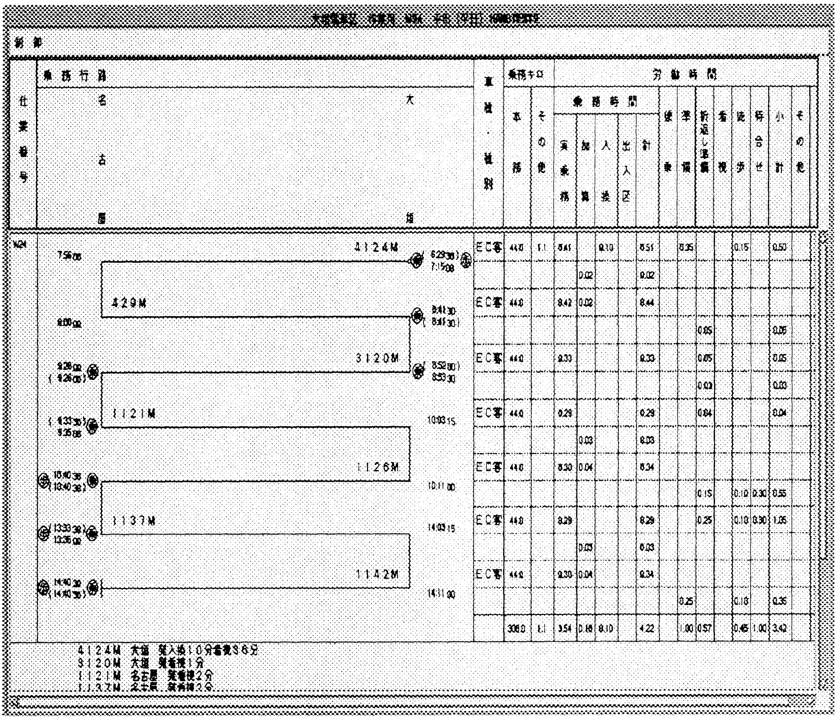

Figure 7: Crew Roster showing Kilos and Hours

OPS5 and C Based Knowledge Database for Checking against Regulations: In the process of planning individual train and grouped trains, legality must be checked against work regulations and agreements. By inputting the several conditions, the knowledge database will first check individual train. Once this process is cleared, the system then automatically draws a diagram for a group of train (called Kouban). If not cleared, the system will assist corrections by providing messages. The system also checks grouped trains (called Kumi) in four categories and assists a planner to make corrections. Because regulations and agreements are fairly complex, the AI based knowledge database helps speed up planning process dramatically.

Printing: CalComp X2020 and LPS20 postscript printers produce a number of diagrams and lists that assist in planning crew scheduling and crew rostering. The information, such as arrival and departure times, train types, locations, etc. are also printed.

5 Future Directions

Already a great deal has been achieved; however, there are issues yet to be addressed. Three key issues are identified in this paper.

(1) Migration to Faster Machines:

Since the data that should be processed for planning is quite large, a faster CPU is preferred. The current main platform is VAXstation4000/90 that operates under a CMOS Microprocessor N VAX Chip Set. Even faster 64-bit Alpha AXP workstations will be the total platform in the near future.

(3) Networking:

Currently standard planning systems for train diagrams, timetabling, car scheduling, and crew scheduling have been networked. Next work is to network all the systems components. This includes transmitting the data to the infrastructure systems, such as CTC (Centralized Traffic Control). The work will involve an intensive networking effort to establish a truly integrated systems environment.

(3) Extending Systems to Service Delivery:

The expanded scope is to involve all stations and depots to completely automate at all levels. Paper-and-pencil work is still seen in daily operations at these sectors. In order to transmit the data to the end-user automatically, large scale system development effort will be required. This effort should be focused not just on automation but also on improving daily work structures to fully utilize the system.

References

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