Recent Train Traffic Control Systems

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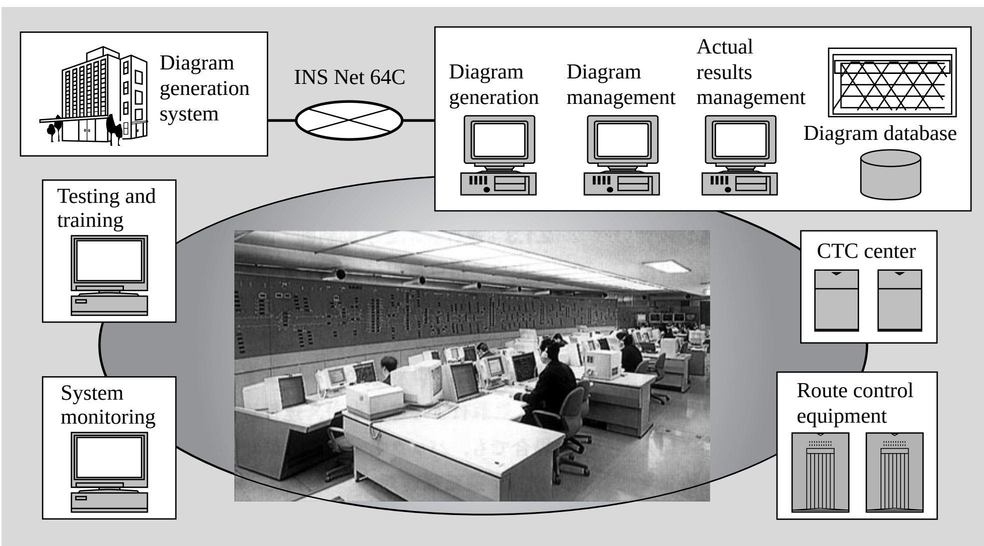
Overview: As passenger demand cannot be expected to increase in the coming years due to a declining birth rate and the aging of society, the need for more efficient rail-transport operations is being felt. As a result, a traffic control system that focuses on train traffic is becoming all the more important. Moreover, the recent diversification in user needs requires a finer response in terms of improving speed, convenience, comfort, and service. The introduction of the train traffic control system developed by Hitachi began with the Namboku Line of the Sapporo Metropolitan Subway System in 1971 and the Comtrack system of the Tokaido and Sanyo Shinkansen lines. Since then, it has been expanding and developing into the backbone system of the railroad system, mainly JR (Japan Railways) Shinkansen and local lines, the municipal subways, and private railways. To make operations more efficient, recent traffic control systems aim for an expanded range of automatic control (control of large stations), in-station switching, etc., control over more equipment, and improved operability for train controller by adding operation adjustment functions based on the train operation diagram. In addition, there is vigorous activity in the introduction of a large-scale, high-performance traffic control system to connect with passenger information equipment to improve customer services, achieve higher density train operations, handle one-person and unattended train operations, and provide information for stations and section offices.

INTRODUCTION

THE basic function of a train traffic control system is to control railroad signals and track switches according to a train traffic diagram so as to operate the trains as the diagram indicates. Recent systems require features that extend beyond the basic functions of tracking trains on medium- and small-scale trunk lines, which have relatively simple line configurations, and automatic routing. Those extended features include: (1) increased automation through the control of large stations, which have more complex line configurations, (2) increased traffic density through control of train groups and equal time interval control, (3) operation adjustment functions for improved support of recovery



CTC: Centralized traffic control
INS: Integrated services digital network

Fig. 1—The Recent Train Traffic Control System.
In the recent train traffic control system, an open interface allows interconnection of subsystems and the use of the most recent workstations to improve operability for train controller.

after disruption of the train traffic diagram, (4) rapid delivery of train traffic conditions to station and train personnel and (5) improvements in information services, such as real-time passenger information according to the traffic conditions (Fig. 1).

Here, we describe the technical trends in recent train traffic control systems.

JR LOCAL LINE CONTROL SYSTEMS

The configuration of the local line control system is illustrated in Fig. 2.

Beginning with the central traffic control equipment, the various devices are connected by a network that employs an autonomous and distributed architecture. By employing a redundant configuration for the transmission paths and software that supports cooperative, autonomous, and distributed communication, a system having excellent reliability, flexibility and expandability is implemented.

The traffic adjustment panels and control panels are implemented on general-purpose computer workstations to distribute the work load. The workstations communicate with the Centralized Traffic Control equipment, which transmits the control signals, by using an open, general-purpose protocol.

Features of the Local Line Traffic Control System

The basic function of a traffic control system is to monitor the location of trains on the lines in real time and perform routing control according to the traffic diagram. In addition to this basic function, recent systems must satisfy the demand for a broader range of automatic control, more support for the tasks performed by control personnel, and improved information services.

Automated control in large stations

Conventional systems are intended to provide automatic control for medium and small stations that have a maximum of 20 to 30 routes, but automated control of large stations that have more than 100 routes has recently become possible to greatly improve the efficiency of station operations.

Automated control of in-station switching

In the past, there was no automatic control of in-station switching from the center; in-station switching work involved only the tracking of trains on the tracks and control was done as part of station management. Recently, however, in-station switching has become a

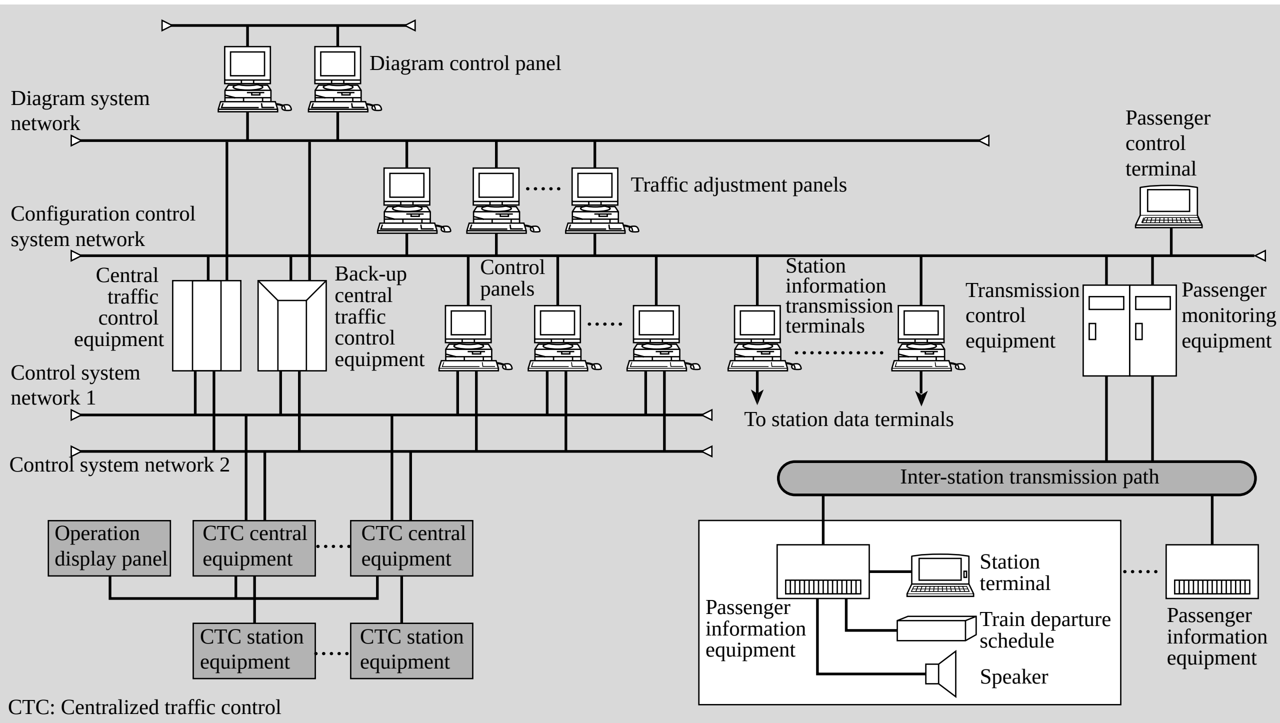


Fig. 2—Example of Traffic Control System Configuration.
The central traffic control equipment employs a fault-tolerant control computer for high reliability.
The human-machine interface is provided on general-purpose computer workstations.

target for automated control as a means of raising the efficiency of station management. To make centralized automated control possible, equipment such as switching signals and guidance signals has become the objects of control.

Traffic display and manual control

The display panel and control panel are arranged for use by the central control personnel. The display panel displays the status of trains on the lines and the status of various types of line equipment. The control panel is used for manual setting of routes from the center. It consists of several computer workstations. This configuration allows for back-up operation even in the event that the central traffic control equipment fails.

Operation adjustment

To strengthen the operation adjustment function as a recovery support function for when the train diagram is disrupted, the actual lines and the predicted lines are displayed and the displayed lines are directly manipulated, thus allowing fast and easy operation adjustments.

Traffic information service

This service broadcasts the approach of train, the delay time and changes in the train diagram automatically and in real time on the basis of the data of the central traffic control equipment, and that information is displayed on the train departure schedule. Data such as the characters of the departure schedule and the broadcast text can be changed from the center, greatly expanding maintainability and expandability when the train diagram is corrected. Also, station data terminals are placed at stations and at operation section offices, making it possible to know the traffic situation and to provide a detailed information service to passengers.

Integrated equipment data tool

The construction of a traffic control system requires programs for train tracking, route control, and so on, and a huge amount of data that defines the attributes of signaling devices, railway circuits, and other such equipment. Although the standardization of these programs is progressing, there is still a tremendous amount of work involved in creating the data to be used by the programs.

To increase the efficiency of data creation and to improve the quality of the input data, Hitachi has applied an integrated equipment data tool that has functions for organizing equipment data items, creating a database of those items to eliminate redundant data entries, and simple data input operations and logic checking.

TRAFFIC CONTROL SYSTEM FOR PUBLIC AND PRIVATE RAILWAYS

Trends in Public and Private Railway Systems

The introduction of the first-phase traffic control systems to existing lines of the public subway systems and the major private railways for the purposes of automation of route control, reducing the workload of control personnel, and improving passenger service, is now virtually complete and studies on the second phase system have begun.

Issues of the second-phase system include: (1) construction of a more efficient form of work, (2) high-density operation technology to ease the congestion in the suburban lines and to reduce the commute time by diversification of train types, (3) conversion to one-person and unattended operation to reduce operating costs and the reduction of maintenance costs, (4) the handing down of technical skills as veteran operators grow older, and (5) increased use of office automation equipment in railroad operations and information services for customers (Fig. 3). Measures for resolving these issues are being extensively studied.

Construction of an efficient form of work

Integration of the traffic, electric power, equipment, and train car control systems will make it possible to more quickly grasp the situation when the train diagram has been disrupted by an accident or disaster and to decide on emergency measures, equipment replacement, and personnel requirements.

Also, integrating the control offices of multiple lines allows flexible operations when an abnormal condition occurs by making it possible to share emergency relief personnel.

High-density train operations

Train’s falling behind schedule during the rush-hour is a chronic problem. When attempts are made to bring individual trains back on schedule, the train following a delayed train may have to stop between stations while the late train is stopped at the station in front of it. This disrupts the train arrival schedule and may cause passengers to specific train. This can cause delays in the schedules of other trains. The most effective way to cope with this kind of situation is train group control,

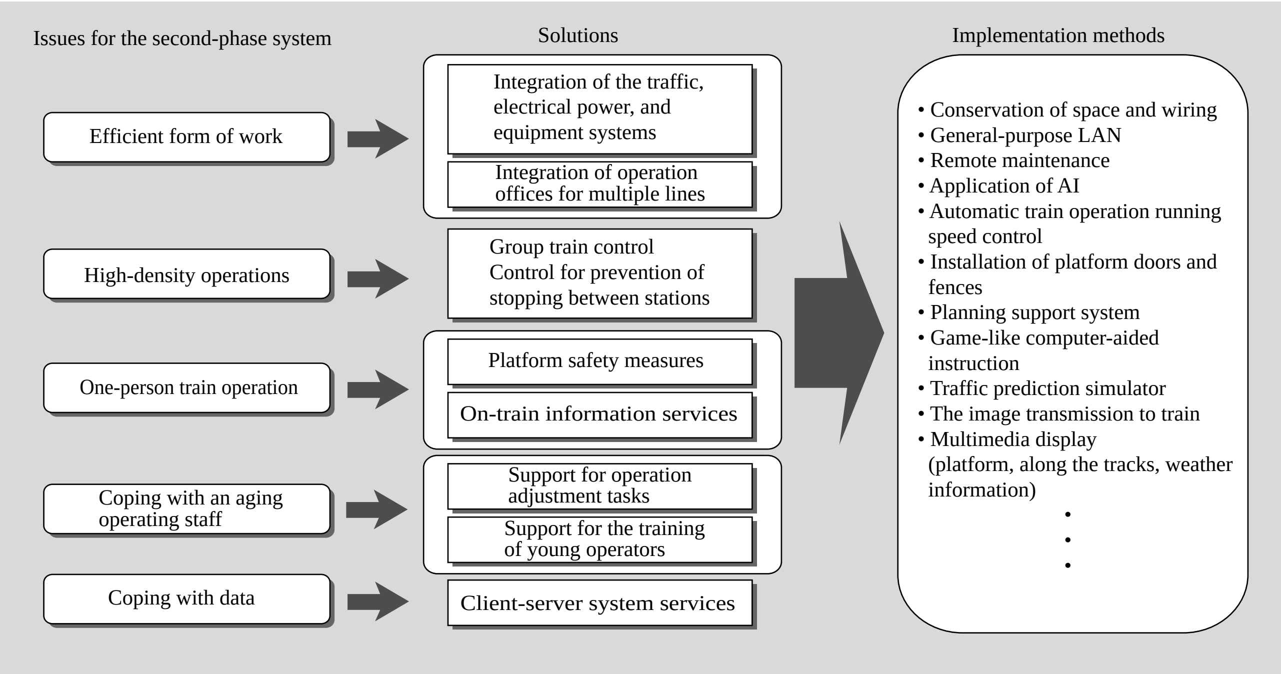


Fig. 3—Issues and Solutions for the Second-phase Traffic Control System.
For the second-phase system, increased work efficiency through system integration is a central issue.

in which trains are handled in groups rather than according to the absolute delay times of individual trains on the train operation diagram. This train group control employs an equal time interval control, in which the relative time interval between trains is maintained. To achieve this control, it is necessary to specify the running speed of trains traveling between stations so that trains proceed slowly to the next station.

One-person and unattended train operation

To implement one-person and unattended train operation, platform doors and fences are essential to keeping the safety of passengers as they get on and off the train. It is also necessary to install ITV (industrial television) equipment for visual monitoring of the platform to the train operator's compartment or at the control office. It is also important to improve the on-board information services for passengers.

Coping with an aging staff

Veteran staff members possess a great deal of excellent knowledge, intuition, and experience. As these veteran staff members are growing older, the transfer of that knowledge, intuition, and experience to younger members has become an urgent task. There is particular need for the introduction of support systems for the operation adjustment task, which requires correct decision-making and rapid action in response to disruption of the train operation diagram, for the diagram creation task, which requires coordination with many related offices, and for the task of drafting the plan for the deployment of on-train personnel and train cars.

Coping with data

Up to now, efforts have focused on introducing a backbone LAN and client-server system services to enable real-time access of information on traffic conditions and train cars collected at operation control offices. This capability allows related offices to respond rapidly to problems and provide accurate information to customers. In the future, a video distribution service for customers is also planned.

Case Study 1: the Fukuoka Metropolitan Subway Operation Control System

This system began operation in 1981 as a total system that comprises systems for traffic control, data transfer control and electric power control. The updating of the traffic control system at this time involved the introduction of a control data client-server system that included all of the office departments (operations, etc.) and all of the stations (Fig. 4).

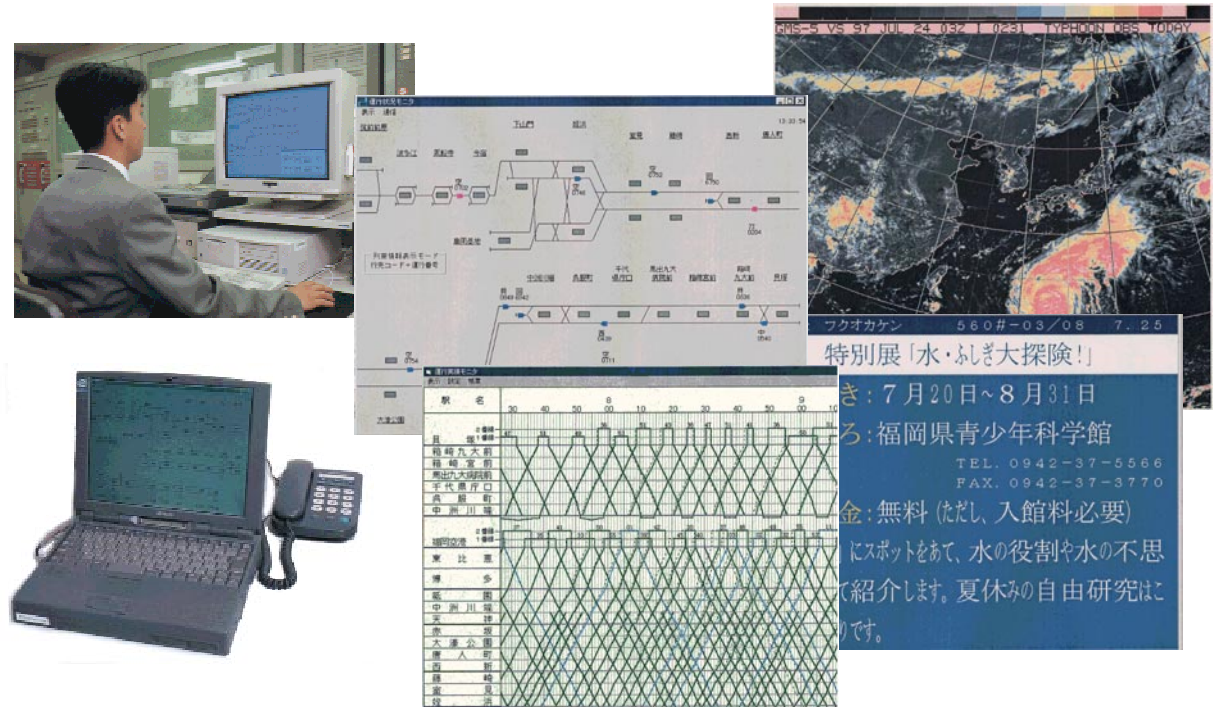


Fig. 4—The Traffic Control Data Client-server System of the Fukuoka Metropolitan Subway. Client terminals installed at each duty station can access train traffic information, weather information, text messages, and so on.

Configuration of the traffic control data client-server system

This system comprises the following hardware.

(1) Traffic data server

The data on actual traffic conditions, control output and other such data that is collected by the central traffic control computer and data that is received by the weather data receiver is stored in a database and in files on the server.

(2) The weather data receiver

Image and text data that are broadcast by the Himawari meteorological satellite are received and sent to the traffic data server by this equipment.

(3) Client machines

The client machines can access the data that is stored in the database of the server. It can search the database, retrieve and manipulate the data, and display the data on the screen or output it in various forms.

These machines are connected to the server via a branch-line LAN using the CSMA/CD (Carrier Sense Multiple Access with Collision Detection) protocol, which is capable transferring data at 10 Mbit/s. They are connected to a transmission path that has a total capacity of 100 Mbit/s.

Overview of the traffic control data client-server system

(1) Traffic status monitor

On the basis of the train data that is output in cycles from the traffic control system to the server, the locations, destinations, and delay times of trains are displayed on a train line diagram. In addition, information on the previous and next train departures, train car dispatch information from the train base, and other such information can be displayed.

(2) Actual traffic information and train operation diagram monitor

The actual traffic information (actual arrival and departure times and delay times) are displayed on a diagram as well as on an execution diagram. In addition, the departure times from each station for each train number can be displayed in table format. Commercial software can be used to display the tables, output them to a printer, or save them on a floppy disk.

(3) Train operation record monitor

The recorded data on actual train operation can be displayed in table form for each track number or each company. The recorded data can be revised on the client side.

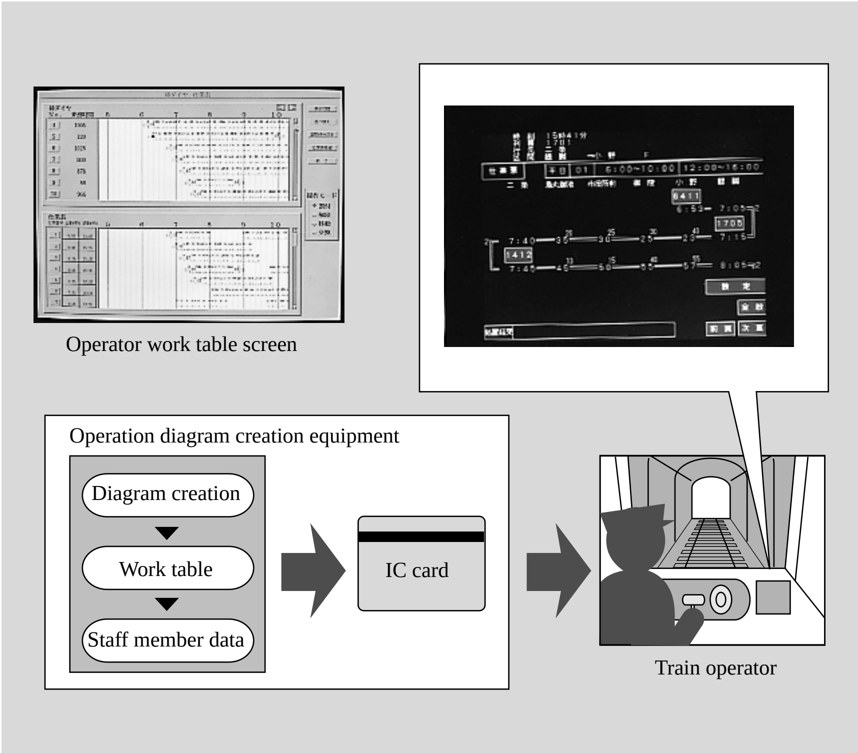


Fig. 5—Train Operator Work Table IC Card.
The train operator carries an IC card that stores operator work table data. Using this card, the operator checks his work for that day via on-train monitor equipment.

(4) Weather data monitor

Images from the Himawari meteorological satellite, weather chart facsimiles, and text broadcast images that are received by the weather data receiver can be displayed.

Other features

(1) Introduction of a train car utilization system

The Train Car Utilization System, which is used to draft a train car utilization plan table and an in-station utilization plan table on the basis of a car utilization table and monthly inspection process table, was introduced.

(2) Personal computer for training control operations

The training of transportation control personnel has, up to now, employed text documents such as system operation manuals and internal regulations related to operations. Now, a training and practice system that is based on a personal computer has been introduced. This system incorporates elements of games that allow the learners to systematically learn the configuration and functions of the control system and the control operation procedures for normal operations and for emergencies. The learner can also refer to related information while using the training system.

Case Study 2: the Kyoto Metropolitan Subway Tozai Line Traffic Control System

The Kyoto Metropolitan Subway Tozai Line was intended to relieve congestion in the city and to improve service for commuters and tourists. It has 12.7 kilometers of track connecting 13 stations between Daigo station and Nijo station. The trains are operated by one person and platform doors are installed at the stations.

System overview

The purposes of the traffic control system are to improve passenger safety and service and to increase the support for and efficiency of the tasks involved in traffic control. The system was constructed with an autonomous and distributed architecture.

Special features

The special features of this system include a monitoring function for the one-person operation of the trains and a function for creating IC cards for creating train operation diagrams.

These functions achieve traffic control system that is both highly efficient and highly safe through the cooperation of on-train and on-the-ground functions.

(1) Support functions for one-person train operation

Train radio equipment is used to exchange information such as emergency reports and emergency communication. When an abnormal situation occurs, an alarm is displayed on the traffic display panel (a 70-inch high-resolution display) to inform the control personnel of the abnormality. The system monitors for abnormalities that require platform monitoring (failure of a platform door, complete stop, emergency stop, etc.) and when such an abnormality occurs, the ITV monitor of the traffic display panel automatically displays the video image of the platform of the station where the abnormality occurred and the system provides support to the control personnel. When an abnormality in the on-train monitor occurs, the affected train is tracked under direction of the control personnel, and while it is stopped at a station platform, ITV monitor of the traffic display panel automatically displays the video image of the platform of that station.

The function described above supports the safe operation of one-operator trains from the ground facility (i.e., the traffic control function).

(2) The function for creating the IC cards used for on-train monitoring

The train operation diagram creating equipment consists of a function for creating the operation curved lines, a function for creating the time interval curved lines, a function for creating the basic diagram, and a function for creating the operator work table. The function for creating the work table creates a work table for the train operators on the basis of the diagram information, but in this system, schedule data for each operator is created on the basis of the operator work table and stored on an IC card. This card is used to supply that information to the on-train monitoring equipment.

The on-train monitoring equipment reads the data from the IC card and displays it on the display in the operators compartment to provide the operator with the information in a form that is easier to view than the operator work table. The concept of this system is illustrated in Fig. 5.

The function described above provides support for the train operator as well as increases efficiency and reduces labor in the work related to revision of the train operation diagram.

PASSENGER INFORMATION SYSTEM

The configuration of a passenger information system that is fully integrated with train traffic control and the configuration of one that is separated but closely connected to train traffic control are described in the following sections. These systems make it possible to provide accurate information to passenger even at times when the train operation diagram is disrupted.

A Passenger Information System That is Fully Integrated with Train Traffic Control

The configuration of this system is illustrated in Fig. 6(a). It is a distributed system that consists of the central equipment and station equipment that is installed in each connected station. The station equipment consists of three processors, which include a dual processor system and an additional processor for the display and sound interface. It is fully integrated into the traffic control system, so when changes are made to the control system train operation diagram, those changes are reflected directly in the passenger information system. Also, as the running order of the trains is always monitored, it is possible to provide accurate information to passengers even though the train operation diagram is disrupted because the order of departure from stations is decided according to the situation of the trains on the tracks.

This system can share hardware and software with the train traffic control system, and so has a good cost-performance ratio.

A Passenger Information System That is Separated but Closely Connected to Train Traffic Control

The configuration of this system is illustrated in Fig. 6(b). The central equipment is the traffic control system that performs the centralized control is connected to the passenger information equipment via a loop in an autonomous and distributed configuration. Operation diagram changes that are input to the train traffic control system are reflected directly in the passenger information equipment, so by regarding the operation diagram as batch traffic control and receiving the train departure order and on-track information that is needed for diagram information and for passenger information at regular intervals, it is possible to provide accurate information to passenger even though the train operation diagram is disrupted.

CONCLUSIONS

We have described some of the recent train traffic control systems. The train traffic control system as a core system for the smooth operation of rail transportation has been increasing in importance. Future development will proceed with the objectives

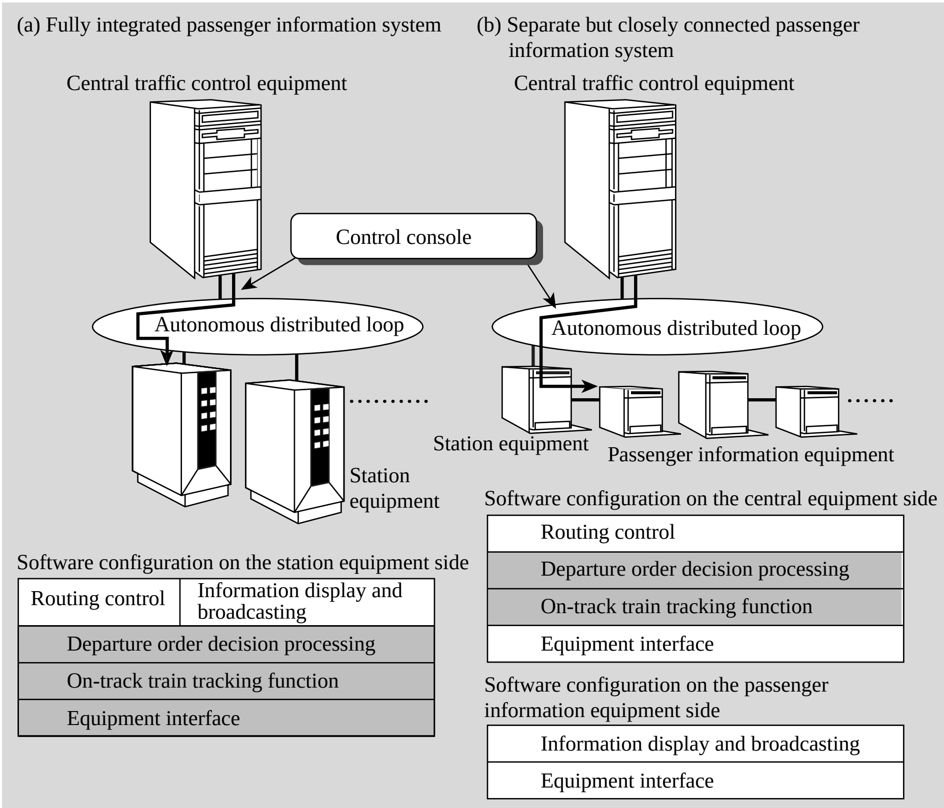


Fig. 6—Examples of Passenger Information System Configuration.
The shading within the software configuration tables indicates software that is shared by the traffic control system and the passenger information system.

of more advanced functions, lower cost, and a broader range of information services.

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