Centralized Information Control System Supporting Safe and Stable Shinkansen Transportation

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Abstract

Since the opening of the Tohoku and Joetsu Shinkansen lines, the Centralized Information Control (CIC) system has been supporting safe and stable transportation. In order to cope with the increased speeds and volume of data transmission, NEC has adopted some innovative solutions. These have been deployed by East Japan Railway Company as an updated version of the CIC system and are contributing to the efficient supervision and maintenance of the system as well as to transportation safety. This paper summarizes the upgraded CIC system and discusses its features.

Keywords

Shinkansen, CIC, CMS, disaster prevention, surveillance system

1. Introduction

The Centralized Information Control (CIC) system operated by East Japan Railway Company (hereinafter JR-East) collects and controls real-time weather information such as wind speed, rain amount, etc. as well as status information of traffic signals and communications systems. This capability enables the control room operators to monitor railway traffic conditions and to control all of the relevant facilities. The first and second generation CIC systems developed by NEC have been employed by JR-East for over 30 years, since the opening of the Tohoku and Joetsu Shinkansen lines. The CIC system is now considered to be essential for safeguarding stable Shinkansen operations.

The previous system, the Centralized Information Monitoring System (CMS)[*1] had been operated for more than ten years. Due to the acceleration of the processing speed of the Shinkansen operations support systems and the increased number of systems that had to be monitored, the demand for higher speeds and larger volumes of data transmission have been increasing. In considering such conditions, NEC has introduced a new system to JR-East that improves the efficiency of the command dispatching and maintenance operations, and also contributes to a safe railway transportation operation. In this paper we present details of the new system.

2. New System Configuration

2.1 Network Configuration

The network configuration between stations and the control center is shown in **Fig**. Stations gather various alarm information, and the control center sends the relevant commands to the stations. Features of the network are described below.

(1) In order to implement a large volume data transmission that is compliant with IP protocol, the new CIC system employs optical fiber for the optical paths that connect the network stations, and it also employs a layer 3 switch (L3SW) for the network configuration. The

[*1] The system was originally known as the CMS because the monitoring function used to be the main operation of the system. However, control operations have become more significant due to the increase in the number of facilities. By taking the opportunity to perform a system update at this time, we have decided therefore to change the name of the system to CIC.

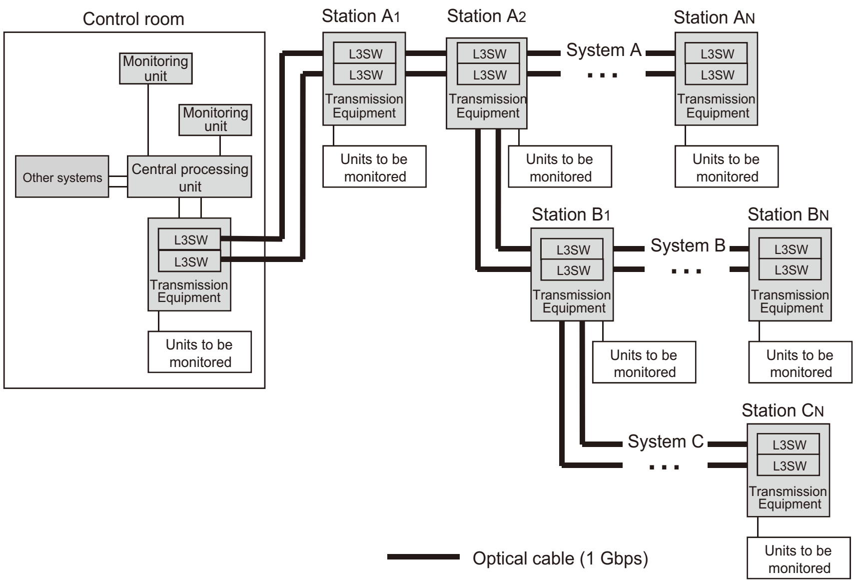

Fig. CIC system diagram.

previous CMS system employed optical transmission devices for the data transmission path, and these devices were the ones that had to be monitored. Employing optical fiber for the data transmission path means that the network configuration does not have to employ a monitoring device, so that the outbound monitoring system can be implemented.

(2) The network employs a ring-type configuration with two systems that connects stations via optical fiber. This configuration prevents communication cutoff of the entire network due to a failure occurring at the L3SW.

(3) The L3SW mounted in the information data transmission unit employs a duplex configuration that allows the network to be supplied with power from different train stations. This arrangement avoids an entire network cutoff even when a single unit failure occurs or a power outage happens at a single station.

(4) In a case where an L3SW failure or optical fiber cutoff occurs, data transmission will be diverted to the detour path within a few seconds.

2.2 Hardware Configuration

2.2.1 Central Processing Unit

The central processing unit (**Photo1**), a major part of the entire system, employs fully duplex configuration so that hardware and software in both the actually running system and the backup system can be operated independently and concurrently. The transmitting information between these systems and the transmission equipment installed at each station are also independently operated. Moreover, in order to avoid system data mismatching, a mechanism is introduced to continually store information equally for both systems. A health check is exchanged between both systems so that if a malfunction occurs in the system that is actually running it is immediately switched to the backup system in order to continue operating the system without interruption. When adding new functions, software may be updated one at a time for each system, so that the system may be transferred without halting system operation.

Photo 1 Central processing unit.

2.2.2 Transmission Equipment

The transmission equipment system (**Photo 2**) installed at each station is connected with the various devices to be monitored. It collects alarm information from the monitored devices and outputs the relevant control signals to them. The transmission equipment handles various interfaces such as contact, analog, pulse, serial and Ethernet. It also performs real-time data transmission with the central processing unit, such as the collected alarm information and the control signals to the monitored devices, etc. In order to prevent data missing during these transmissions via the transmission path it employs a specific mechanism. Moreover, the processing section in the unit employs a duplex configuration that enables both systems to have the same information such as a log, setting data, etc. all of the time. Continuous health checks are also conducted in the processing section of both systems and automatic switching over to the backup system is carried out when any malfunction is detected.

The units for the information transmission system are housed in the type 1 and type 2 racks. The type 1 rack houses duplex common sections (L3SW connecting the process sections and network devices), and the type 2 rack houses the sections that mount various interfaces to connect the monitoring target devices. With the updated CIC system, connection with a monitoring target device via Ethernet becomes available, which was not possible with the CMS system. In considering future expandability, the unit is designed to be capable of mounting a large number of interfaces - 1,024 contact items, 8 analog items, 12 pulse items, 6 serial lines and 5 Ethernet systems.

2.2.3 Monitoring Control Terminal

The monitoring control terminal shown in **Photo 3** is operated by a command operator who sends control commands directly to the devices to be controlled and monitored. The terminal provides various functions to the operator. These include a real-time display of the information collected by the central processing unit, a function to search control operations and log information on work carried out by users on the devices to be monitored and controlled, displaying disaster prevention information charts, and so on.

The monitoring control terminal provides various screens that display information in different formats. This function will help a command operator to recognize intuitively a number of different alarms prepared for a huge number of monitored target units and to make a quick response. Terminals installed at the maintenance sites can also display similar information to that displayed on the ones at the control room. Checking alarms occurring at other locations and controlling other units is thereby available for the maintenance sites by connecting their units to the central processing unit via the CIC network.

2.3 Software Configuration

Java applications feature high versatility and expandability without dependence on hardware or OSs. Due to such characteristics, Java applications are employed for the central processing unit and the monitoring control terminal in order to provide a smooth software development environment. Linux which features favorable reliability and availability is therefore employed for the server OS installed in the central processing

Photo 2 Transmission equipment system.

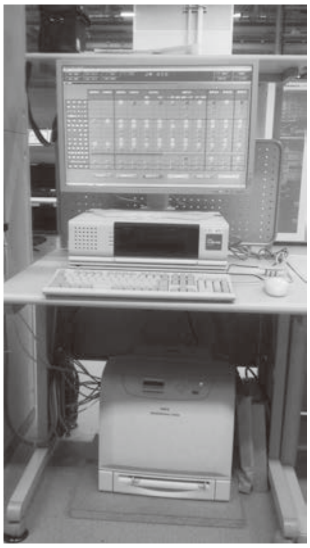

Photo 3 Monitoring control terminal.

Table Main monitoring target facilities with CIC.

Items	Monitoring facility
Traffic signals	Traffic signal facility
	Interlocking monitor
	ATC/Feeder section monitor
Communications	Train wireless facility
	Optical transmission unit, various communications facilities
	Facility to monitor devices along the railway
	Power supply unit
	IP network
Disaster detection	Anemometer
	Rain gauge
	Rail track thermometer
	Snow depth indicator
Linkage with other systems	Train operation control system
	Power management system

unit. Windows for the OS installed in the monitoring terminal due to its user-friendly usability. The transmission equipment is run via dedicated embedded software.

Alarm information and measured information for disaster prevention are collected by the CIC system and are merged at the central processing unit. The monitoring control terminal accesses the central processing unit in order to acquire required information in order for it to be displayed on its screen. Each time the monitoring control terminal is booted, it downloads the latest applications from the central processing unit so that it will not be necessary to update software when functions are upgraded.

2.4 Functions Overview

2.4.1 Monitoring Targeted Facilities

Major systems to be monitored and controlled with the CIC system are listed in **Table**. The CIC monitors and controls traffic signals and communications facilities located at Shinkansen stations and along the Shinkansen tracks, and also collects disaster related information such as wind speed, rain amount, rail track temperature, snow amount, etc. Moreover, the CIC is linked with other systems such as the train operation control system located at the control room. Therefore, the disaster related information detected by the CIC may also be used by the train operation management system for providing train control commands such as train speeds, etc.

2.4.2 Various Unique Screens with CIC System

The monitoring control terminal provides various screens that enable a command operator to understand the displayed information quickly and accurately. Examples of some of these screens are described below.

- **Matrix display screen**
  This screen is displayed as a start-up screen. Monitored target units and their locations are indicated with buttons on the matrix map. The buttons for the units for which an alarm is generated are turned on and the button's color will be changed so that the operator can confirm at a glance which monitored device has an issue. Each time the button is pressed, enables transit to a lower level screen, and eventually the screen that displays details of each of the monitored target units is reached.
- **Individual unit monitoring screen (system diagram display, table format display, etc.)**
  Various types of screen are provided such as a unit system diagram and a table displaying a list of related alarms, etc. These screens are created uniquely for each single unit to be monitored, so that operators may intuitively recognize a unit failure occurrence.
- **Chart display screen**
  This screen presents measured values in a chart format and displays disaster prevention information such as wind speed, rain amount, etc.
- **Log display screen/log search screen**
  This screen displays a list of the generated alarms in a timeline format. By narrowing down the listed data within various conditions, it is also possible to show other related alarm generation data in a timeline on this screen. Moreover, by clicking the item displayed with the log, the screen moves straight to the relevant individual monitoring screen. On the log search screen, targeted objects are searched by specifying various conditions in the alarm logs accumulated in the central processing unit.
- **Tree format display screen**
  In order to improve the accessibility of the detail screens, each of the monitored items from the different levels is displayed in a tree format. By clicking on a certain monitoring item in the tree format, the screen moves directly to the specified screen. When an alarm occurs, the color of the relevant item in the tree format will change so that the operator can quickly access the relevant detail screen.

3. System Function Tests and System Switchover

After installing the new system in the JR-East operations site, various function tests were conducted over about a year and a half. These function tests were conducted at night when the Shinkansen was not running. Contact point connections for the monitoring cables had to be changed so that monitoring operations could be performed with both the CMS and CIC systems operating in parallel. Various works were then carried out each night and the connection of serial LAN cables were changed from CMS to CIC. The connection points were checked and all of the connections were changed back to the original connections before the first train started in the morning.

After twice thoroughly performing these rehearsals in order to check work performance and contact procedures, etc., it was found that switching of the system from CMS to CIC could be achieved by approx. 300 staff; some allocated in the control room and some at various stations (forty-odd stations). This work was carried out during nigh and the available work time was for less than five hours. In such a tight schedule, connections of all units installed at each station were changed from CMS to CIC, as well as the cable connections for other systems being changed accordingly. Eventually, all of the work was completed and the facility monitoring operation using the CIC system was started the following morning.

4. Conclusion

When looking back to the time that preceded the introduction work, it took four years to complete the project of updating the Centralized Information Control (CIC) system for the entire Shinkansen network of JR-East. We would like to extend our gratitude to all of those people that were involved in the project, the staffs of the construction companies, the device and unit manufacturers and the entire staff of JR-East.

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