Features of the Next-Generation Traffic Control System as Seen in an Introductory Example at the Shin-Tomei Expressway

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Abstract

Traffic control systems are designed to manage highway traffic conditions in an integrated manner in order to assure safe, smooth, and comfortable traffic flow. Their aim is to effectively provide the collection and processing of traffic information as well as achieving prompt and accurate information provision. This paper discusses features of the next-generation traffic control system that has been prepared by NEC for the Shin-Tomei Expressway.

Keywords

ITS, traffic control system, big data, disaster recovery

1. Introduction

NEC's traffic control systems contribute to the safety, security, and comfort of highway drivers by providing them with roadway information. This service is achieved using variable message signs (VMSs) or other similar system, that are fed from sources that include roadside sensors and emergency telephones. Drivers are thereby kept connected to important instructions from the Expressway Control Center that uses large screens and various operation terminals.

The new system, installed at NEXCO Central's Tokyo control center, provides traffic information at speeds approaching real time by rapidly processing large volumes of data ("big data") collected from roadway sensors at approximately 1 minute intervals. This is roughly 5 times the frequency processed by existing systems. Moreover, IP networks efficiently transmit information from roadway sensors to the control center, where traffic conditions can be easily observed via large scale screens. Furthermore, this system is connected with both the Tomei and Chuo Expressway systems, which enables effective backup responses in the event of large scale emergencies (such as disaster recovery). This next-generation traffic control system offers support from developed technologies that lead the world.

2. Overview of the Traffic Control System Functions

The main functions of the highway traffic control system are as follows.

(1) Collection system function

Information on various traffic conditions is collected from terminals installed on highways such as vehicle detectors, meteorological station equipment, surveillance cameras, and emergency telephones. The collected information is then notified to the central processing and traffic control function.

(2) Central processing and traffic control function

Based on the traffic data received by the collection system function, various processes and treatments are performed in order to accomplish creation and management of details of the provided information. Additionally, road conditions are monitored by large scale screens installed at the traffic control center and events regarding accidents and traffic restrictions are entered from console desks. Past records of traffic conditions are also output by this function.

(3) Provision system function

Traffic information generated by the central processing

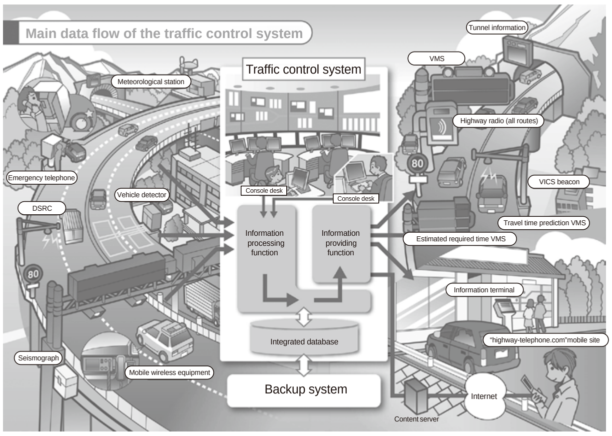

Fig. 1 Main data flow of the traffic control system.

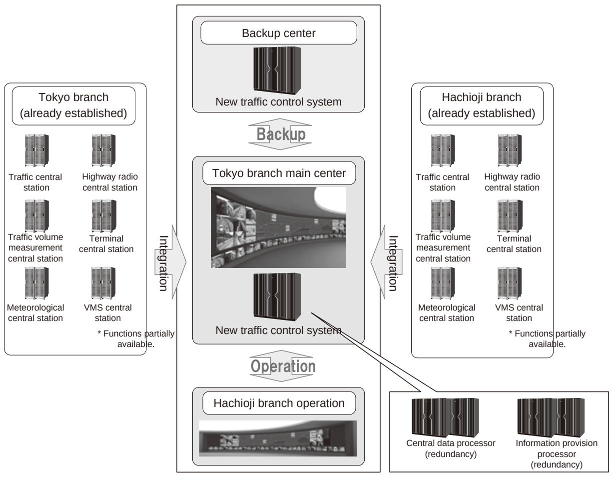

Fig. 2 Schematic diagram of the consolidation of equipment and functions.

and traffic control function is provided to motorists as appropriate. The provided media includes VMSs displaying characters and graphics and highway radio using audio, as well as information terminals installed at rest areas.

The main data flow of the traffic control system is shown in Fig. 1.

3. New Functions Added to the New System

The new traffic control system recently developed by NEC features functions that inform road managers and drivers of information in real time and more accurately while achieving increased energy-saving and space-saving properties compared to conventional systems. The system is also provided with functions that enable continuous operation even in a major disaster.

3.1 Achievement of Energy-saving and Space-saving Properties via Consolidation of Devices and Functions

Conventional traffic control systems are provided with a central processor that performs integrated management of data. Subsystems are also provided to deal with the collection and provision functions. These functions are built into the configuration that connects these subsystems. When we at NEC created this new system, we consolidated the system functions and equipment based on server (equipment) processing performance improvements while also reviewing the functions of each piece of equipment. Scrap-and-build measures were also reviewed. The result is a system that has achieved approximately 90% reduction in the server installation footprint and approximately 40% reduction in power consumption compared to conventional systems. A schematic diagram of the consolidation achieved for the equipment and its functions is shown in Fig. 2.

3.2 Achievement of Shorter Cycles of Information Update and Display

Vehicle detection at the Shin-Tomei Expressway is performed by the generation of data such as the number of travelling vehicles and their speeds based on images shot by roadside traffic counting devices installed at intervals of 2 km. The traffic control system provides the estimated required time and the congestion time based on this data. In case data acquisition is impossible for some reason, the system can continue data provision by performing spatial and temporal backup using the data obtained from adjacent traffic counting devices and the data from previous cycles. The number of connected terminals amounts to about 6,000 when the collection system equipment and the provision system equipment are combined. Thanks to the improvement in the performance of the servers that comprise the system, high-speed processing of large-volume data is now possible. As a result, the system has achieved the generation of traffic information in a manner that approaches real time by shortening the interval of data collection and update time from 5 minutes to 1 minute. In addition, information provision of abnormal actions such as driving on the wrong side and stopping in the middle of the road is also obtained based on the data from the traffic counting devices.

3.3 Construction of a High-Speed, High Reliability Communications Network for Roads

All 744 roadside access points feature emergency telephones and sensors and are equipped with a network access capability. These access points support the transition from existing metal lines to the IP's high speed optical lines, which connect networks to access point sensors and emergency telephones. As a result, emergency telephone calls and "big data" received from roadside sensors, such as traffic counting devices can be

Photo NEXCO Central's Tokyo Control Center.

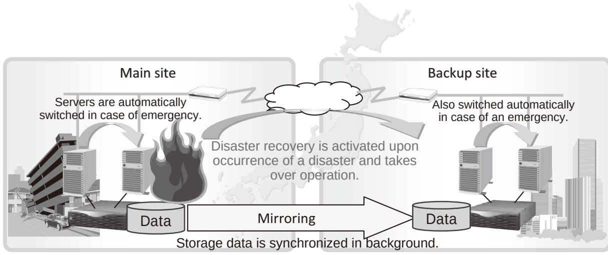

Fig. 3 Schematic diagram of disaster recovery system.

processed rapidly.

Ethernet ring protocol enables local networks that connect between access networks to maintain high-speed switching (within approximately 0.5 seconds) even when an optical fiber fails. Furthermore, a wide-area backup configuration utilizing trunk networks ensures that a highly reliable broadband network remains, regardless of road damage or other such issues.

3.4 Improved Visibility of Large Scale Displays

The roadway control center features large scale displays of 46 × 64 inches and 32 × 28 inches that allow the observation of current roadway conditions and enable staff to share and confirm traffic information (Photo) in real time. Use of LCD monitors with the world's slimmest-class bezel width helps achieve seamless screens while ensuring excellent visibility.

Even in maintenance procedures where a part replacement is required due to malfunction, the displays are so designed that only the operations of the sections subject to part replacement need to be stopped with a view to minimizing the area affected by the procedure.

3.5 Disaster Backup System

The backup sites for the traffic control systems of the Shin-Tomei, Tomei, and Chuo Expressways were built in remote locations.

Even if the main site becomes unusable as the result of a major disaster, the backup (disaster recovery) system enables continuous operation by connecting itself with roadside sensors and various other systems via networks built in a loop formation. It thereby also contributes to the establishment of new roles and values for highways as emergency networks if a major disaster should occur. Fig. 3 shows a schematic operations diagram of the disaster recovery function.

4. Patent-applied Technology for Future Applications

Improvement of server performance and consolidation of functions facilitate system coordination and the addition of functions that have been rather difficult conventionally. This section discusses future applications of our patent-applied technology with a view to solving problems that may arise when lane restrictions are enforced on highways.

The abrupt braking of drivers who have reached a lane restriction area that has been enforced due to road maintenance or cleanup after an accident often causes traffic congestion on highways. One of the measures adopted to eliminate or alleviate such congestion is to let the drivers know in advance where the lane restriction area is and how fast they should drive until they reach that area so that they may continue to drive while slowing down gradually.

Variable-type speed regulation displays are installed on the roads to notify the imposed speed limits to motorists on the highway.

Nevertheless, the conventional speed limit information using variable-type speed regulation displays is zone-dependent (limited variable numbers) and is therefore restricted in its provisions at intermittent intervals. In other words, the present situation is that it is not a system that can vary speed limits in fine increments according to the traffic flow conditions.

As one of the measures designed to improve the above-mentioned current condition, our technology (patent application filing no. 2012-281897*1) is expected to eliminate the cause of traffic congestion by setting and providing speed limits until the lane restriction area at continuous values. These limits are based on the traffic densities in the lane restriction area and its vicinity, as calculated from the traffic volume data collected in real time, thereby helping the drivers of the succeeding vehicles to brake less often (Fig. 4). Because this technology allows for precise operation by utilizing real-time traffic volume data, our proposed next-generation traffic control system using the "big data" processing technology is expected to be used for

*1 For reference: Only applicable in Japan.

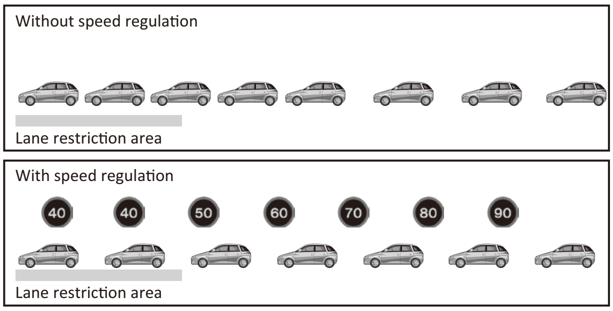

Fig. 4 Schematic diagram of traffic congestion elimination by speed regulation.

various applications.

5. Prospective Deployment to Overseas Markets

In Japan the construction of highway traffic control systems has been completed already. These systems are currently at the phase of maintenance and improvement. In the developing countries, especially those in Southeast Asia, projects to manage traffic flow by building highways and using traffic control systems as one of the measures to cope with increasing vehicle densities and to thereby eliminate chronic traffic congestion are now underway.

The functions of a traffic control system are classified into a collection system function, central processing function, traffic control function, and provision system function, and this framework is applicable to anywhere in the world. Therefore, we believe that the experience and technological expertise that we have gained in Japan can be suitably utilized in overseas markets. Currently, we are planning deployment to overseas markets by packaging the minimum functions required for traffic control. The product is aimed at achieving low cost and short delivery time while offering a solution that enables the easy addition of functions according to the needs of each customer as an option.

(1) For areas where highways will be newly built

We will propose a traffic volume measurement function that measures traffic volumes of existing roads to help draft the plans of the highway, as well as part of the traffic control function for monitoring the measured conditions. When the highway is completed, we will support development of an advanced traffic system for the area by improving the traffic control function.

(2) For areas where services need to be improved as toll roads

We propose a system that can provide motorists with information using console desks at which the road managers can enter information regarding accidents and traffic restrictions and by using VMSs. This will be followed by a step-by-step approach in which services will be improved by installing collection system terminals and providing information using dynamic data from the terminals.

(3) For areas where there is no electronic toll collection system at toll gates

In Japan, the usage rate of the electronic toll collection system (ETC) is nearly 90%, helping thereby to alleviate traffic congestion at entrances and exits of toll roads. However, in areas where the electronic toll collection system and similar technologies have not been popularized, occurrence of traffic congestion at entrances and exits of toll roads caused by payment of tolls is likely. We now propose the building of VMSs that show the estimated time required to pass the congested sections near the entrances and exits with a view to reducing the stress on the motorists driving near to these locations. The areas where information is collected and provided will be restricted in order to achieve a small-scale system and low cost.

6. Conclusion

In this paper, we discussed features of the next-generation traffic control systems.

We believe that every detail of the functions we are now able to deliver will become indispensable in the context of projected conditions that will require more and more information and better-equipped services. Having previously built various systems supporting road enterprises, we at NEC will confidently continue to assess customer needs and make every effort to propose and deploy next-generation traffic control systems, both in Japan and overseas.

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