Development of Advanced Train Information Service System (ATISS)

Mayumi Korekoda*, Hiroshi Abiko* and Mitsuyuki Osawa*

In an AC Train (Advanced Commuter Train) having been developed to create a suburban commuter train meeting 21st-century requirements, we have developed an advanced train information service system as part of our effort for improving passenger services. This system allows the on-board information contents, Internet and mail services to be provided through the train LAN equipped with a means of communication with the wayside equipment. The system manufactured in a prototype production has been put to a basic evaluation test on the transmission of data over the train's LAN and communication between the wayside equipment and on-board equipment. In this development, we have built a train LAN that serves as an information platform applicable to various on-board information services.

● Keyword : AC Train, On-board information service, Internet, Ethernet, TCP/IP

1 Introduction

JR East has been making efforts to develop the AC Train (Advanced Commuter Train) with the aim that this shall become the suburban commuter train meeting 21st-century requirements. A prototype car (Series E993) has been built, and is now being put to a running test. The major of development concepts of the AC Train are "improvement of passenger services", "improvement of transportation reliability", "cost reduction", "barrier-free design" and "ecology". As part of the "improvement of passenger services", one of the AC Train development concepts, we have developed an Advanced Train Information Service System (ATISS).

Amid the rapid progress in information technologies, passenger requirements for a higher level of on-board information are considered to be diversified and complicated. The final goal of the ATISS is to provide the information required by the passenger at any place and at any time. The AC Train is a suburban commuter train. In the development of an information service system, however, we determined to study the information service system for the limited express trains as well, without our goal being restricted to the suburban commuter train alone. Of the prototype cars, part of car No. 5 is used as a test area of the commuter train, while car No. 4 where limited express train seats are arranged is employed as a limited express train service test area. Under this condition, we planned to create an information service platform for the train.

2 System overview

Fig. 1 shows the system overview. The system comprises an on-board LAN portion (inter-car transmission) as the basis of the system, and an on-board LAN portion (intra-car transmission) connected with various types of equipment for providing services. This system ensures both reliability and operational ease by using the TCP/IP and Ethernet technologies with consideration given to working conditions specific to the railway rolling stock including vibration, temperature and humidity. The following describes the system characteristics and major equipment:

2.1 Train LAN

As an inter-car information transmission controller, a WMS (Web & Media Server) is installed in cars No. 1, 4 and 5, and WMS relay equipment is mounted in cars No. 2 and 3. The WMS equipment has a function for communication with wayside equipment in car No. 1, in addition to video information storage and distribution functions, and web information storage and distribution functions.

The inter-car transmission control is designed to achieve a high degree of reliability, economy and efficiency. The following describes the characteristics.

(1) High speed characteristic

This system uses a twisted pair cable for the car and a jumper cable

*Advanced Railway System Development Center, Research and Development Center of JR East Group

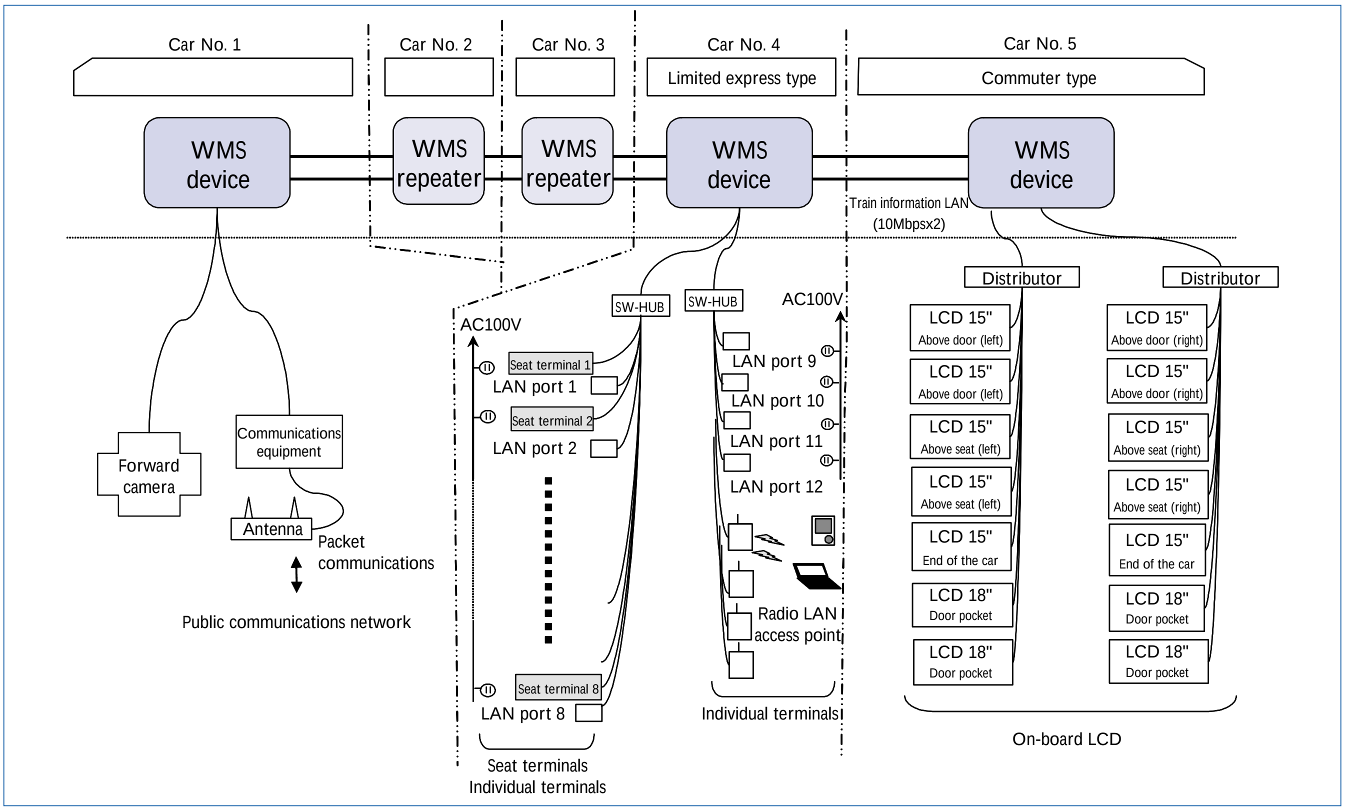

Fig. 1 General View of ATISS

for inter-car, and realizes the high-speed inter-car transmission of 20 Mbps (10 Mbps x 2 systems). Further, a circuitous path is established by forming a two-system transmission path when trouble has occurred. This reduces the impact of the trouble.

(2) Decentralized server

When the server is designed in a decentralized configuration where the server is mounted in each car, the load of inter-car transmission can be reduced and different services can be provided to each car. Further, even when the server is out of order, the impact on the entire system will be smaller than that of the centralized server.

(3) Control system with consideration given to reliability and efficiency

The WMS equipment and repeater are not designed simply to send data. They check the data and transmit only the normal data, thereby ensuring efficient control without excess load being applied to the transmission path. In addition, the control system ensures that one problem will not cause the entire system to break down. Further, it is easy to identify the faulty equipment, and the control system allows multiple nodes to carry out simultaneous data transmission.

2.2 LAN for each car

For transmission of information between various on-board devices, system connectability and extensibility are achieved by Ethernet and TCP/IP compatibility. The WMS equipment is connected to other on-board equipment through the Ethernet. Since an OS compatible with TCP/IP and other protocols is adopted, any special transmission control procedure for the connection with other equipment is not required. Accordingly, when a PC is connected to this system, the same steps as those normal for Internet and TCP/IP LAN can be taken, without having to give consideration to the on-board LAN. This demonstrates the excellent connectivity of this system. This means that the passengers can use the same operation procedures as those for normal PC operation. Further, system expansion is very easy when a new device is added to the system.

The following describes the major devices to be connected to the on-board LAN (Fig. 2). Table 2 shows the services to be provided by their use.

(1) Communication device

Car No. 1 is provided with radio equipment for communication with the wayside equipment. Multiple methods have been tested for communications between the radio equipment and car.

(2) On-board LCDs

In car No. 5, 15-inch liquid crystal displays are installed above the doors, above the seats and at the ends of a car, and 18-inch LCDs are

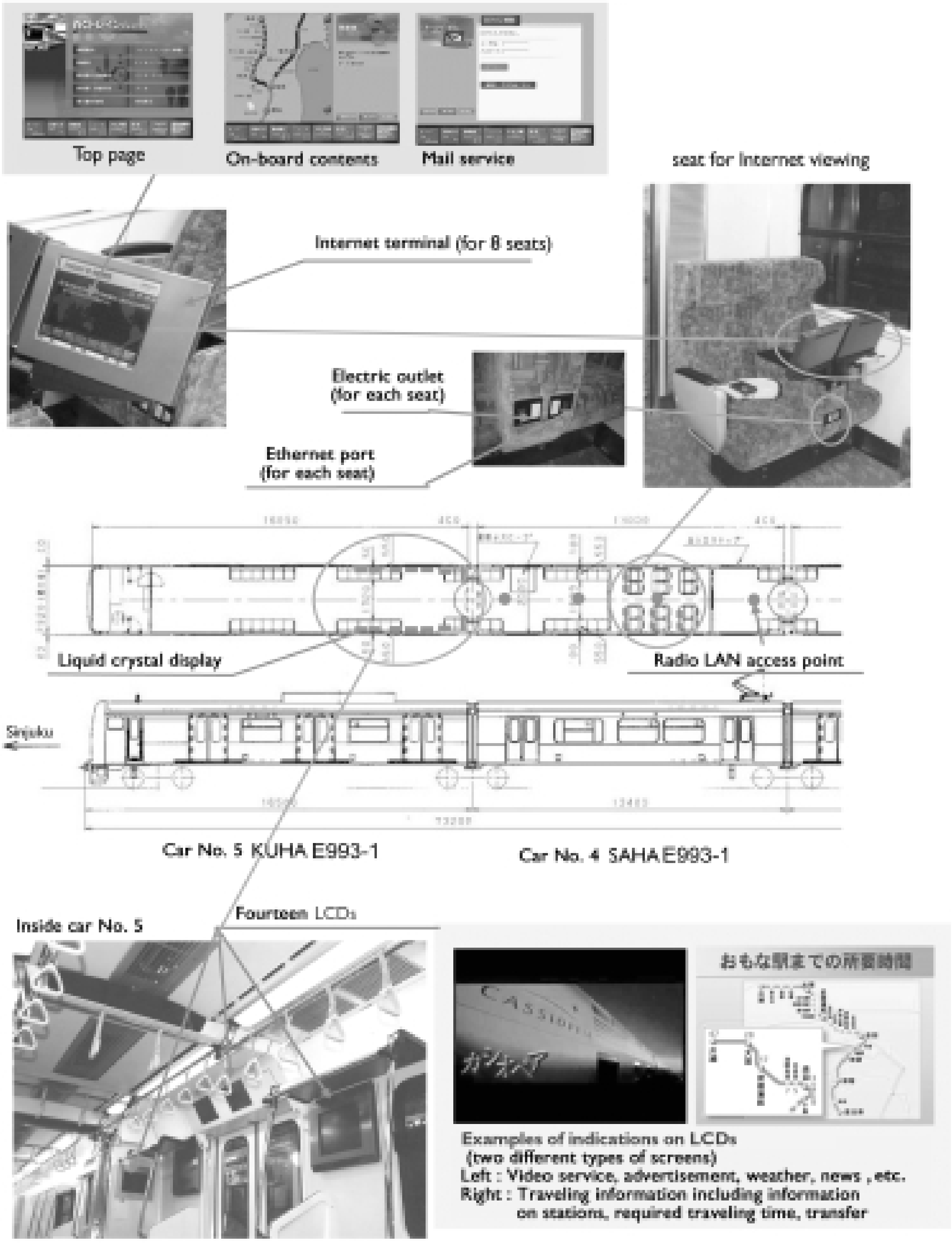

Fig. 2 On-board facilities and services

Table 1 Overview of services in AC Train

Services	Overview	Features	Operation			
			Seat-specific terminal	Carry-on PC (wired)	Carry-on PC (wireless LAN)	On-board LCD
E-Mail service	E-mail transmission and reception services are provided by obtaining the account from the terminal equipment on car No. 4	- A web-mail system that can be used without having to install mail software packages. - An improved method for getting mail into the car to ensure good response for passengers.	○	○	○	—
Internet service	Provides access to on-board web content and external Internet websites. Transmission and reception of ISP mail	- For connecting externally to the Internet, a proxy server was installed to reduce the communications load between the on-board equipment and wayside equipment and to improve the response. - ISP mail may not be sent or received, depending on the provider.	○	○	○	—
Video service	Provides moving image content and moving image content filmed by the forward camera.	- To meet the requirements of subsequent digitization, digital data is sent and received by the train LAN using the same twisted pair cable as that of other data. (Inter-car transmission of video images has so far been made in analog mode using a coaxial cable)	○	○	○	○
Message from wayside equipment	Real-time display of the message sent from the wayside equipment, including information on train service.	- Provides real-time information	○	—	—	○

mounted on the door pockets. Moving images, still picture and text information can be provided on these LCDs. Two different types of display can be provided; for example, text information can be indicated on the right of the two displays arranged in parallel, and video information can be indicated on the left.

The visibility has been improved by increasing the screen size over that of the VIS (Visual Information System) introduced into a new car (Series E231) on the Yamanote Line. Further, all display data is digital to meet the subsequent requirements for digitalization.

(3) Seat-specific terminal

Seat-specific terminals are installed on some of the limited express seats. These terminals allow transmission and reception of E-mail, linkage to the Internet and browsing of on-board content. The basic operation is performed by touch panel. The terminals are also provided with a text input device for entry of E-mail. Further, they permit connection of a mouse or keyboard to the USB port, and allow text to be entered via the infrared ray port using the pad function of a cellular phone. In this way, the seat-specific terminal is characterized by diversified entry methods.

(4) LAN connection port and power outlet

All the limited express seats of car No. 4 are provided with a LAN port and power outlet. A LAN-compatible PC can be connected via the Ethernet cable, and the same services as those of the seat-specific terminal can be provided. Further, the power outlet is also provided to supply electric power to the PC.

(5) Radio LAN access point

The access point of the radio LAN (IEEE802.11b) is installed on the ceiling of car No. 4. The radio LAN-compatible PC and PDA can also provide the same services as those of the seat-specific terminal.

3 Test and evaluation

The system prototype has been put to the test for evaluation of performance and functions both on a test bench and mounted aboard the prototype car.

(1) Train LAN (inter-car communications) evaluation test

Transmission waveforms and transmission errors were measured while the system was on the bench test and aboard the car.

In the bench test, an actual cable was utilized to measure waveforms in a configuration simulating the inter-car jumper cables using an unshielded single line. No transmission error was observed and there was no problem with the level of received waveforms (Fig. 3).

Further, using the same configuration, a 2000-volt, 1-microsecond noise was applied to measure the waveform. No error was observed and there was no problem with the level of the received waveform.

In the prototype car, transmitted waveforms were measured both when the train was stopped and while running. No error was observed and there was no problem with the level of the received waveform.

The test verified that the train LAN ensures a stable transmission even under the conditions where noise was applied and while the car was in motion.

We also measured the transmission speed of the main LAN. The transmission speed very close to the theoretical value was obtained (about 13 Mbps) with consideration given to the processing speed of the WMS equipment and influence of the data header, etc.

(2) Communications between wayside equipment and on-board equipment

In the running test section (between Kawagoe and Akabane), a communications evaluation test was conducted using two types of means for communications.

To examine each radio connectivity and transmission speed, 500 byte messages were sent from the wayside equipment to the on-board communications server at specified intervals, and were received by the on-board equipment. The response messages of the same magnitude (500 bytes) were returned to the wayside equipment, and the measurements were recorded.

Table 2 shows the number of messages sent, number of messages returned and percentage of response. Lost response messages occurred mainly in the underground section. The transmission speed of communication A1) was about 2.2 kbps.

In this test, connectivity of communication A was stable, except for the underground section. For communication B [2], response time

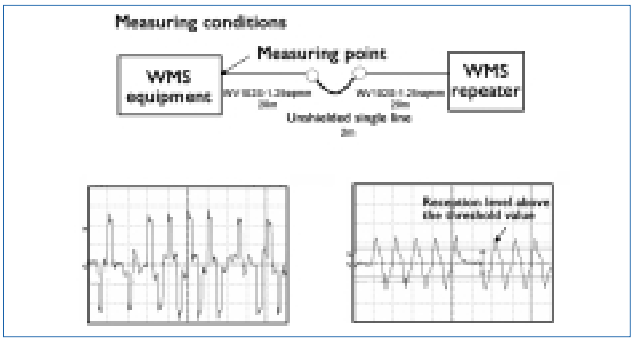

Fig. 3 Transmitted and received waveform in bench test

Table 2 Results of measurements for state of reception

	Communication A (outdoor antenna)	Communication A (outdoor antenna)	Communication B (outdoor antenna)
Number of transmitted messages	1795	1795	2335
Number of transmitted messages	1758	1024	837
Response (%)	97.9%	57.0%	35.8%

was about 0.5 seconds on average when only the connected time was taken into account. However, connection was not possible for a considerable period of time. In this test, stable connection was ensured for communication A, but not for communication B.

(3) Service system evaluation test

We measured the response speed of each operation in mail services and Internet connection. The response time of various operations requiring communications with the wayside equipment ranged from a few tens of seconds to a few minutes. In this test, the speed was not sufficient to provide the user with operating comfort.

We have established a unique mail service system with consideration given to the small size communication volume between on-board equipment and the wayside equipment, resulting in improved responses from passengers.

4 Conclusion and subsequent objectives

In this development project, we have established an on-board LAN serving as an information platform applicable to a great variety of information services provided in the train. Evaluation of this system is still going on using the prototype car.

The following two matters can be enumerated as our major challenge of the future:

(1) Communications between wayside equipment and on-board equipment

We have evaluated communications between wayside equipment and on-board equipment according to two communication methods. Nearly stable connection has been obtained for communication A except for the underground section. For communication B, however, the communications infrastructure is not yet sufficient as compared to that for communication A, and stable connection could not verified in this test.

At present, the response of the Internet services using the communication between the wayside equipment and on-board equipment largely depends on the transmission speed between the wayside equipment and on-board equipment. This transmission speed is not considered to be high in the present phase. Users do not feel comfortable in using this system.

Fig. 4 Communications test utilizing a satellite (rooftop of car No. 1)

We are planning to test the communication between the wayside equipment and on-board equipment, using various communication systems, with consideration given to the subsequent technological trends. We have used a communications satellite to test communications between the wayside equipment and on-board equipment as one of the concrete communication methods (Fig. 4).

Giving consideration to the transmission speed at the present phase, it is necessary to find a means for reducing the communications stress by improving the measures for minimizing the communications load between the wayside equipment and on-board equipment, and by appropriately modifying the on-board information storage method and operation methods of restricting the browsing services, etc.

(2) Diversified methods for providing information

To meet the diversified requirements of the passengers, it is necessary to provide adequate information in conformity to the type of information to be provided and the situation where it is used. To achieve this, we assume various connection methods including the equipment installed on the car, and the hard-wired and radio equipment to be used as a medium for providing information, and are conducting tests to examine the requirements for using the radio LAN in the train.

Through these studies. we will continue our development efforts to create an easier to use system.

References:

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[1] Communication A: Packet communication (9.6 kbps) by cellular phone
[2] Communication B: Packet communication (384 kbps) by a third-generation cellular phone