Featured Articles

Development of On-board Passenger Information Display

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OVERVIEW: Advances in ICT and display panels in recent years have led to on-board passenger information displays becoming commonplace on commuter trains. Hitachi commenced serious development in 2006 with the development of an on-board passenger information display based on the concept of experience design from a user's perspective and achieving a high level of equipment utilization by adopting the autonomous decentralized architecture that was already being used for our traffic management systems. This involved performing information design (visibility and intelligibility) for the passenger information display to suit the diverse variety of people who ride on commuter trains. Hitachi adopted open system interfaces and software to implement the functions of a total system (including both on-board and wayside systems) that would be able to grow over time without becoming obsolete.

INTRODUCTION

PASSENGER information displays have become a common sight in railway stations and trains in recent years. On trains, in particular, there is growing use of liquid crystal displays (LCDs) to present information. Hitachi has developed on-board passenger information displays based on the concept of formatting the information that train users need in order to get to their destinations in ways that suit their needs, and displaying the destination, service type, next station, current time, and other details so that they can make the journey with confidence, safety, comfort, and convenience.

ARCHITECTURE OF HITACHI'S ON-BOARD PASSENGER INFORMATION DISPLAY SYSTEM

Hitachi has always adopted autonomous and decentralized architecture for our railway applications (particularly traffic management systems), with open interfaces and software used to implement the functions of a total system that can grow over time without becoming obsolete. While this autonomous decentralized design provides excellent reliability with a very high degree of redundancy due to each device that has its own central processing unit (CPU), the disadvantage of every device having a CPU is higher cost. Nevertheless, Hitachi has decided to use an autonomous decentralized design for on-board passenger information display systems, considering it to be the best architecture given the advances in technology that have reduced the size and price of CPUs, and taking account of factors such as the difficult environment for the distribution of video signal around a train, issues with noise, future requirements for higher definition video reproduction, and ease of maintenance.

System Configuration

The autonomous decentralized system consists of a host system, client units, smart LCD display units, and an on-board Worldwide Interoperability for Microwave Access (WiMAX[*1]) unit for communicating with the wayside system. Fig. 1 shows the system block diagram.

Host System

Each train has a single host system with two main functions. The first is to receive advertising contents from the wayside system via the on-board WiMAX unit. The second is to store content data that will be required by client devices in the event they fail. Fig. 2 shows the host system hardware.

The host system communicates with the wayside system via the on-board WiMAX unit to download schedules and content data. The use of WiMAX allows communications to occur over a wide area and at high speed, whether the train is moving or stopped.

*1 WiMAX is a trademark or registered trademark of the WiMAX Forum.

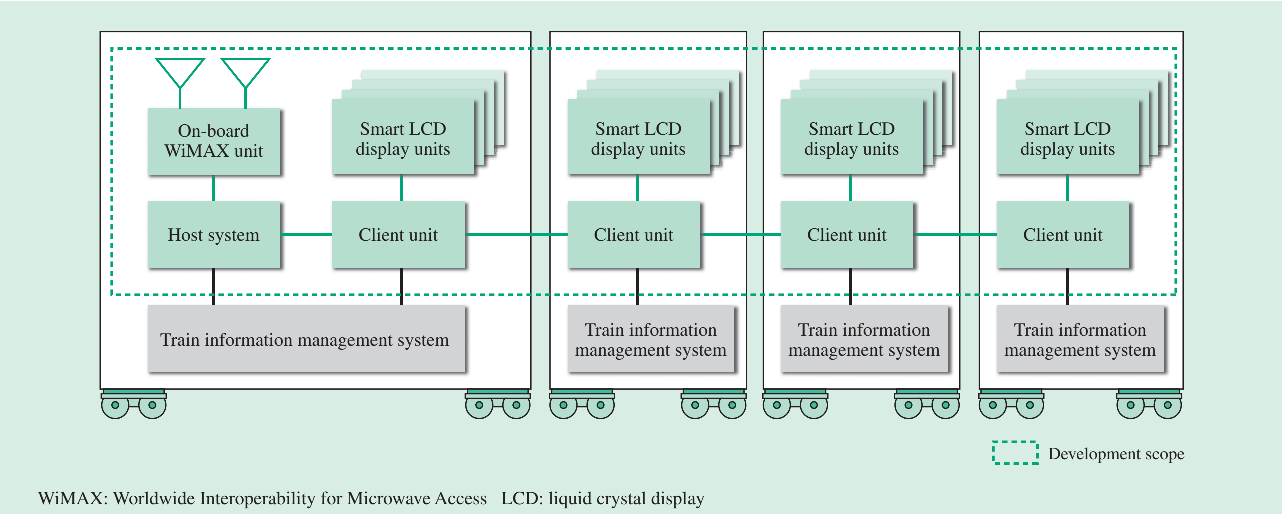

Fig. 1—Block Diagram of On-board Passenger Information Display System.
The on-board passenger information display consists of a host system, client units, smart LCD display units, and on-board WiMAX unit.

Compared with the previous use of wireless local area networks (LANs), millimeter-band radio, and other wireless systems that worked in only particular locations, this has considerably reduced the time taken to complete the distribution of a new update. Also, content can be updated even when the train is at the depot as long as it is within the WiMAX radio coverage area. Content updating is fast and efficient. Even if communication is interrupted during a download, the download will restart from where it left off once communication is restored.

Fig. 2—Host System.
The host system receives display information from the wayside system, and stores and forwards it to the client units.

Furthermore, if a client unit or LCD display unit managed by the host system develops a fault, its data can be resent by the host system without downloading the data again from the wayside system. If the client unit in car number 6, for example, has a fault, the faulty unit can be identified from the train information management system screen and replaced with a spare. However, the replacement unit will not have the correct Internet protocol (IP) address, passenger information display settings, advertising content, and schedule data. For a technician to set this information, it would require specialist knowledge and it would take the technician time to perform the required operations. Instead, the host system has a function for automatically transmitting these settings and other data. When a unit is initialized from the train information management system screen, the system automatically identifies where each device is installed and sets the IP address accordingly. That is, the replaced client unit is detected as being in car 6 and the host system sends it the content data it requires. This improves maintenance productivity because it simplifies the job of the technician replacing the faulty unit and prevents problems due to incorrect settings and so on.

Client Unit

Each car has a single client unit with three main functions. The first is to receive advertising content from the host system and forward it to the LCD display units. The second is to store the required content data in the event that an LCD display unit fails (similar to the equivalent function on the host system). The third is to distribute the service information it receives from the train information management system, such as the train's current position and any delays. Fig. 3 shows the client unit hardware.

The purpose of the client unit is to communicate with the host system and transmit large amounts of advertising content to the LCD display units quickly and efficiently. Because it is based on an autonomous decentralized architecture, configuring the system requires that content is transmitted to multiple LCD display units at high speed. This is achieved by using middleware developed for traffic management systems.

As on the host system, the function for distributing content in the event of a fault handles the case when any of the connected LCD display units are out of service. Passenger information is sent to passenger information LCDs and advertising to advertising LCDs.

Fig. 3—Client Unit.
The client unit receives display information from the host system, and stores and forwards it to the displays.

Smart LCD Display Unit

The LCD display units used in the autonomous decentralized system have three features. The first is that faults are prevented from affecting other devices, the second is that they are designed to facilitate installation and maintenance, and the third is safety and security. Fig. 4 shows a photograph of an LCD display unit.

An advantage of the autonomous decentralized design is that, if a fault occurs on one LCD display unit, the others will continue to operate. While this requires radial connections for the client units, to reduce rolling stock weight and simplify installation, Hitachi incorporated a hub into the LCD display unit to allow cascade connections. Internally, each LCD display unit consists of this hub, a CPU and auxiliary memory. In addition to using a small embedded CPU with advanced functions, Hitachi used a sophisticated structural design to combine high performance with low power consumption and heat generation in a sealed, fanless housing. The compact flash (CF) card used for the auxiliary memory has a large capacity and is tolerant of sudden power disconnections. The ability to install LCD display units with a cascade wiring layout is made possible by designing the hub to be independent of whether the CPU is running, meaning that it can continue to operate even if the CPU is down.

Because the autonomous decentralized design means storing passenger information or advertising content on each of the LCD display units, they need to be installed at three particular locations in the car, namely, on each side for passenger information and in a space for advertising. Because 16 LCD display units need to be installed in each car, this poses the problem of additional work to identify the intended location of each LCD display unit and to determine which one goes where during installation. To overcome this and allow any LCD display unit to be installed at any location, Hitachi developed a technique that allows them to be installed without any settings or pre-loaded passenger information data and advertising content, and then to specify their location and download content data automatically after installation is completed.

LCD display units are installed above the doors where they will catch the attention of passengers. This means that the surfaces of the panels are in easy reach of passengers and there is a potential for vandalism. Accordingly, they are protected by polycarbonate or laminated glass. The polycarbonate used is one that has been demonstrated, from experience with subway fires overseas, to be nonflammable and does not release drops when melting. Similarly, the laminated glass has excellent strength and does not create flying shards in the event of breakage.

Fig. 4—Smart LCD Display Unit.
The display unit presents the service information and advertising content (video) that it receives from a client unit.

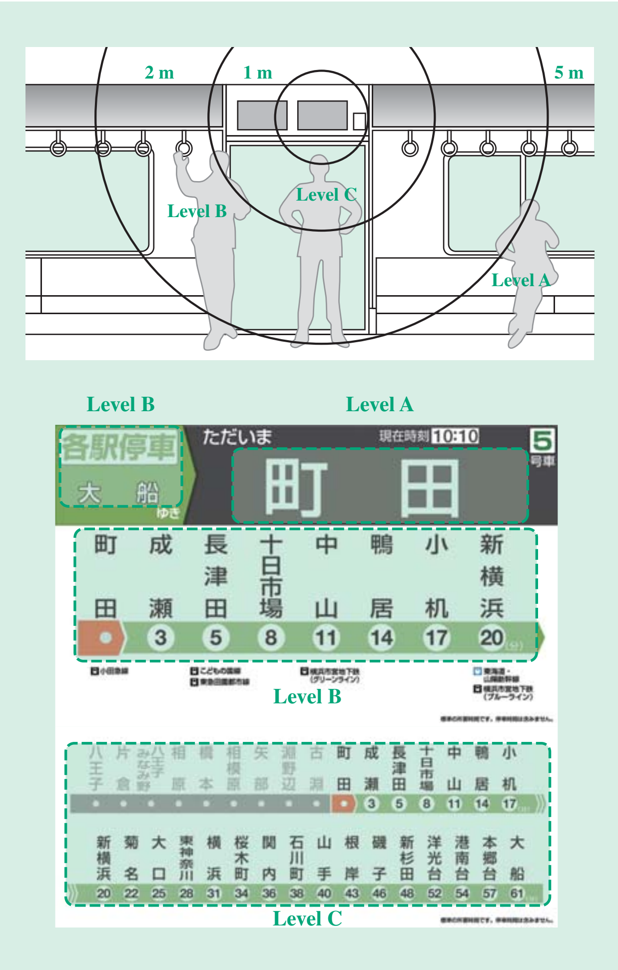

Fig. 5—Viewing Angle and Text Size.
The design divides the distance between the passenger and display unit into three ranges and uses a text size based on the priority of the information.

PASSENGER INFORMATION

The passenger information display uses both slide-show and object-based formats. The slide-show format involves the scheduled and sequential display of predefined images and therefore can be produced without a complicated program. The problem with this format, however, is the large volume of schedules and images required, which makes content production time-consuming and maintenance costly. This applies in particular to long or complex railway lines that have a number of different service types, or where trains are separated or coupled, for example.

The object-based display format, in contrast, requires a high-performance CPU, sophisticated middleware, and complex application programs. It also delivers better presentation and lower maintenance costs than the slide-show format, being able to display animated passenger information and allowing the consolidated management and modification of the associated symbols (images).

LCD display units support the object-based format to provide sophisticated display of passenger information with high visibility and intelligibility.

Universal design considerations are incorporated into the design of information for display on passenger information screens in three different ways. The first is the viewing angle and text size. Designs that can be read easily from any viewing location are achieved by dividing the distance between the passenger and LCD display unit into three ranges and selecting the text size based on the priority of the information to be conveyed (see Fig. 5). The second is the legibility and visibility of the text. The designs are required to have a contrast ratio between the character color and background color of 3:1 or better, with a target of 5:1, so that it is easy (for the elderly) to read the information. The third is to take account of the elderly and people with color-impaired vision*2. The designs avoid color combinations that people in this

*2 Meaning limited ability to distinguish between certain colors. Other terms include color-vision deficiency, color-blindness, and dyschromatopsia.

Fig. 6—Consideration for Elderly People and People with Color-impaired Vision.
Color displays are checked in black and white, and adjusted to use colors in ways that are easy for the elderly people and people with color-impaired vision to distinguish.

Fig. 7—Color Combinations that are Difficult to Distinguish for People with Color-impaired Vision (Examples of Color Combinations to Avoid).
The color combinations shown here are best avoided because they are difficult for people with color-impaired vision to distinguish. Their appearance differs depending on the type of impairment, with the examples shown here appearing as the same colors to people with red-green vision impairment.
If gray and blue-green are used to distinguish between buttons with different functions, for example, there may be people who cannot tell these colors apart. Likewise, some people may not be able to read blue-green text on a gray background.

latter group may find difficult to distinguish between. Because some people with color-impaired vision find it difficult to distinguish between red and green, for example, the designs clearly delineate these using techniques such as inserting a white border (see Fig. 6 and Fig. 7).

ADVERTISING

Although on-board passenger information display systems were first introduced at a time when television was still based on analog transmission, the original systems also supported widescreen content in anticipation of the shift to this format in conjunction with the switch to digital TV broadcasting. To meet diverse needs, an autonomous decentralized architecture was selected that supports multiple channels and high image quality.

The main functions required for displaying advertising are seamless video display, support for multiple formats, and high-speed content distribution. Here, seamless video display means a smooth transition from one item of content to the next. Support for multiple video formats means that the Hitachi system can play both Moving Picture Experts Group-2 (MPEG-2) and H.264 video format.

The on-board distribution function is particularly important when using an autonomous decentralized design. As described above, Hitachi uses distribution middleware to transmit content at high speed that proves its worth when updating content that requires realtime performance, such as news and weather reports.

ADVERTISING CONTENT DISTRIBUTION SYSTEM

The nature of advertising means that it requires not only the on-board systems, but also a wayside system for obtaining the advertising content and sending it to the correct trains. Because Hitachi has stipulated that its wayside system will use an open interface for communicating with trains, it can also be used to distribute content to on-board systems supplied by other vendors. Along with support for multiple lines, the same wayside system can also be used to distribute content to on-board passenger information display systems from different vendors on the same railway line. Furthermore, if an increase in the number of railway cars causes the wayside system to run short of resources, the use of cloud servers means that capacity can easily be upgraded.

CONCLUSIONS

This article has described newly developed on-board passenger information displays. These are being used to provide passengers with steadily improving services, with the on-board passenger information displays requiring advanced functions and ongoing development. In the future, Hitachi intends to continue developing better products in pursuit of security, safety, comfort, and convenience.

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