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Bus Location System for Shizuoka Railway

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Recent traffic jams caused by rapid increases of automobiles have lowered bus speed, making it difficult for buses to provide service punctually. In order to improve the convenience and reliability of public transportation, FUJITSU TEN, in cooperation with the Shizuoka Railway Co. Ltd., has recently developed a bus location system. To improve the quality of service and efficiency of operation, this system informs passengers at a bus stop of an approaching bus and gives instruction to the bus driver to assure punctuality.

This paper describes an outline of the bus location system, the configuration and the techniques.

1. Introduction

The rapid increase in motor vehicles in recent years has caused serious traffic congestion in cities. This has resulted in slower speeds for buses on their routes and has made it difficult for buses to be punctual. This has caused passengers to use other public transportation or cars rather than wait for buses that may not arrive on time.

Under these circumstances, bus passengers have decreased year by year. It is estimated that three percent of bus passengers quit bus transportation every year.

FUJITSU TEN developed and supplied a bus location system to Shizuoka Railway Co., Ltd. to cope with this situation. Operation of the bus location system started on June 15. This system is based on a brand-new idea to detect the current location of a bus from the distance the bus has run, which has never been applied in conventional bus location systems. This new design enables not only passengers but also operation administrators to be informed of various and accurate items of information.

This report describes the outline, functions, and technology of the new bus location system.

2. Background of system development

The bus transportation department of Shizuoka Railway Co., Ltd. has routes in many parts of the prefecture, centering on Shizuoka city. On its major routes in cities, particularly during commuting hours, traffic jams caused buses to run behind schedule or bunch together on the same route.

Under such conditions, passengers at a bus stop are impatient at the delay and the lack of information about the location of the next bus.

Shizuoka Railway Co., Ltd. decided to use the new bus location system to eliminate the source of irritation to passengers and improve service.

This bus location system aims at ① keeping the running cost as low as possible, ② eliminating special handling so the driver can devote himself to driving, and ③ making the system flexible and expansible.

The bus location system has the following features:

1) Reduced running cost due to the use of the wireless system
2) Distance detection system using running sensors
3) Nearly automated system operation in buses and base stations

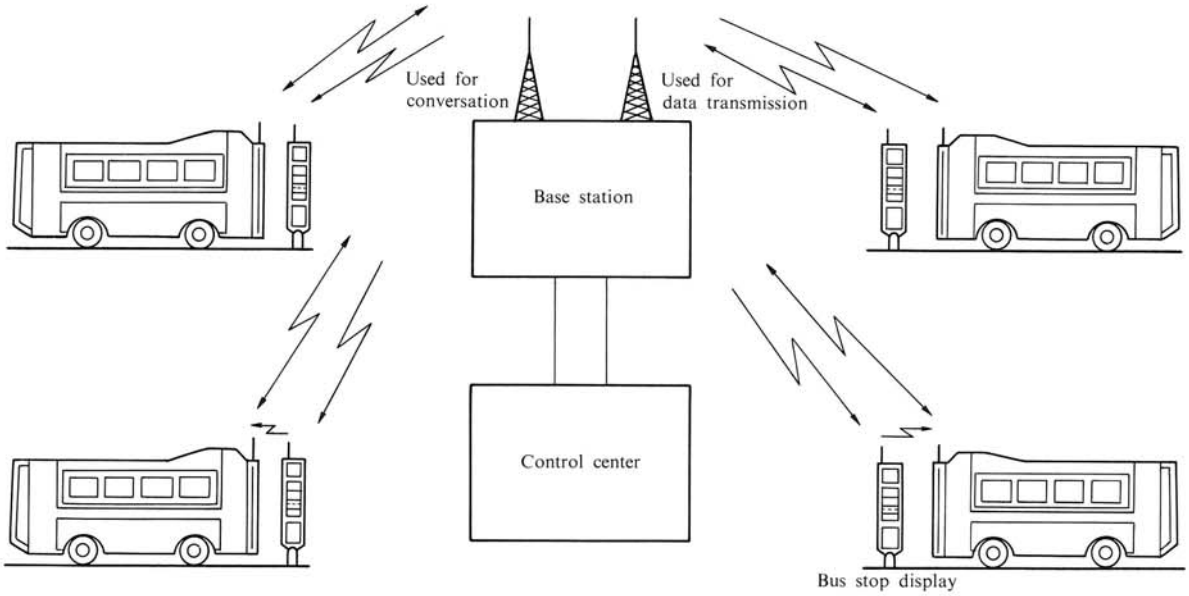

Figure 1. System outline

4) Integrated control of all operations at base stations for easy compliance with changing conditions

3. System outline

3.1 Outline

Figure 1 shows the outline of the bus location system. This system consists roughly of a base station, a control center, buses, and bus stop displays.

This section outlines the operation of facilities and equipment.

3.1.1 Base station and control center

The control center is located in the service office administering the routes on which the bus location system is used. The control center has the central processing unit (CPU) and a service control panel to display bus locations.

The base station has radio equipment that is connected via an NTT line with the CPU in the control center, for data communication.

Normally, the CPU operates automatically. Its operation is started and stopped by the control of an internal timer.

The CPU automatically starts the opening procedure at opening time and peripheral devices also start operation at the same time.

After that, the CPU performs polling via the radio equipment to collect bus location data. It performs the following control operations on the basis of the collected data.

1) The CPU displays bus locations on the location display panel.
2) The CPU controls the bus stop displays via radio and indicates control status on a CRT display.
3) If the distance between two buses running on the same route is less than the specified distance, the CPU informs both buses of the short distance.

As closing time, the CPU performs the closing procedure and stops operation.

3.1.2 Bus

Buses have a signal processing unit and an operation unit. The signal processing unit is connected with the signal lines from the running sensor and the destination indicator of the bus.

The bus driver has to execute the following to start the system devices in the bus.

1) The engine of the bus must be started. (The power of the devices is turned on.)
2) The destination indicator is set as usual.

Table 1. System specifications

1) Route name	Western loop line Line via Nakamachi and line via Komagata
2) Number of buses	15 (including reserve)
3) Number of bus stop displays	20 (including one unit which has displays for both lines)
4) Voice guide	At 5 bus stops (built in the bus stop display. One bus stop display gives voice guide for both lines.)
5) Distance correction function	At 8 bus stops (built in the bus stop display. Two bus stop displays have the distance correction function for both lines.)

Table 2. Data collection specifications

1) Communication method	Semi-duplex (Data collection and covnersation use different frequencies.)
2) Data collection method	Polling system
3) Signal format	1200 bps minimum shift keying (MSK) signal
4) Data format	BCH codes which can correct errors of up to 2 bits
5) Polling time	3 seconds The following processes are performed during that time. – Control of up to 24 bus stop displays – Control of up to 16 buses – Select call

3) When the bus arrives at the starting station, the devices start operation automatically and starts answering the polling.

As shown above, the operation performed by the bus driver is the same as usual.

After starting operation, the signal processing unit calculates running distances on the basis of the signals from the running sensor and returns response signals in synchronization with the polling signals from the base station. If the distance between buses is less than specified, a buzzer is operated by the control of the base station, and an indicator lamp blinks to notify the driver of the special condition.

When a signal is received from the distance correction equipment, the distance measurement error caused by traffic condition is corrected.

The procedure to end the operation of bus is as follows:

1) The destination indicator must be set to "FOR XXXX."
2) The system automatically stops operation when the bus arrives at the end point.

3.1.3. Bus stop display

A bus stop display has a data processing unit which controls lighting and indicator lamps and radio equipment. The bus stop displays at major bus stops have voice guide devices and equipment to correct bus running distance data.

The outline of bus stop display operation is as follows:

1) Opening procedure

When receiving the control signal for the opening procedure sent from the CPU in the control center, the bus stop display turns on the light and starts operation.

2) Operation

The bus stop display turns the approach-indication lamps on and off and gives voice guide to passengers according to the control data included in the polling signals from the base station.

The weak signal transmitter of the distance-data correction equipment keeps sending correction signals.

3) Closing procedure

When it receives the control signal from the base station for closing procedure, the bus stop display turns off the light and stops operation.

3.2 Specifications

Tables 1 and 2 list the specifications of this system.

3.3 Functions

This section explains the major functions of this system.

3.3.1. Control center

Figure 2 shows the CPU, CRT display, and keyboard installed in the control center. The function of the CPU are as follows:

Figure 2. CPU, CRT display, and keyboard

1) Location indicator panel control

Figure 3 shows the location indicator panel. The location indicator panel is divided into two sections: display by routes and display by buses.

The route display indicates bus locations with LED dots. The bus display indicates the location of each bus with a numeric value.

2) Bus stop display control

The CPU controls the approaching-bus indicator lamps on each bus stop display on the basis of the data collected from buses. At the same time, it indicates the control status of approaching-bus indicator lamps on all bus stop displays on the CRT screen. Figure 4 shows an example of the display on CRT screen.

3) Indication of out-of-service bus

The CPU indicates the buses that have finished the daily service or become out of service during operation with their bus numbers and time data on the CRT display.

4) Voice communication

The CPU enables the administrator to have voice communication with bus drivers. The method of voice communication is as follows:

① Individual call

Calls and communicates with the bus specified on the keyboard.

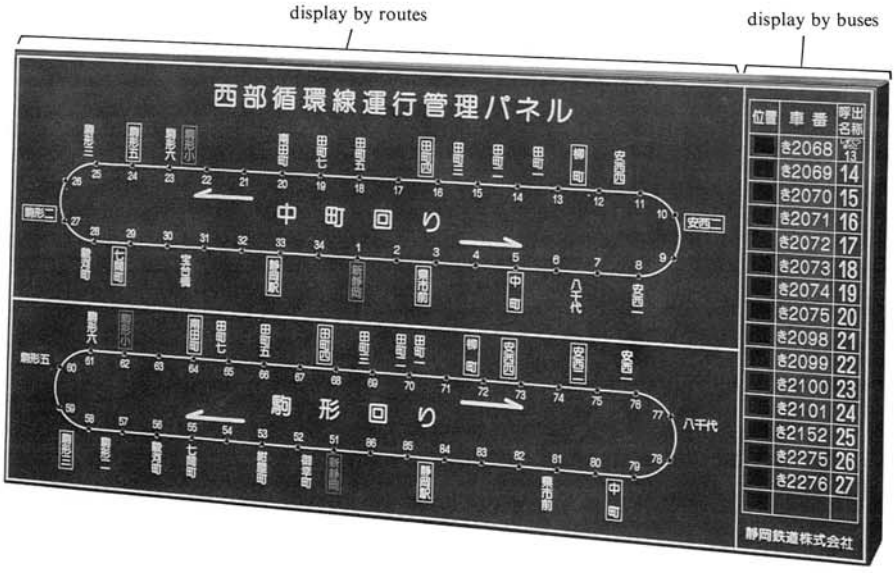

Figure 3. Location indicator panel

② General call

The keyboard is used to call and communicated with all buses.

③ Call request

When call is requested by a bus, its bus number is displayed in the CRT screen. Then, the bus is called from the control center for communication.

5) Maintenance

The CRT display can be switched to display the maintenance screen by using the keyboard, and various items of system data can be modified. Figure 5 shows an example of screen display.

The main contents that can be changed here are described below.

① Specification of the distance that determines the timing when the approaching-bus indicator lamps on the bus stop display are turned on

② The timer settings for opening and closing times for automatic operation

③ Setting of internal clock

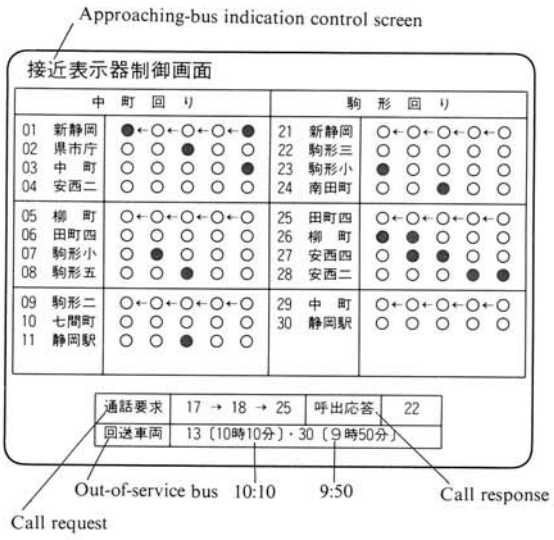

Figure 4. Example of approaching-bus indication screen

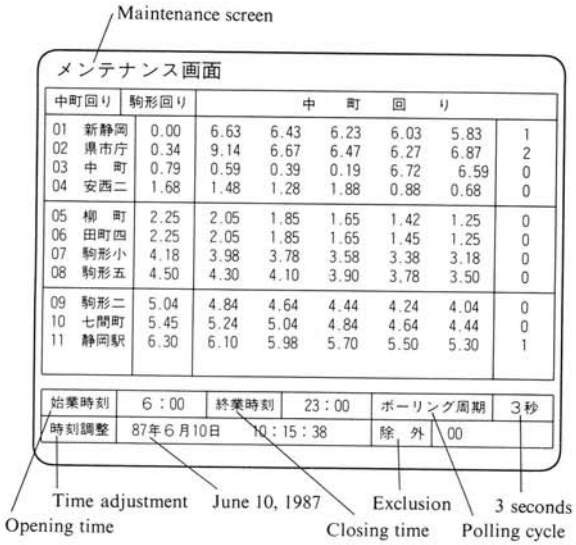

Figure 5. Example of maintenance screen

3.3.2. Bus

Figures 6 and 7 show the signal processing unit and the operation unit installed in a bus.

Figure 6. Bus equipment

Figure 7. Operation unit

1) Route setting

The route and line are set according to the signal from the destination indicator of the bus.

2) Distance correction

Among the bus stops where the bus stop displays incorporate distance-correction equipment, the bus stops at the start and end points of the route are called base points. Each time measured distance is automatically corrected at these base points, corresponding one of two lamps in the base-point switches on the operation unit light.

The distance can be corrected also by pressing the switches.

3) Bunch-up alarm

When buses are bunched up, the bus drivers are notified, by a lamp and buzzer, that the bus is too near the preceding bus or the bus behind is too near.

4) Disappear

This switch is used when the bus needs to disappear temporarily from the bus stop display, when, making a detour, for example.

5) Communication function

Voice communication between the bus and the control center is available. The bus is called by the control center or vice versa.

When voice communication starts, the radio automatically switches from the data channel to the communication channel. When communication is over, the channel is automatically reset to the data channel.

3.3.3 Bus stop display

Figure 8 shows the bus stop display.

1) Approaching-bus indication

Approach of buses is indicated by using five lamps. The approach conditions in up to three lines can be indicated at the same time.

2) Voice guidance

Voice guidance of up to eight seconds can be made by using a speech synthesizing unit. The guide can cover up to three lines.

3) Out-of-service indication

When the display cannot operate because of power failure, etc., the out-of-service indication is automatically displayed to inform passengers that the bus stop display is inoperative.

4) Test mode

Lamp operation and speech synthesizing unit operation can be checked by using internal switches.

Figure 8. Bus stop display

3.4 Features of the bus location system

Major features of this bus location system are listed below.

1) Radio system

Radio system is used to collect bus data and control bus stop displays. Consequently, system running cost is less than when data transmission is via NTT lines.

2) Travel distance detection system

Conventional bus location systems report current bus locations only in units of bus stops. The new system reports bus locations all along the route. For example, the control center can detect bus locations in units of 10 meters.

This system results in the following advantages.

① The timing for the approaching-bus indicator lamps on bus stop displays to light can be set in units of 10 meters. Therefore, the setting can be flexible according to traffic conditions.

② Because the distance between buses is known, bus bunch-up can be detected correctly.

However, measured distances may be in error

because of different bus types or traffic conditions. To solve this problem, error correction equipment using weak radio signals is installed in several bus stops.

3) Operability

As described in Section 3.1, normally, this system does not require special attention by the driver.

4) Approaching-bus indication

The bus stop display indicates bus-approach conditions with five lamps. Therefore, passengers at a bus stop know exactly where the approaching bus is.

Lamp on/off timing can be arbitrarily set by the CPU in the control center.

5) Polling system

This system uses a polling system to collect data from all buses accurately and effectively.

However, if the number of buses increases, the polling cycle must be long, resulting in low accuracy of collected data. To avoid this problem, this system sets a limit on the number of operating buses.

If data transmission speed and method are improved, this problem can be solved.

4. System configuration

4.1 Base station and control center configurations

Figure 9 shows the base station and control center configurations.

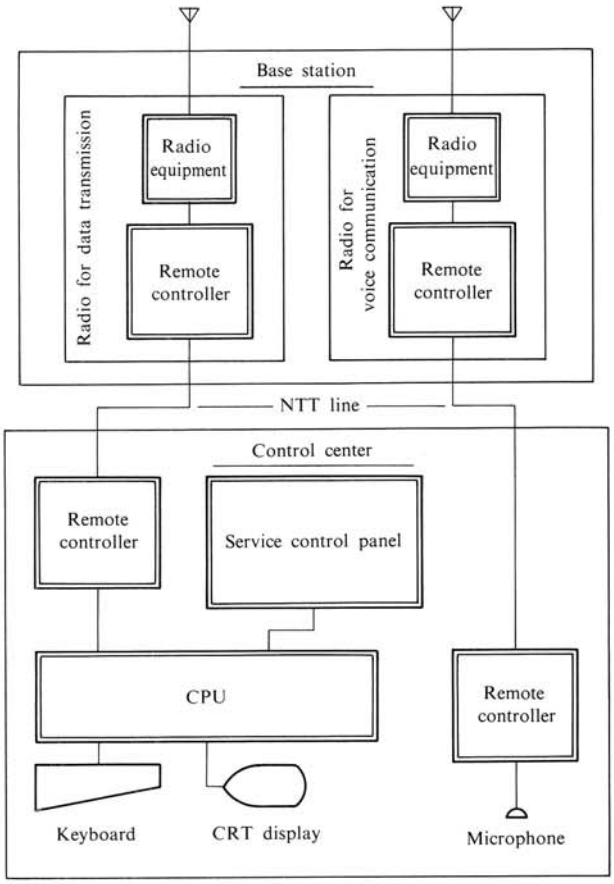

Figure 9. Base station and control center configurations

4.1.1 Base station facilities

Pairs of radio equipment and remote controller for data transmission and voice communication are installed. These facilities are connected to the equipment in the control center via remote controllers and NTT lines.

4.1.2 Control center facilities

1) Central processing unit (CPU)

The CPU incorporates a modem, a CRT display, a keyboard, and an RS-232C interface. It performs data processing and control, using an 8-bit microprocessor.

The CPU uses the modem to send and receive polling data and control signals via the remote controller.

The CPU also controls the service control panel via the RS-232C interface.

2) Service control panel

This panel uses LED dots and 7-segment LED indicators to display bus locations.

3) Remote controller for voice communication

The remote controller for voice communication controls the communication with buses via the radio for communication.

4.2 Bus equipment

Figure 10 shows the bus equipment configuration.

4.2.1 Signal processing unit

The signal processing unit incorporates radio equipment, a weak signal receiver, and a data processing unit.

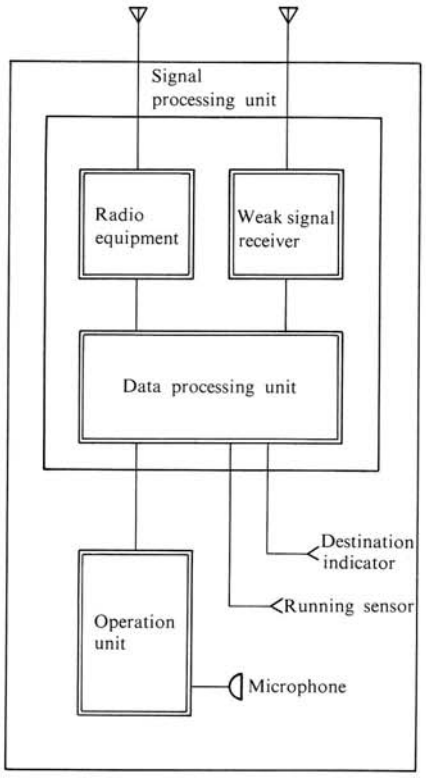

Figure 10. Bus equipment configuration

1) Data processing unit

The data processing unit has a modem and an I/O interface and is controlled by an 8-bit microprocessor and an 8k-byte ROM. It performs the following.

① Data communication with base station
② Weak signal processing for distance correction and the detection of start and end points
③ Processing of running sensor signals
④ Processing of destination indicator signals
⑤ Control of operation unit

2) Running sensor

The running sensor is connected to the speedometer cable in the bus and generates the signals corresponding to wheel rotation.

3) Destination indicator

Destination indicator signals are obtained from the controller of the motor-driven destination indicator on the bus. These signals are converted into route data in the CPU board.

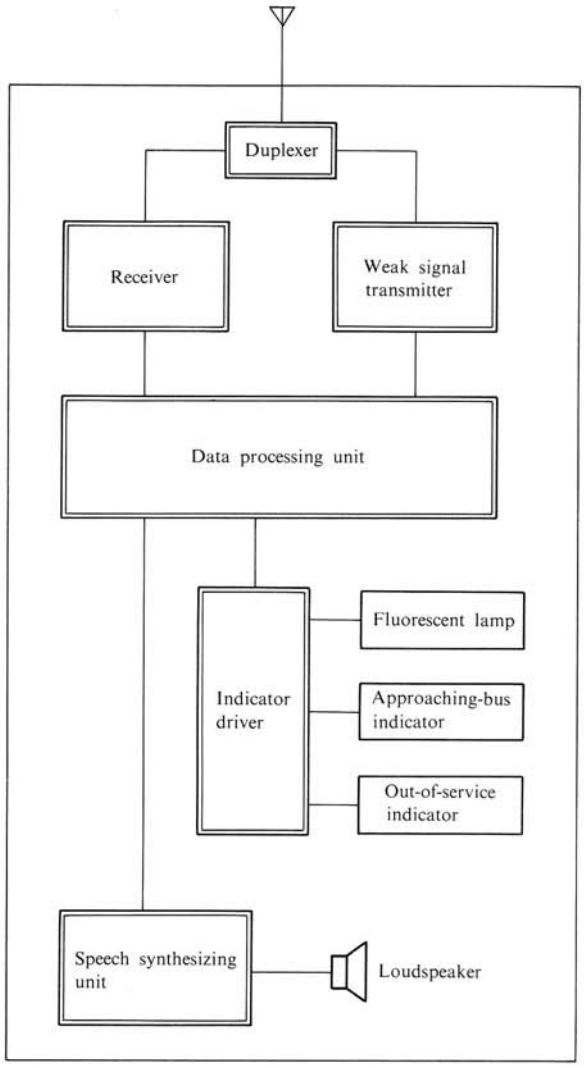

Figure 11. Bus stop display configuration

4.2.2 Operation unit

The operation unit has switches, lamps, a loudspeaker, a microphone, and a buzzer for the integrated control of indicators and operation in each bus.

4.3 Bus stop display

Figure 11 shows the bus stop display configuration.

1) Data processing unit

The data processing unit consists of an 8-bit processor, an 8K-byte ROM, an I/O interface, a modem, etc. It performs the following operations.

① Control of lighting, indicators, and voice guidance system according to the data re-

ceived from the base station

② Transmission of distance-correction signals from the weak signal transmitter

2) Indicator driver

The fluorescent lamps for lighting, the approaching-bus indicators, and out-of-service indicator are driven by solid-state relays.

The out-of-service indicator is not only controlled by the CPU but also lights if the power of the bus stop display fails.

3) Voice guidance unit

The voice guidance of up to eight seconds can be made by synthesized speech. The guide can cover up to three lines.

4) Weak signal transmitter

The weak signal transmitter and the receiver share an antenna by using a duplexer. This design enables even the bus-stop display having the distance-correction equipment to have only one antenna.

5. Advantages

This system gives the user the following advantages.

1) Exact bus locations can be known at the control center. Therefore, bunched-together buses and traffic jams can be known accurately.
2) The advantage described above results in appropriate bus operation control, for example, to let buses make a detour in the middle of the route or become out of service.
3) Maintaining proper bus intervals and introducing bus-stop display give bus passengers improved service to regain the reliability of bus transportation. We anticipate an increase in the number of bus passengers.
4) The bus company's attitude toward improved services will appeal to general passengers.

6. Conclusion

The decrease in number of of bus passengers nationwide has become more serious with the years.

Shizuoka Railway Co., Ltd. installed this bus location system as a way to improve service to cope with this problem, and the use of this system has shown favorable results. For example, on Saturdays and Sundays when there are few commutation passengers, the fare income has increased.

Bus transportation is charged with a mission as a means of public transportation, and improved punctuality and convenience is therefore an important issue. It is expected that various demands will be made for the bus location system. FUJITSU TEN plans to develop more advanced systems while answering the demands.

Finally, we appreciate the cooperation obtained from the staff of Shizuoka Railway Co., Ltd. and FUJITSU KIDEN Ltd. in the development of this system.

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