New Terminals Installed on Commercial Vehicles

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Abstract

In the transportation industry, there is a steady demand for a system that helps guide vehicles to their destinations quickly and accurately, and enables more efficient vehicle dispatching.

Responding to this demand, Fujitsu Ten, in conjunction with Fujitsu Limited, Offers the system that makes optimal use of navigation and communication functions in support of the transportation business.For This System, Fujitsu Ten has developed the new terminals to be installed on a vehicle.

This vehicle-installed terminals combines an array of navigation and communication functions, as well as business capabilities, to increase efficiency and improve conplicated operation.

The function that Because specific business applications can easily be built into this terminals,saves development costs.

In addition, our terminals can be equipped with driving safety and environmental protection features that enhance functionality, and support the Intelligent Transport System (ITS) being promoted by the Japanese government.

This thesis reviews,the functional requirements from the system the development concept behind the vehicle-installed terminal system, and highlights its distinctive features.

1. Introduction

In industries that use automobiles for business operations such as those providing service in the form of distribution and transportation, in addition to those involved in public works and security, demand exists for the following:

1) Improving competitiveness by raising the level of sophistication of the transportation and distribution services provided, and enhancing the efficiency of transport operations
2) Improving driving safety and preventing accidents
3) Reducing the total cost of the system

The following describes the transportation and distribution systems currently in use and the problems accompanying them in terms of the above items in demand.

1) Vehicle operation control system

   The vehicle operation control system records the vehicle information in the IC memory card of a vehicle-mounted unit and, after completion of the operation, uploads the information onto the main unit at the office, enabling management of vehicle transport operations and vehicle safety. Although this type of system enables improvements in transport operations efficiency and driving safety, it is unable convey information on a real-time basis.

2) Vehicle status monitoring system

   The vehicle status monitoring system transmits the positions of vehicles, etc., to the office, using a vehicle-mounted unit with a communication function, and manages the movement of vehicles and freight on real-time basis. This system enables transport operations efficiency and driving safety to be improved, but covers only a limited area (MCA radio communication) and the associated cost of communication (cellular phone data communication) is high.

3) Vehicle dispatching system

   The vehicle dispatching system provides dispatch and route instructions to the most appropriately positioned vehicles, for efficient vehicle use and quick response to passenger requests for transportation services. This system enables improvements in the level of sophistication of transportation and distribution services as well as improvements in the efficiency of transport operations. However, it cannot ensure that the driver will arrive at the requested location on time if the driver is not familiar with the roads leading to the requested location or if the driver ends up being delayed by traffic jam or other traffic-related problems.

Other problems with the system include the following:

The system is not associated to an accounting or business system or distribution management system.

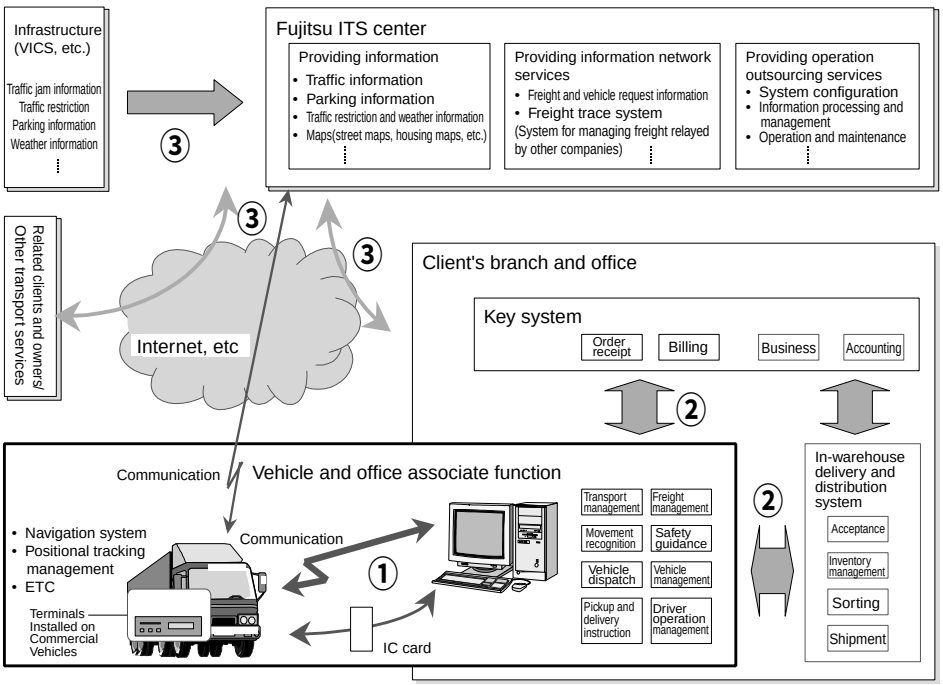


Fig. 1 Next-generation logistic information system overview

The system is made up of the products of different manufacturers and thus the functions and operations of the system as a whole are not uniform.

There is a growing number of drivers who are entering the business from other industries, and who are unfamiliar with roads.

Current systems are able to only partly accommodate market demand. Fujitsu TEN is proposing a "next-generation logistics information system" in conjunction with Fujitsu Limited (a first in the industry). To meet all these challenges, this system enhances the performance of conventional transportation and distribution system navigation and packet communication as well as performance related to linkage with the distribution system at the office or the Fujitsu ITS center.

Fujitsu TEN has developed "new terminals for installation on commercial vehicles" with navigation and communication functions (a first in the industry).

2. Functions of Next-generation Logistic Information System

The next-generation logistic information system consists of vehicle-mounted units manufactured by Fujitsu TEN, the client's office system, and the ITS center advocated by Fujitsu. Fig. 1 shows the overall image of the next generation logistic information system as exemplified in transportation and distribution businesses. The following describes the functions of this system.

2.1 Vehicle and Office Associate Functions (① in Fig. 1)

1) Vehicle operation control and vehicle status monitoring functions
   A vehicle-mounted unit collects on an IC memory card, and then transmits to the office, the position and road information obtained from a navigation device as well as the information about the freight. The information is then used by the office system to perform transport management and transmit vehicle dispatch instructions taking into consideration the amount of traffic on the relevant roads, traffic restrictions, and weather information.
2) Vehicle dispatching instruction function
   On the basis of the vehicle dispatch instruction provided by the office system via an IC memory card or data communication, the vehicle-mounted unit automatically provides route guidance to the relevant destination via the navigation device. The system can provide an instruction concerning the appropriate route calculated via transport management.
3) Freight management function
   The vehicle-mounted unit communicates the loading and unloading status of freight to the office system, enabling freight tracking management. Additionally, a vehicle-mounted temperature sensor, etc., enables freight status management. Any abnormality is reported to the vehicle driver and the office personnel.
4) Safety management function
   If the system detects sudden acceleration and deceleration, speeding, or abrupt swerving, it reports on this to the vehicle driver and the office personnel. This capability also gives consideration of safety of operations by, for example, hiding the vehicle dispatch information display and disabling the key input while the vehicle is in motion (to ensure that the driver does not attempt to use the device and drive the vehicle at the same time).

All of the above capabilities provide far more accurate vehicle positional information than a conventional GPS due to the map matching capability of the navigation device, thus improving the reliability of the entire system.

2.2 Function Relating with Other Systems in the Office (② in Fig. 1)

The logistic information system can integrate various systems in the office and speed up processing by linking up with the distribution management system in a warehouse and with such key systems as those handling order receipt, billing, business, and accounting. The logistic information system consequently enables all of the data to be used in electronic format.

2.3 Fujitsu ITS Center Associate Function (③ in Fig. 1)

1) Information supply function
   We provide customers with information useful for business but burdensome for the customers to collect and analyze on their own. This information is collected from the customers' vehicles and such infrastructure as the VICS.
2) Providing information sharing network services
   We provide services for establishing systems and supplying information as the capabilities that can be implemented when multiple companies share information. These capabilities cover freight and vehicle requests and the freight tracking (including management of freight relayed by other companies).
3) Providing operation outsourcing services
   To enable small-scale and inexpensive system

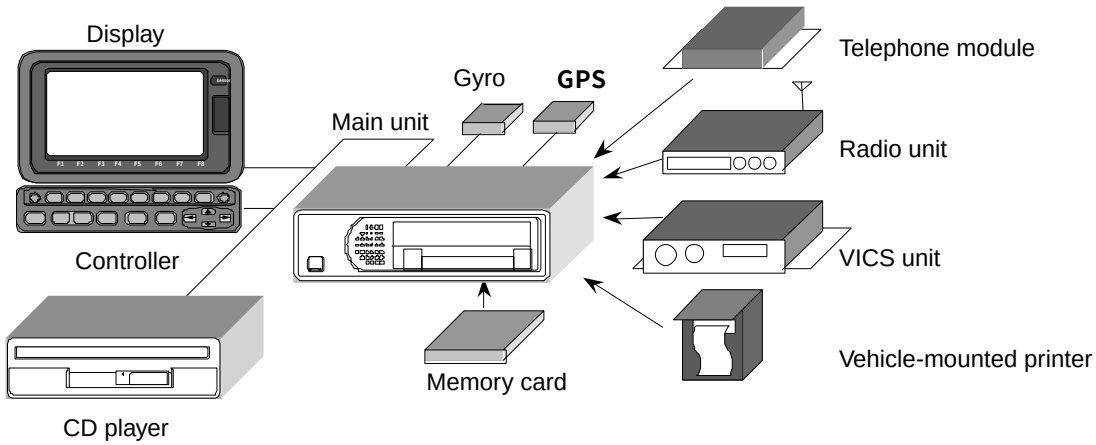


Fig. 2 Configuration of setup of new terminals for installation on commercial vehicles

implementation (by reducing the financial burden associated with owning and operating equipment), we provide business data processing and consultation in addition to outsourcing services that include such system operation functions as transport management data analysis.

3. New Terminals Installed on Commercial Vehicles

3.1 Previous Problems

a) Persons who develop a business processing application-software need to understand the circuit configuration (only a limited number of persons can engage in the development of applications).

b) To replace a business processing application-software, all of the software needs to be replaced (accordingly an application cannot be easily replaced).

c) The positional accuracy of vehicles varies depending on the GPS reception status.

d) The relevant road information needs to be entered via keyboard.

e) It is dangerous for a driver to check the vehicle dispatch on the display while the vehicle is in motion.

f) An external interface box that connects various sensors (door, temperature, etc.) is required.

g) The system consists of products of different manufacturers and thus the capabilities and operations are not uniform.

h) Recognizing the vehicle movements on a real-time basis is expensive in terms of communication costs.

i) A driver unfamiliar with the relevant roads may not be able to keep appointments.

3.2 Development Goals

To implement the capabilities described in Section 2.1, "Vehicle and Office Linkage capabilities," we developed this product on the basis of the following concepts. An alphabetical letter enclosed in parentheses corresponds to a problem described in the previous section.

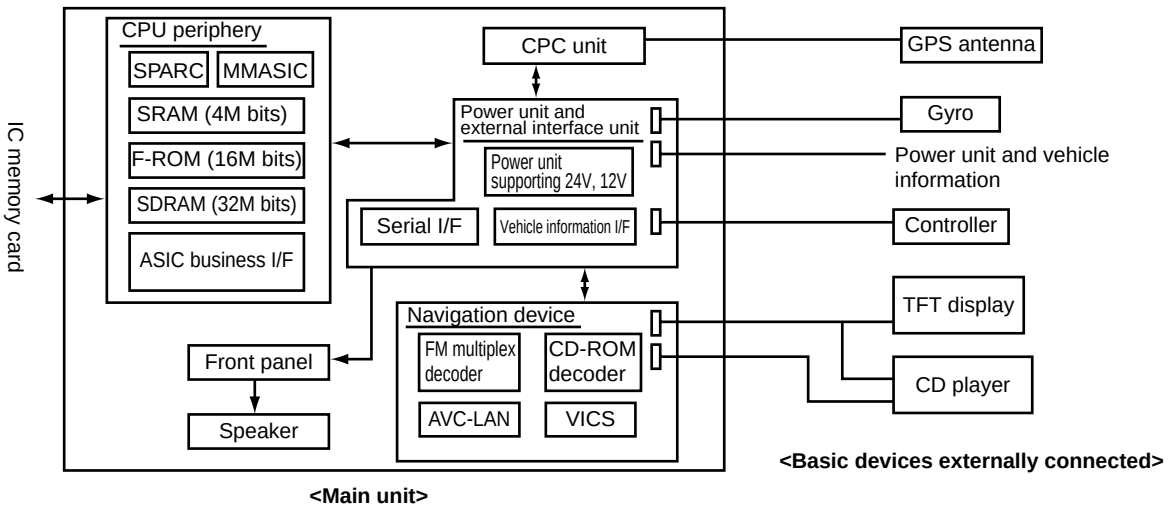


Fig. 3 Hardware configuration

1) Upgrading the capabilities useful for developing a business processing application that raises the levels of sophistication of transportation and distribution services and enhances transport operations
   • Facilitating the development of a business processing application-software (allowing a systems engineer [SE] company to develop a business processing application-software) (a)
   • Utilizing a navigation capability in business processing (map matching [c], map information acquisition [d], route guidance [i])
   • Utilizing a mobile communication capability that enhances the efficiency of linkage between a vehicle-mounted unit and the office computer (to overcome poor line transmission) (h)
2) Upgrading the capabilities useful for managing quality while transporting freight
   • Connection interface with a variety of vehicle-mounted measuring device such as door and temperature sensors (f)
3) Upgrading the capabilities useful for improving driving safety and preventing accidents
   • User interface mainly using voice synthesis (eliminating the need of reading text while driving) (e)
   • Connection interface for vehicle-mounted electronic devices (such as a vehicle-to-vehicle distance sensor) useful for safe driving (f)
4) Upgrading those capabilities useful in reducing the total cost of the system
   • Supporting the DoPa (DoCoMo packet) single-mode service that is advantageous both in terms of coverage and cost (h)
   • Ease of installation and replacement of a business application (b)
   • Executing all functions on a single display unit and a single controller (g)

3.3 Configuration

To support, in addition to the above-mentioned items, the various patterns of operation and installation requirements of customers, we have decided on the basic configuration for this product. This basic configuration includes the main unit, TFT display, CD player, controller, and gyro in hide-away format. Also provided are such optional external devices as a communication modem, and a printer. Fig. 2 shows the configuration of this product. The product can also be operated using only the main unit (without a TFT display and a CD player).

4. Circuit (Hardware) Configuration

The following describes the configuration of the hardware for this product, for each circuit block. Fig. 3 shows the configuration of this hardware.

4.1 CPU Periphery

We adopted a 32-bit CPU (SPARCLite) and the MM-ASIC (MB87F116) to use software assets most effectively.

The memory configuration includes the software storage memory (F-ROM) and execution memory

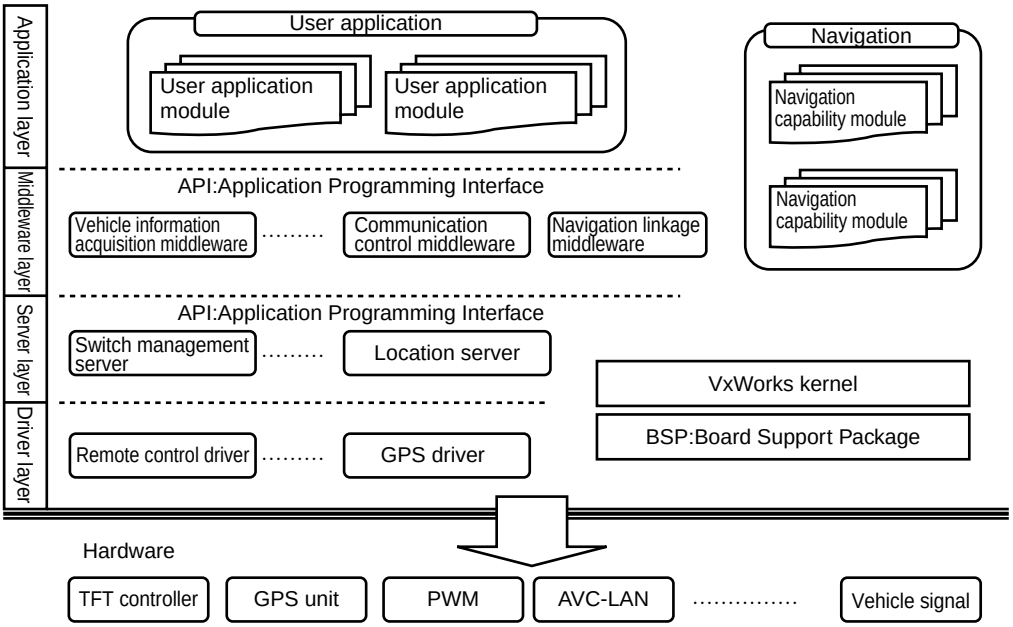


Fig. 4 Software configuration

(SDRAM) to allow for the replacement of each software module as well as expandability.

4.2 Navigation Device

The navigation device houses such circuit blocks required for navigation as interface circuit of a TFT display, CD player, controller interface circuit, D-GPS FM tuner, and VICS. We decided to provide a gyro as a separate unit to facilitate its installation because as a separate unit the gyro would be installable at any angle.

4.3 External Interface Unit

We developed a new gate array (160-pin QFP) with a 56-channel parallel interface and a 9-channel serial interface. This rich external interface unit includes interfaces with a cellular phone and business-use radio used to transmit to the center such data as vehicle dispatch information and vehicle positional information. This unit is designed also to support future expansions such as ETC and millimeter-wave radar.

4.4 Power Unit

4.4.1 Support of 24V battery voltage vehicles

The power unit houses a converter that converts the voltage from 24 volts to 12 volts. This eliminates the need for external DC-DC converters for 24V battery voltage vehicles that make up the majority of vehicles in use, consequently reducing the cost and facilitating unit installation. Additionally, the DC-DC converter in this product can supply power to the display and the CD player that are included in the basic configuration of the navigation device.

4.4.2 Sleep startup circuit

The circuit configuration automatically powers on this product, if powered off, when an incoming call arrives, or in fixed intervals for the purpose of enabling power-on and the transmission of information to and from a remote location.

4.5 IC Memory Card Interface Unit

An IC memory card interface is provided as an external storage medium for storing transport instruction-related data, business instruction-related data, and the like. A flash memory or SRAM memory module of up to 8M bytes can be installed as an IC memory card for use these purposes.

5. Software Configuration

The software for this product was developed on VxWorks (real-time OS) of Wind River Systems so that the existing navigation software components can be used. Using VxWorks as the OS allows applications to run in parallel (multitasking) as well as information from various sensors, etc. to be read immediately (on a real-time basis).

5.1 Structure of Software

Each group of programs that perform a specific function are designed as a component, each running as an independent task. An independent group of programs performing a specific function has a role in each layer, as Fig. 4 shows, with application programming interfaces (APIs) specified for each layer. Providing APIs allows a developer to create an application without having to learning about hardware.

The layers have the roles shown in the following figure.

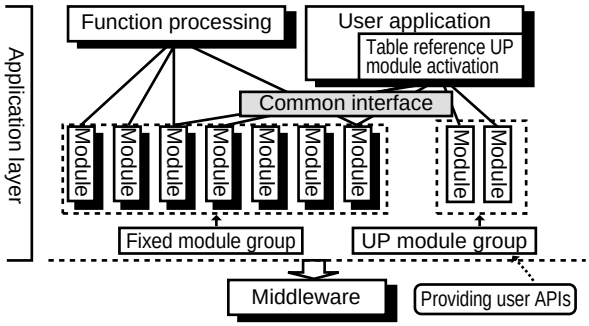


Fig. 5 User application configuration

5.1.1 Device driver layer

The device driver layer directly accesses hardware. When the hardware is changed, you can perform smooth porting by changing this layer while maintaining the interface with the upper layer (server layer).

5.1.2 Server layer

The server layer, positioned between the device driver layer and the middleware layer, provides individual functions to the middleware layer.

5.1.3 Middleware layer

The middleware layer performs common processing and information collection processing. This layer selects the required information and capabilities from the server and driver layers to provide APIs to applications.

5.1.4 Application layer

The application layer, designed on the basis of a customer's specification requirements, provides customer-specific capabilities (specifications). A business processing application (user application) is positioned in this layer and, using APIs provided by the middleware and server layers, allows the user to develop a program without having to learn about hardware.

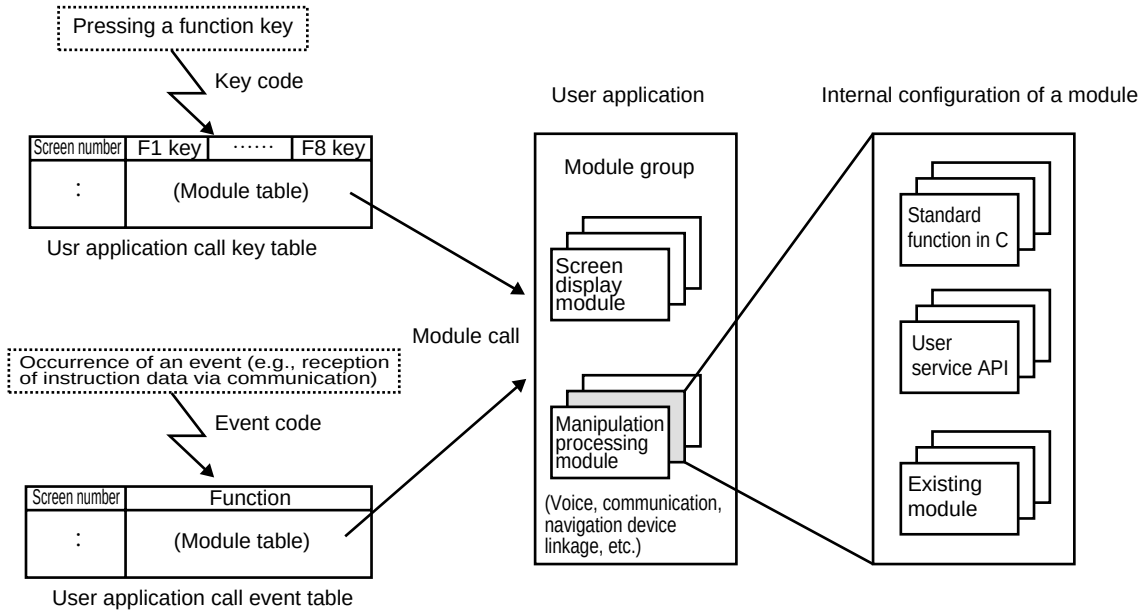


Fig. 6 Operation of user application

5.2 User Application

5.2.1 Configuration

The software configuration allows a user application to be quickly and easily customized in accordance with the business processing required by a customer. Fig. 5 shows the configuration of a user application. You can customize a user application by combining as required the modules that are grouped into capabilities. Modules are grouped into capabilities with each status change, due to key entry or data reception in communication. If a capability cannot be realized by combining the existing modules, you can add or change modules to provide the newly required capability. This configuration allows a user application to be easily customized.

5.2.2 Execution format

A user application is realized when, upon a status change (event occurrence) due to key entry or data reception in communication, middleware executes modules in accordance with the status change table (event-driven format).

For a user application, a developer need only to specify modules to be executed for each event, and need not to understand how an event occurs.

The following explains the execution format of modules that make up a user application and that are executed by the middleware for the purpose of executing a user application. Fig. 6 shows the execution format of a user application.

1) Key entry processing
   - Pressing a function key activates a "key code."
   - A "module" corresponding to the key code is retrieved from the "user application call key table (status transition table)" and called.
   - The called module is executed to realize a function expected when the function key is pressed.

2) Event occurrence processing
   - Receiving instruction data via communication causes an "event code".
   - A "module" corresponding to the event code is retrieved from the "user application call event table" and called.
   - The called module is executed to realize a function expected when the instruction data is received via communication.

5.2.3 Internal configuration of a module

A module is a function format to be called or returned by the middleware. A module consists of the items given below, to enable its creation in a general development environment.

- Standard functions in C
- User service APIs
- New and existing modules

Fig. 6 shows the internal configuration of a module.

5.2.4 User service API

A user service API is provided to enable a user application developer to proceed with development without having to consider the configurations of the hardware, OS, and system software.

The following shows the features of a user service API. Table 1 lists the capabilities of a user service API.

- Contains a function with a single capability.
- Has an easy-to-use interface.
- Handles the portion dependent on hardware.
- Adjusts the timing with the operating system and system software.

Table 1 User service API capabilities

Capability	Description
Screen display	Provides capability for controlling display on a monitor.
Voice output	Provides capability for synthesizing and outputting voice.
File manipulation	Provides capability for controlling input to, and output from an IC memory card.
Printing	Provides capability for controlling printing on printer.
Navigation linkage	Provides capability for providing linkage with navigation device
Data storage	Provides capability for controlling data storage to S-RAM (with power supply backup)
Cellular phone communication	Provides capability for controlling communication via cellular phone
Timer	Provides capability for causing timer event
Hardware status read	Provides capability for reading the hardware status.
Other	Provides other functions.

- Call/return function format

6. Capabilities

6.1 Communication Capability

A communication capability must be installed to provide transportation and distribution services on a real-time basis. This vehicle-mounted terminal has (1) a communication capability (PDC-C version) using a cellular phone and an external modem to ensure a wide communication area. Additionally, (2) to support the single-packet communication service among the DoCoMo packet communication services (DoPa) (a first for vehicle-mounted terminals), this terminal is installed with TCP, IP, and PPP (PDC-C version). Thus, two communication capabilities (1) and (2) are provided. Fig. 7 shows the configuration of the communication equipment.

All of the interfaces used for connection with external devices are RS-232C with the transmission rate of 9600 bps and use a common driver. The server and middleware layers that are upper-level software relative to the driver are two different software products for the two communication capabilities.

However, they have a common interface with a user application (user service API) for both the PDC-C and PDC-P versions, to provide smooth switching of the

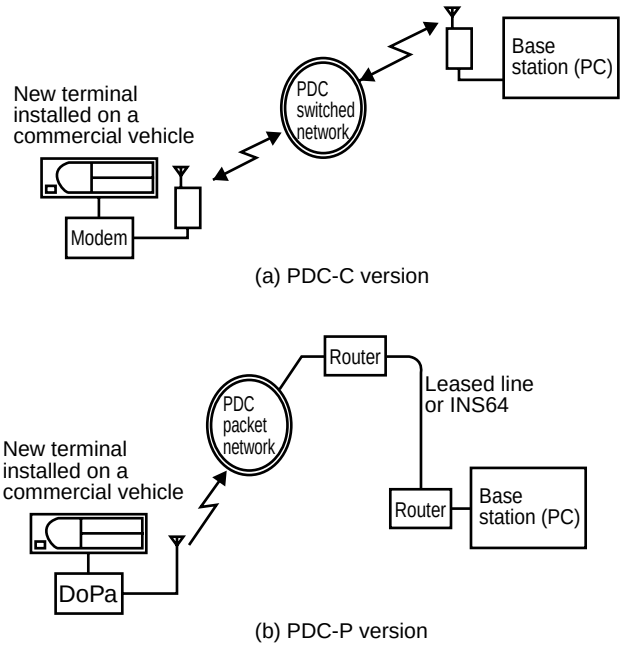


Fig. 7 Communication device configuration

communication capabilities. Fig. 8 shows the configuration of communication capability blocks.

This terminal, providing these two types of

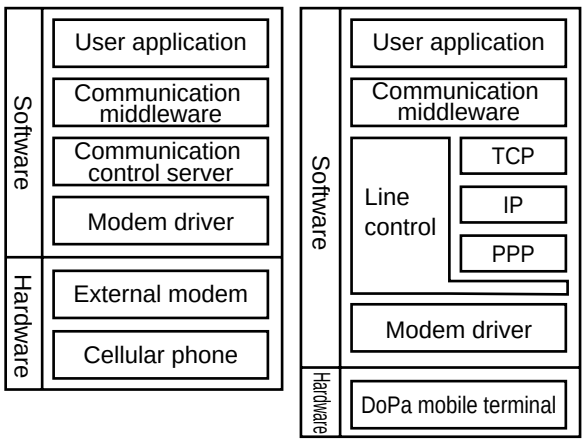


Fig. 8 Blockdiagram of communication function

communication capabilities, has a significant advantage in allowing the user to select a more inexpensive means of communication depending on the number of times and data amount to be transmitted.

Additionally, while this product is powered off (in sleep mode), it can be powered on by a trigger in the form of an incoming call (incoming call activation). This function allows the terminal to communicate with the base station during business operations even after the driver has stopped the engine and left the vehicle.

6.2 Navigation Associate Functions

To raise the level of sophistication of transportation and distribution services and enhance the efficiency of transport operations, this product provides a user application with a function for using most effectively such navigation functions as route search and guidance.

For example, route search and guidance automatically provided in tandem with the business operations assist a worker (driver) not familiar with the relevant roads to carry out the required business operations. Route search and guidance may be based on the pickup and delivery destinations obtained via communication with the office (center) or prerecorded in an IC memory card.

This product provides the navigation linkage functions shown in Table 2 as user service APIs, to realize linkage capabilities between a user application and the navigation capability.

Table 2 Navigation associate functions

Setting	Overview
Route point registration function	Accepts point registration request from user application and notifies caller of distance covered in each section.
Start point search function	Searches for route to start point and starts providing guidance.
Route point arrival function	Notifies navigation device that next route point has been reached.
Next-section search function	Searches for route in next section and starts providing guidance.
Route point arrival cancellation function	Cancels status of arrival at route point
Route distance retrieval function	Obtains distance information in Course 9 of navigation device.
Course switching function for estimate	Changes course number of navigation device to 9 and clears route information for Course 9.
Route initialization function	Clears the route information stored in the navigation linkage as well as the route information stored in Course 10 of the navigation device.

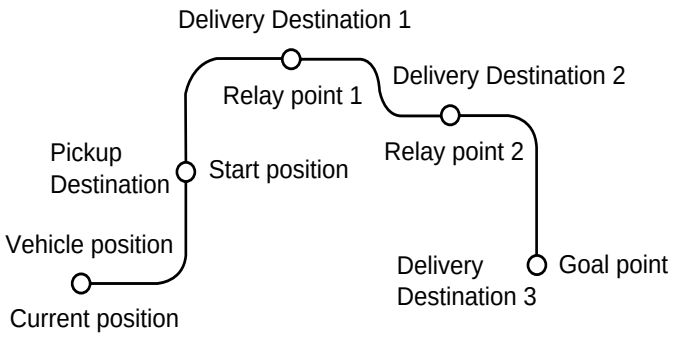


Fig. 9 Sample transportation route

The following describes a typical example of how these functions are used, based on the route shown in Fig. 9.

If a driver needs to collect freight at Pickup Destination and deliver freight to Delivery Destinations 1 through 3, the driver must:

1) Use the route point registration function to register the information on pickup and delivery destinations.
2) Use the start point search function to search for the route from the current position to Pickup Destination and start providing guidance.
3) Use the route point arrival function to notify the navigation device that Pickup Destination has been reached.
4) Use the next section search function to search for the route in the next section (to Delivery Point 1) and start providing guidance.
5) Hereafter, repeat steps 3) and 4) until the goal point (Delivery Destination 3) is reached.

If the driver sets by mistake the status of reaching a delivery destination, the driver can use the route point arrival cancellation function to continue to have the route guidance provided until the driver reaches the delivery destination that needs to be reached.

Additionally, the route point registration function, being able to obtain as a return value the point-to-point distance calculated by the route search, allows the driver to know what distance must be covered before reaching each of the points, thereby providing detailed driving schedule information.

This vehicle-mounted terminal, using a navigation software developed by Fujitsu TEN, offers the advantage of allowing the user to easily enhance the capabilities, such as by adding user service APIs.

Additionally, this product is superior in operability because it can simultaneously display both the business processing screen and the navigation screen as two separate windows without overlapping them, thereby letting the user control both of them with a single controller.

6.3 User Application Software Installation Capability

This product allows the user to easily install a user application software independently without affecting the already installed system software. This product also allows the user to easily upgrade only an individual user application. For this function, we developed a function for installing (or replacing) a user application by simply installing (replacing) a user application file. The following shows an example of installing a new user application software in this product using an IC card as the media (Fig. 10).

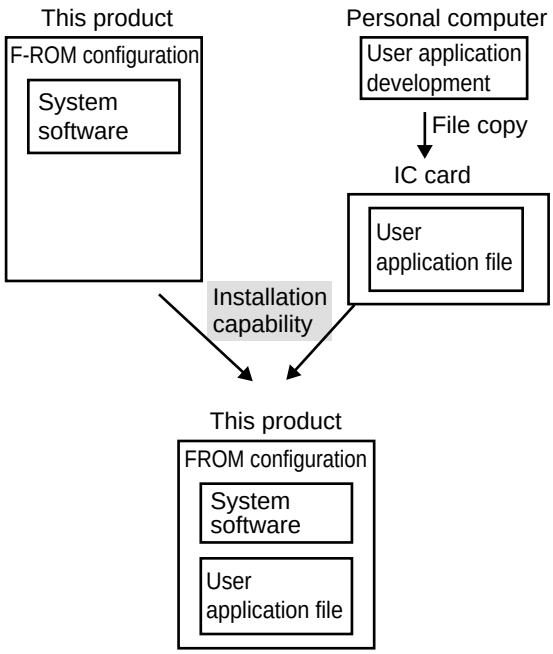
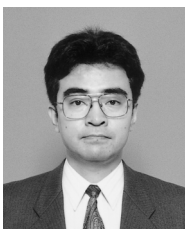


Fig. 10 Example of using the installation capability

7. Conclusion

The new terminals for installation on commercial vehicles realizes a high level of business operation linkage and operability, because they combine for the first time the business processing, navigation, and communication capabilities, all provided by a single manufacturer. As there will be demand from users in the future for further improvement of business operation relation and operability, we will work actively toward incorporating technological innovations and ITS-related technologies for the purpose of constantly upgrading the capabilities of this product.

Profiles of Writers



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