AVM System

Satoshi SHIGEMATSU
Yoshikazu CHUJO
Haruo YOSHIDA

Abstract

Based on the mobile communication technology used for radios installed in commercial vehicles, in 1981 FUJITSU TEN developed "distributed-transmission AVM system," which locates vehicles by signposts. Since then, we have been successful in making vehicle-dispatching work more efficient for taxi companies by developing a vehicle locating system by GPS and then by connecting it to taxi companies' customer management, taxi automatic dispatch, and, most recently, CTI.

Our latest model realizes an unmanned vehicle dispatch system by automation of the dispatching work or "completely-automatic vehicle dispatch, using an interactive voice response system and internet order- receiving system.

This paper reports on the outline and characteristics such as "completely-automatic vehicle dispatch" of our latest AVM system.

1 Introduction

AVM (Automatic Vehicle Monitoring) system refers to the system that enables computers in a control center to monitor and control the location, vehicle dynamics, and other operation service situations of their vehicles. The AVM systems that FUJITSU TEN has developed are "taxi dispatch systems," which are intended to be used by taxi companies.

In 1981, we developed the "distributed-transmission AVM system," which locates vehicles by signposts, based on mobile communication technology used in in-vehicle radio for business use. Starting with that, we have since developed and supplied cutting-edge AVM systems: in 1994 we launched "GPS-AVM system," which located vehicles using the GPS; We achieved an automatic vehicle dispatching system by linking it to our customer's control system in 1996; and we released, in 1997, "GPS-AVM system link to the CTI," which combines the caller ID function. Moreover, we commercialized digital radios for business use for the first time in the industry in 2003. Since then, we have had the largest market share in the industry.

This paper elaborates on the outline and characteristics of our latest AVM system.

2 Outline of our AVM System

2.1 Functions

The taxi AVM system is a vehicle control system that selects and dispatches the most efficient vehicle for picking up a customer soonest who requests a taxi on the telephone or the Internet.

With reference to **Fig. 1** "Explanatory Illustration of Function," the function and procedure of the AVM system is explained here, dividing it into several steps from order-receiving and search for the optimum vehicle to dispatching instructions. The individual numbers showing the steps in the explanation below correspond to the ones shown in **Fig.1**.

①When receiving a request for a taxi from a customer on the telephone, the customer's telephone number is gained by using the caller ID service.

②Based on the telephone number, the customer's information [name, location (longitude and latitude), address, building name, route, etc.] is searched from the accumulated customer database.

③Locations of vehicles (by GPS or navigation) and current situation of their availability (of being occupied, vacant, or in waiting from taximeter or input to AVM terminal) are collected in advance from data communications between taxi vehicles and the control center.
The AVM system automatically searches for and selects the optimum vehicle according to that data in addition to the customer data in ②.

④The server transmits dispatch instruction data, ②, (address, building name, customer's name, route, notes, etc.) to the vehicle selected in ③.

⑤The dispatch instruction data is transmitted to the selected vehicle from the radio at the base station.

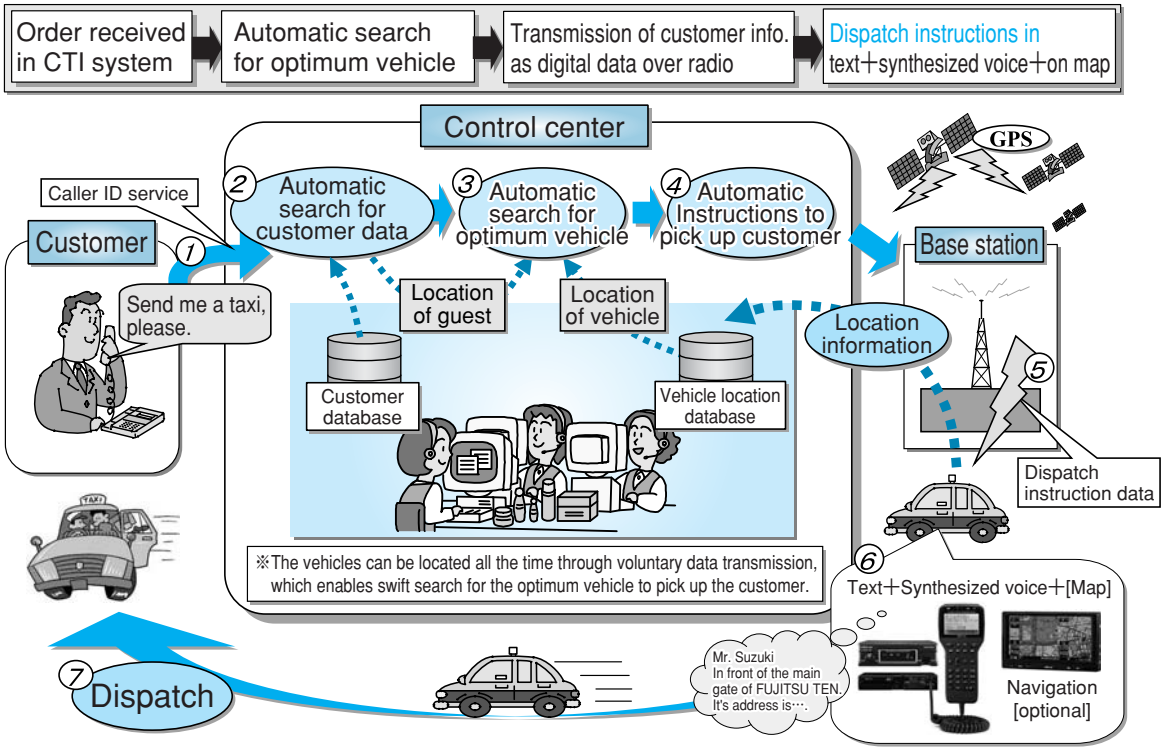


Fig.1 Outline of Functions

⑥The selected vehicle conveys to its driver the received dispatch instructions on a display, in a synthesized voice, and/or on the route map.
⑦The vehicle that receives the instruction goes to pick up the customer and the dispatch process is completed when the vehicle arrives at the destination.

2.2 Product Lineup

The product lineup of our AVM system includes Type-A for large businesses and Type-S for small businesses. There are two types of terminals (ECU) for mobile stations: one is high-performance handy terminal and the other is simple six- button terminal available only for Type-S.

Table 1 shows our product lineup.

2.3 Composition

2.3.1 Key Components

The AVM system comprises the following three components,

- **Center equipment: server, PC, etc. installed in the control center**
- **Base station equipment: radio unit installed in the base station**
- **Mobile station equipment: radio and ECU installed in vehicle**

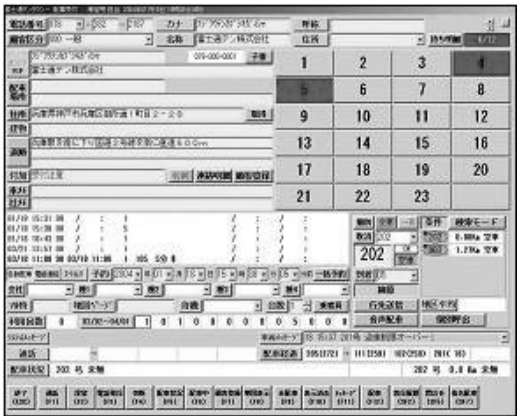
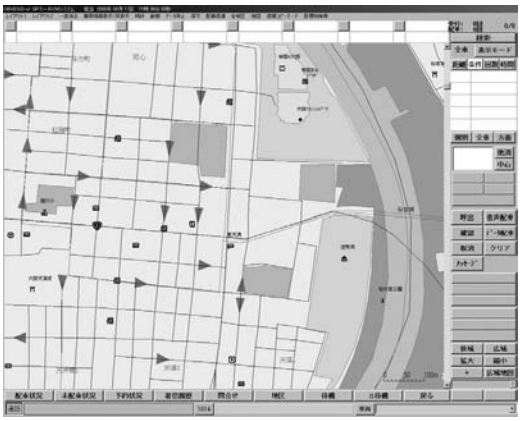
The following section explains the composition taking **Fig. 2** as an example.

In this example, the system is composed of a server in the center and two PCs at our client. Those PCs include telephone function by a dedicated board, and they are connected to a telephone exchange, which enable receiving orders on the telephone.

In the actual situation, the system is combined with ledger sheets, printer for various ledger sheets, a backup server, an uninterruptible power source, MOs for data back-up, and other equipment to improve the reliability of the system.

The equipment at the base station comprises a radio unit including a radio and an antenna, radio table for operation of calls, etc. This example shows the simplest form where a radio for the base station is installed in the control center. Depending on the size and the location of the taxi company, multiple radios for the base station are

Table 1 Product Lineup

	Type－A	Type－S
Base	Client server	PC
Shared by	10,000 vehicles	100 vehicles
Operation of order-receiving	Separated from vehicle dispatch	Integrated with vehicle dispatch
Example of display	Screen for vehicle dispatch Automatic dispatch of the vehicle selected by the computer after the customer information is checked. 	Screen of Map The control center selects and dispatches a vehicle, checking the locations of vehicles on the map. 
Terminal for Mobile station	Handy terminal (for Type-A and Type-S) 	Six-button terminal (only for Type-s) 

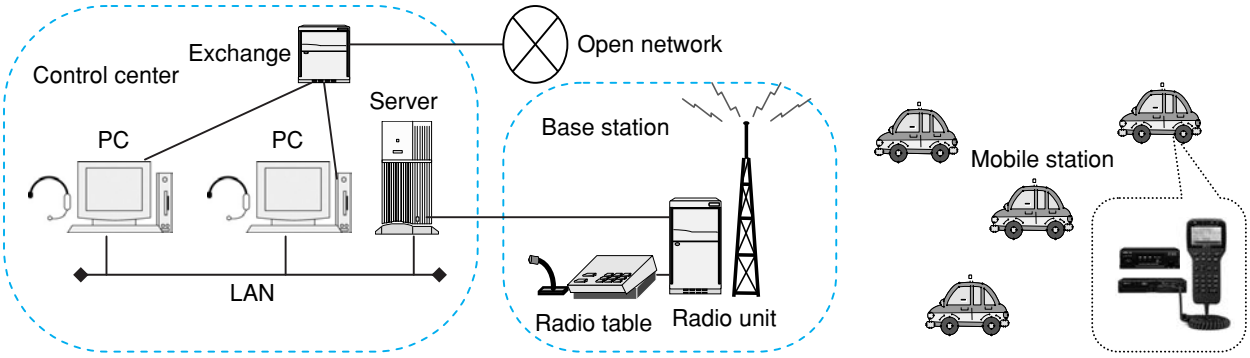


Fig.2 Image Drawing of AVM System Components

installed at multiple places within its business area. The case where multiple radios are installed at multiple places is explained in Section **3.2.1** "IP Connection of Radios at Base Station."

A radio, ECU, and handy terminal are installed in each vehicle as a mobile station. An emergency switch, navigation and drive recorder can be connected to the system as options.

2.3.2 Improvement of Reliability

In order to improve reliability of the system according to the scale of the system and requests from each taxi company, fail safe systems are available such as back-up server, hardware duplexing, automatic switch-over to back-up radio at the base station, etc.

3 Characteristics of System

"Full automatic vehicle dispatch" and "use of IP network" are among the keywords of the latest AVM system.

"Full automatic vehicle dispatch" means that full automatic operation from receiving an order from a customer who needs a taxi to guiding the taxi to the destination. It enables a taxi to be dispatched in an automatic and efficient manner.

"Use of IP network" means that IP network, such as Internet network, is used for the digital radio to be connected to the server in the center. This has enhanced affinity between data over LAN and open networks, and it established the base for wide area communication and share of equipment among base stations.

This section explains proven examples of "full automatic vehicle dispatch" and "use of IP network" in the AVM system and their mechanisms.

3.1 Full Automatic Vehicle Dispatch

The conventional AVM system only included the functions to select a candidate vehicle from the information about where the customer is located, to automatically send the pick-up instructions to the candidate vehicle, and to guide the vehicle to the customer based on the pick-up instruction data. Orders from customers were received by operators.

"Full automatic vehicle dispatch" automates the order-receiving operation by the interactive voice response (IVR) system and the Internet. As a result, taxi users do not have to talk to operators to request a taxi to go to their destinations.

3.1.1 Interactive Voice Response (IVR) System

On the IVR system, a computer answers telephone calls instead of operators, which automates the order-receiving operation.

(1) Function

In the automatic order-receiving, a computer can handle orders of "one taxi" or of "multiple taxis."

A taxi company can select the order-receiving operation process of "one taxi" or "multiple taxis" for each telephone line (if the taxi company has multiple telephone lines, they can select and set the process of "one taxi" or "multiple taxi" for each line), and the functions included in each process shown in **Table 2** can be selected according to the situation of taxi company.

Table 2 Available Setting Function of IVR

	One taxi	Multiple taxis
Notification of license number (only for order receiving)	Selectable	Selectable
Transfer when the number is unavailable or unregistered	Selectable	Selectable
Transfer to operator after the predetermined minutes	Selectable	Selectable
Transfer to operator of customer operation	—	Selectable
Operation of confirmation	—	Selectable
Largest number	—	Selectable

(2) Characteristics

The IVR system automated the order-receiving operation. However, it did not automate all patterns but only certain patterns.

The following are the conditions for the automatic order-receiving.

- **Only one pick-up place for each telephone number (=identify the pick-up place by the telephone number)**
- **The customer information is registered in the center database and the taxi company can identify the customer by the caller ID function**

These conditions are intended to eliminate complicated operation, a disadvantage of the IVR. Normally, a customer needs to handle all troublesome operation because the IVR required the customer to input all information with push buttons on the telephone. With our new technology, this disadvantage was eliminated by limiting the patterns that customers request taxis. We designed a simple flow such that only one push of a button is enough to arrange a taxi after the customer calls the taxi company with the IVR system.

Moreover, in the case of a taxi company, another call from the same telephone number within a certain number of minutes after receiving an order often turns out to be an inquiry or complaint. Therefore, when the same customer calls again within those specified minutes, the phone call is transferred to an operator. We improved the operability of the IVR to increase its use by customers.

(3) Flow outline

Fig. 3 shows the composition of a system using IVR.

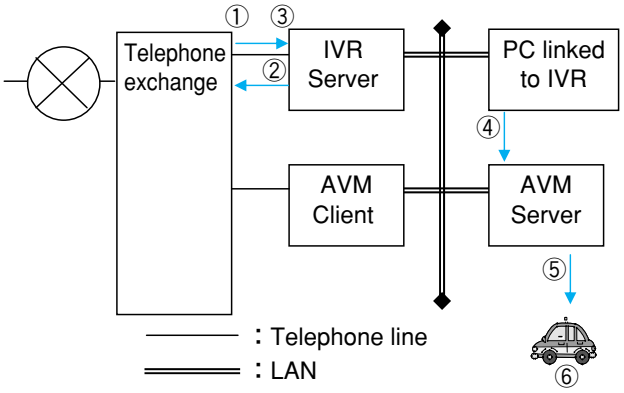


Fig.3 Composition of IVR System

The outline of the flow from order-receiving to pick-up of the customer is explained below, referring to **Fig. 3** "Composition of IVR System." The individual numbers showing the steps in the explanation below correspond to the ones shown in **Fig.3.**

Flow outline:

①The IVR server recognizes the customer ID (telephone number) and sends his/her ID number to the PC that is connected to the IVR system when a customer calls.

②The IVR-connected PC searches the customer data on the AVM server based on the customer ID and transmits it to the IVR server.

③When the IVR server receives the confirmation from the customer, the server transmits it to the IVR-connected PC.

④When the IVR-connected PC receives the confirmation, it creates dispatch specifications based on the customer data, and transmits it to the AVM server.

⑤The AVM server transmits instructions to the vehicle in the neighborhood of the customer based on the dispatch specifications.

⑥The mobile station that receives the dispatch specifications goes to pick up the customer following the displayed text and navigation.

These operations acheive full automatic vehicle dispatch without an operator in the center.

The programs that run on the IVR-connected PC in this system produce dispatch specifications from signals from the IVR system, although the specifications are usually produced by an operator when he/she receives an order on the telephone. As a result, the base of the AVM system did not have to be changed to add the IVR function.

3.1.2 Internet Order-receiving System

In order to improve operability, the IVR system is available only in some limited situations. Accordingly, the registered pick-up location is limited to only one for each customer. However, in the actual order-receiving, an increasing number of customers call for taxis from outside on the mobile phones that are popular now. Those phones include functions for use both as a phone and the terminal for the Internet. We use the Internet function of the mobile phones to realize the automatic order-receiving.

(1) Function

The Internet order-receiving is available from PCs or mobile phones through the Internet network. The following items can be completed on the Internet order-receiving system.

- **Registration and change of user information**

User information such as name, password, etc. can be registered and changed with user ID that is an e-mail address.

- **Request for a taxi (right now or reservation for a requested time)**

It is possible to pick up the customer not only right now but also at a requested time

- **Request for picking-up at the designated place**

Since a customer can request a taxi from outside, he/she can designate a place to be picked by registering the place in advance or can select from landmarks.

- **Check the order processing situation**

It is possible to check the reservation and location of the taxi on the way on a map by the tie-up with the map website.

- **Confirmation**

An e-mail is sent to the designated e-mail address to confirm the order, notify the taxi's license number, and announce the taxi's arrival.

(2) Characteristics

First, for "customers who requests a taxi from outside," Internet ordering from a mobile phone is available through the Internet network. It is available from mobile phones of all three carriers in Japan (docomo/au/Softbank). Operation to enter letters on mobile phones is more difficult than on PC. Therefore, mobile phone model ID (unique number for each mobile phone) is recorded so as to allow the customer to log in without user authentication (entering ID and password) from the second time and thereafter.

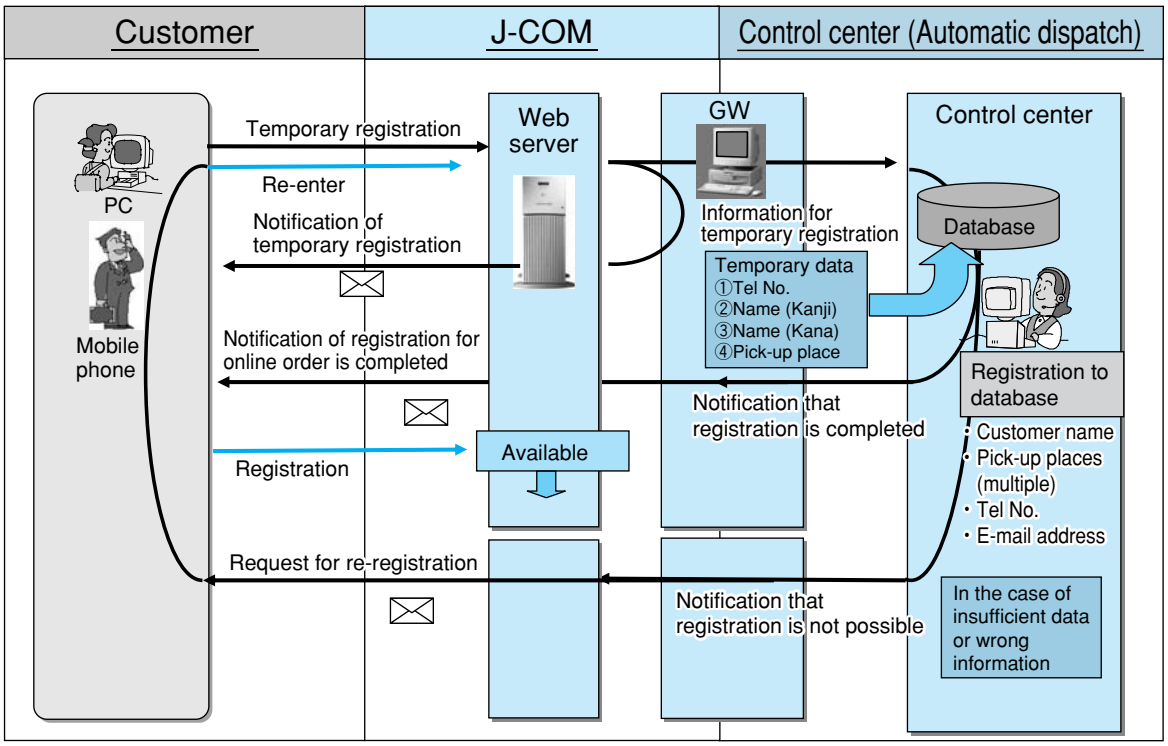


Fig.4 Flow from Receiving Order on The Internet to Taxi Arrival

Second, the Internet ordering system has an advantage that a customer can designate and enter a pick-up place. However, it may be a disadvantage for the taxi company that dispatches a taxi because they cannot judge whether or not the entered place is correct. Therefore, we decided to make this service available only after the registered place is confirmed between the customer and the taxi company in advance. (Refer to **Fig. 4** Flow from Receiving Order on The Internet to Taxi Arrival.)

The pre-registration contributes not only to decreasing misunderstanding of the pick-up place between the customer and the taxi company but also to reducing entering operation by customers because he/she can select a place from the list of pre-registered places.

Third, we enabled the customer to check the situation of the taxi on the way to him/her. The order confirmation e-mail includes an URL, which jumps the customer to the map company website that shows the latest location of the taxi heading for the customer on the screen of his/her PC or mobile phone. The coded customer ID and the information of the vehicle to be dispatched is embedded in the order confirmation e-mail. When the customer accesses the specified URL, the web application inquires the latest taxi vehicle information to the AVM system. The AVM system transmits the latest location of the vehicle to the web application, the application jumps to the website of the map company to show the map with the coordinates. With this function, we realized that the inquiry from the customer can be answered automatically without asking an operator.

(3) Flow

Fig. 5 shows the flow of the Internet order-receiving system.

The system shares the composition and the flow with the IVR system. By installing a web connecting server between web application on the Internet side and the AVM system, the IVR function for the Internet order-receiving could be added without any change of the base application of the AVM, like the IVR.

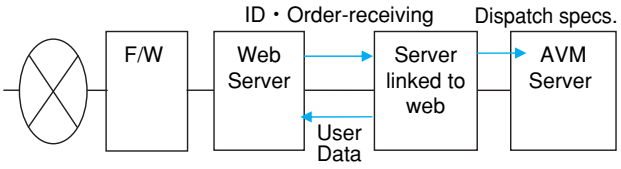


Fig.5 Composition of Internet Order-Receiving system

(4) Security

Because this system uses private information on the Internet, the following security measures, although they are common technologies, are taken.

①Cryptographic communications in SSL

SSL is a cryptographic protocol for information communications over the Internet. It encrypts data for communications.

②Encryption of information

URL is assigned to each taxi customers. Therefore, the customer information is encrypted by our original coding not to easily identify those customers.

③Network establishment

As shown in the example of the system composition,

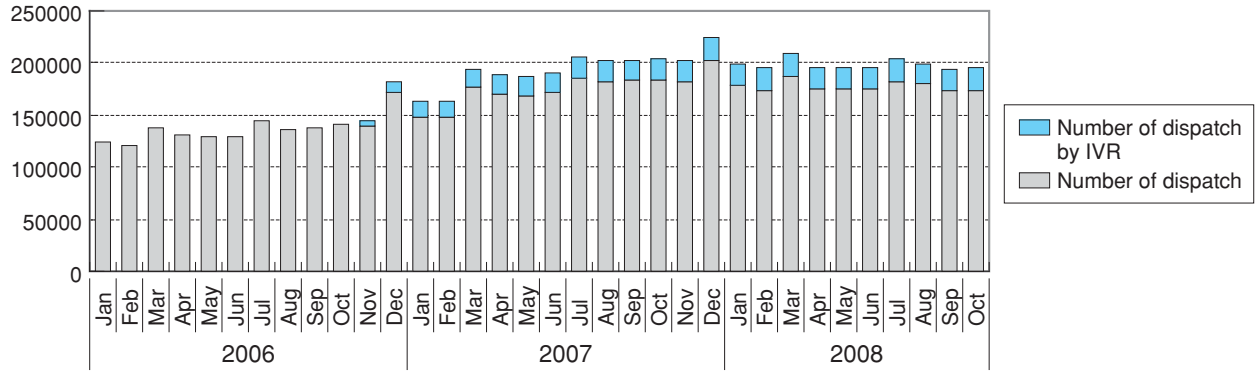


Fig.6 Shift of Number of Vehicle Dispatch

the system is divided into segments and only the web server can be seen from the outside. The firewall is set up to block unauthorized access to the web server.

④Database unification

All data including private information such as customer information is brought together in the AVM server so as not to be accessible.

3.1.3 Result and Challenge of Full Automatic System

Fig. 6 shows the actual dispatching result of a taxi company that has used the IVR system. Since November 2006 when the company introduced the IVR system, the number of dispatches has greatly increased. The rate of the full automatic dispatch is about 10 percent. It can be concluded that one of the reasons for the large increase is because operators can have extra time to take other orders due to the full automatic dispatch (approx. 120% more than the previous year).

The challenge of the full automatic dispatch system is how to convince users to use it.

Conventionally, those who use such system were operators of taxi companies. The problems related to the specifications and operating methods were solved by discussion with those taxi companies. However, in the case of the IVR system, those who use the system are taxi users. Therefore, we need to understand the policies and sales promotion efforts of each taxi company. In the beginning of the system's introduction, there were some cases where users did not use the system (which means no sales increase). However, advertisement and campaign activities to users about the automatic order-receiving system by the taxi companies have gradually increased sales.

Moreover, some functions have been added as taxi companies carry out promotion activities such as cash-back to those who use the full automatic dispatch system. Due to our efforts linked to those activities, there are some cases where the full automatic dispatch accounts for 20% of the total.

3.2 Use of IP Network

In addition to the Internet order-receiving, the IP network is promoted for control of the base station and connection among business offices.

3.2.1 IP Connection of Radios at Base Station

As explained in Section 2, in the case where a radio cannot cover all the business area of a taxi company, the second radio is installed in a remote area (referred to as the advanced base) in order to cover all the necessary area. **Fig. 7** shows an example of the structure of two base stations.

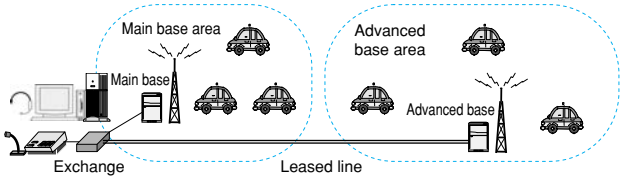


Fig.7 Composition Example of Two Base Stations

The server automatically determines the main station or the advanced station for communication with a vehicle based on the location of the vehicle.

Conventionally, the control center is connected with the advanced base station by an analog line and modem.

Recently, as the IP network infrastructure is more extensive, the connection between the control center and the advanced base are compatible with the IP where the digital line or optical communication line are used. **Fig. 8** shows the structures of the analog and digital lines.

While the conventional analog communications required two lines, one for text data and the other for audio data, the IP communications needs only one line because both audio and text data are transmitted by using the IP, which is the advantage of the IP communications. Moreover, the digital line costs less than the analog line in the case of long-distance communications. Therefore, it makes a long-distance connection feasible, for example, connection between Tokyo and Osaka.

The changes mentioned above leads to an idea that the remote communications between the control center and the base station can be used not only to "supplement the radio area by installing the advanced base" but also to "integrate the dispatch functions at main business offices of large nationwide companies." In fact, some companies started a system where vehicles needed in Tokyo are dispatched from the dispatch center in Kyoto.

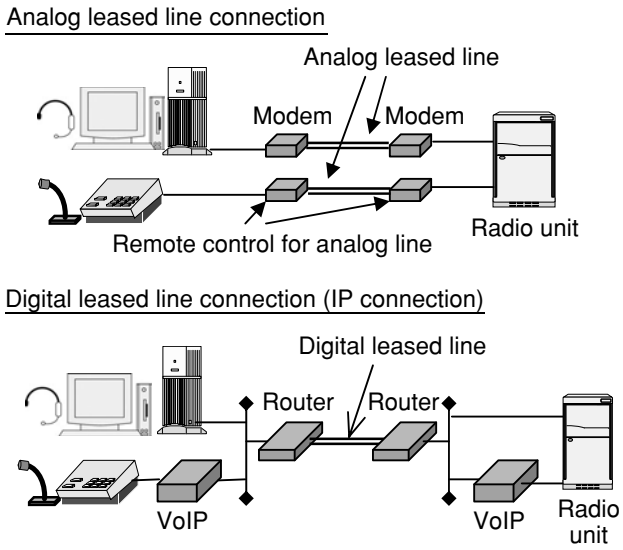


Fig.8 Analog Connection and IP Connection

3.2.2 Link between Business Offices

Another example of the IP communication network is a link between business offices.

Contrary to the recent integration of dispatch functions, there has been some demand for deconcentration of dispatch terminals to individual business offices to dispatch vehicles from each of those offices. The link between business offices meets the demand. It enables the dispatch from multiple bases by connecting a company server with the one of its client by the optical network.

Fig. 9 shows the structural example of the connection among business offices.

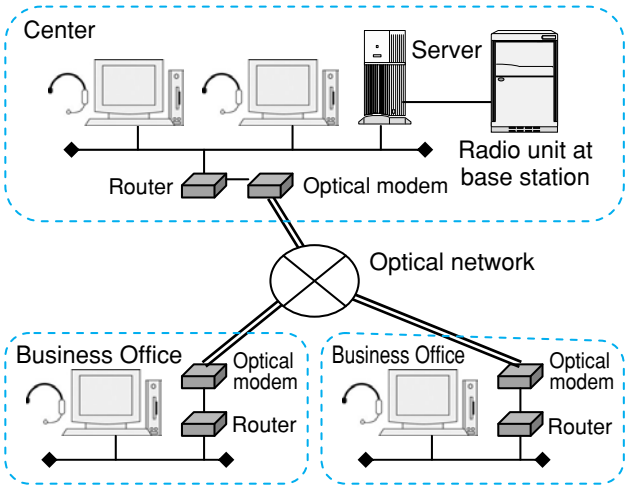


Fig.9 Connection among Business Offices

4 Conclusion

We explained the latest technology and characteristics of our new AVM system.

All radios used in taxis need to be digitalized by 2016. The taxi industry was deregulated and taxi companies are fiercely competing with each other to survive more than ever. Some of them try to find a way to survive by offering a service different from others with the introduction of the AVM system. In these circumstances, we need to support them by providing solutions for smooth and safe taxi operation with the system, in addition to automation and efficient dispatch of taxi vehicles.

Furthermore, the better connection with computers leads to the ongoing discussion about expansion or supplement of service area by sharing a base station among multiple companies or about prediction of traffic congestion from the information obtained by the system.

We hope to develop the AVM system further as a more sophisticated dispatch system and also as a system that can serve various other purposes by using information.

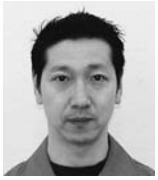
Profiles of Writers

Satoshi SHIGEMATSU

Entered the company in 1998. Since then, has engaged in GPS-AVM system (center application) development. Currently, in the Information & Communication System Engineering Department, CI Aftermarket Group.

Yoshikazu CHUJO

Entered the company in 1982. Since then, has engaged in GPS-AVM system development by way of development of automotive radio devices. Currently, in the Information & Communication System Engineering Department, CI Aftermarket Group.



Haruo YOSHIDA

Entered in the company in 1997. Since then, has engaged in GPS-AVM system (center application) development. Currently, the Team Leader of the Information & Communication System Engineering Department, CI Aftermarket Group.