

# Onboard System Devices for a Vehicle Information and Communication System

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In October 1991, the vehicle information and communication system (VICS) promotion council began examining FM multiplex broadcasting, roadside beacons, and teleterminals as a way to offer new traffic information. In November 1993, the council held a public demonstration to promote the VICS and to bring this system into practical use as early as possible.

Fujitsu TEN produced an onboard system for the VICS for Toyota and exhibited an experimental car in cooperation with Fujitsu Limited. Our onboard system displays graphical traffic information provided by a radio infrastructure. Our system shows the driver the vehicle location by combining positioning data from roadside beacons and map data from FM multiplex broadcasting. We improved the user interface by introducing a voice synthesis and voice recognition system.

This paper describes the VICS experiment and an onboard communication and control system we developed for the VICS experiment.

## 1. Introduction

In recent years, air pollution and energy wasting because of traffic congestion have become serious social problems in large cities.

Conventional car navigation assistance gives route guidance, but cannot provide information in real time when a traffic accident, traffic congestion, or other problem occurs. In answer to this, the Ministry of Construction, the National Police Agency, the Ministry of Posts and Telecommunications, and private enterprise are now cooperating to develop a Vehicle Information and Communication System (VICS). VICS can provide road traffic information or information on parking space availability to car drivers 24 hours a day and in any location, in a form which is useful to the car driver. Their aim is to make use of road networks more efficient and to relax or eliminate traffic congestion.

## 2. Public demonstration of VICS

A public demonstration was given at Tokyo Prince Hotel on November 9 and 10, 1993. The demonstration included test rides in experimental vehicles, an exhibition

of onboard system devices, and a symposium. For the demonstration, 45 vehicles (from 26 companies) were provided for test rides and 13 systems (from 16 companies) were exhibited. Fujitsu TEN exhibited an experimental vehicle, and onboard system devices.

In addition to conventional road traffic information and guidance system FM multiplex broadcasting, a radio beacon, and an optical beacon were used as new ways to transfer information. These new media provide information that car drivers want, 24 hours a day and in any location. Table 1 lists the installed information transfer media, and Table 2 lists their features.

**Table 1. Installed information transfer media**

	Quantity	Remarks
Radio beacon	10	Mainly confined to the Tokyo Metropolitan Expressway.
Optical beacon	20	Installed mainly on general roads.
FM multiplex broadcast station	1	82.5 MHz (NHK FM Tokyo)

**Table 2. Features of the information transfer media**

	Radio beacon system	Optical beacon system	FM multiplex broadcast system
Area covered	Intermittent micro-zone (about 70 m)	Intermittent micro-zone (about 3.5 m)	Wide range (about 25 km)
Transmission speed	64 kbps	1024 kbps	16 kbps (including error-correcting code)
Transmission frequency (or light wavelength)	2499 MHz (location detection, amplitude modulation of 10%, 1 kHz)	850 nm±50 nm (LED for near infrared rays)	82.5 MHz (76 kHz subcarrier) (NHK FM broadcasting in Tokyo area)
Modulation method	GMSK modulation (NRZ code)	Pulse amplitude modulation (Manchester code)	L-MSK modulation
Error control	CRC-CCITT	CRC-CCITT	Difference-Set Cyclic codes

## 2.1 Purpose of the demonstration

The demonstration was given to help speed up use of VICS. The aim was to increase the understanding of VICS by the public by explaining the concept of VICS and by showing the actual system.

## 2.2 Demonstration system configuration

Figure 1 shows the demonstration system configuration. The VICS center (the tentative name) integrates management of road traffic information. The demonstration system provides information more accurately and quickly than current information panels.

Onboard system devices show car drivers received road traffic information in different ways, depending on the device type. The demonstration system distributes information to the onboard system devices about 5 minutes after the information source sends out the information.

## 2.3 VICS onboard system devices

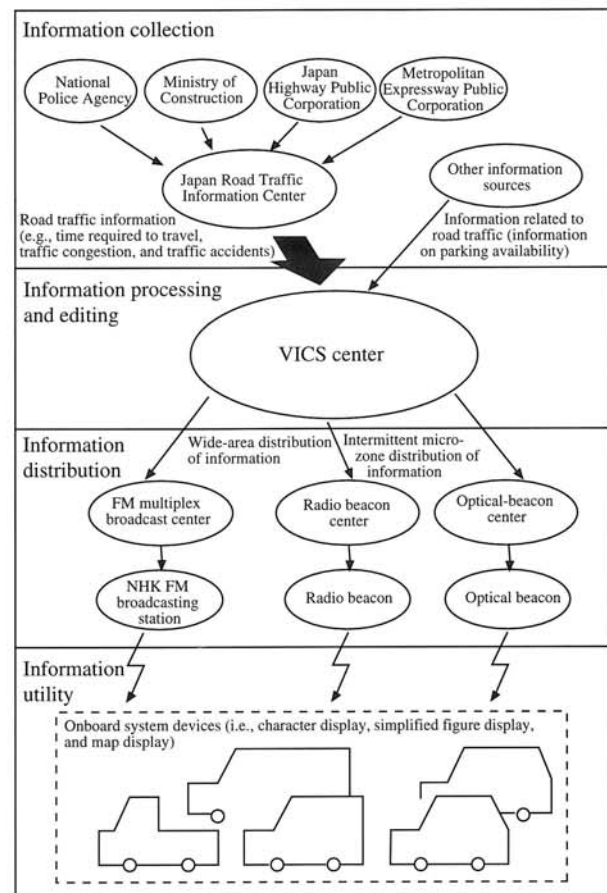
Onboard system devices are classified into the following three types, depending on the information display mode for the way they are used.

### 1) Character display type

The character display type displays information (character codes) sent from infrastructure on a simple display unit. (See Figure 2.)

### 2) Simplified figure display type

The simplified figure display type combines character codes and graphic information sent from the system

**Figure 1. Demonstration system****Figure 2. Character display type****Figure 3. Simplified figure display type**

infrastructure, and then displays the result on an existing onboard device such as a TV. (See Fig. 3.)

### 3) Map display type

The system with a map display is combined with a navigation assistance unit that contains a map database. This type of system displays superposed road information sent from the system infrastructure on the map display screen.

To produce commercial diversified VICS onboard system devices, different types of information are needed for different display types. Information can then be used on various types of onboard system devices. Onboard system devices are produced commercially for systems offered by individual companies.

To demonstrate VICS, Fujitsu TEN has developed an onboard system device with a simplified figure display. This system is described below.

### 3. Onboard system devices with the simplified figure display

Figure 4 shows the configuration of the experimental onboard system. The onboard system shown stores

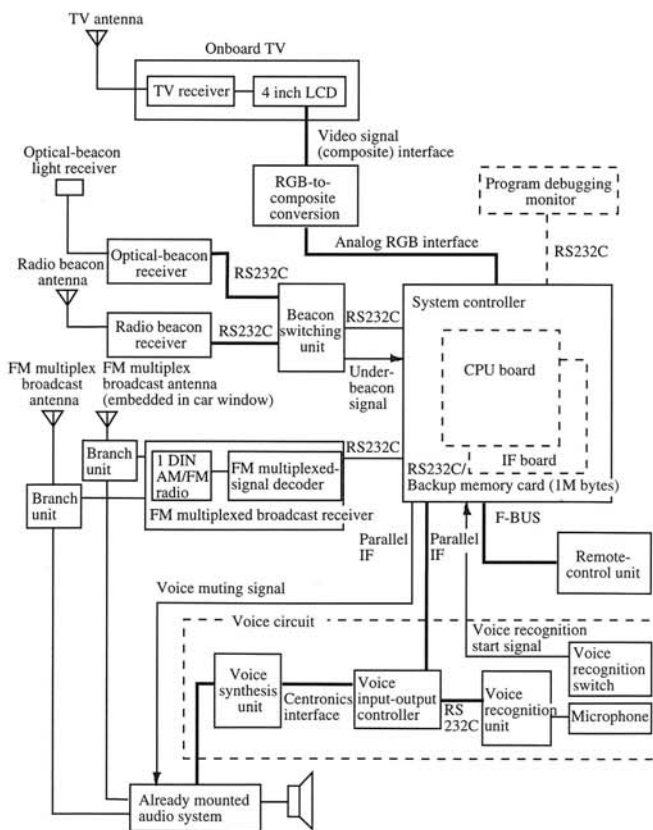


Figure 4. Onboard system configuration

information sent by FM multiplex broadcasting and that sent from beacons, displays simplified figures, remotely controls the screen, controls voice input and output, and manages information. It also has a system controller and performs integrated information management to handle requests from the car driver.

The system controller has communication interfaces with an FM multiplex broadcast receiver, beacon receivers, and a voice input-output controller. It also has input-output ports for the voice recognition start signal, under-beacon signals, and the voice muting signal. The system controller has dedicated interfaces, i.e., the F-BUS interface, for a remote-control unit and the analog RGB interface, for video signal output. Table 3 lists system controller specifications.

Table 3. System controller specifications

Item	Description
16-bit microprocessor	Memory space: 16M bytes (extended mode) Clock frequency: 24 MHz (operating frequency 12 MHz) Peripheral devices: ICU, TCU, SCU, and WCU
High-speed drawing processor for graphic-display control	VRAM: 512K bytes Display clock frequency: 5.26 MHz Drawing clock frequency: 6 MHz (half of CPU operating frequency)
Program	ROM 512K Byte
Memory	DRAM 4M Byte
Serial interface	Interface built in CPU: 1 channel (SCU) Interface equivalent to 8251: 4 channels (1 channel for built-in ASIC, 3 channels mounted on IF board)
Parallel interface	Interface equivalent to 8255: 24 ports
F-BUS interface	Transmission speed: 14 kbps Communication method: Half-duplex asynchronous communication, multiple-master method
Video output interface	Analog RGB signal, 75 , 0.7 Vp-p, 2-channel output, 248 dots x 204 dots
Backup memory	IF board

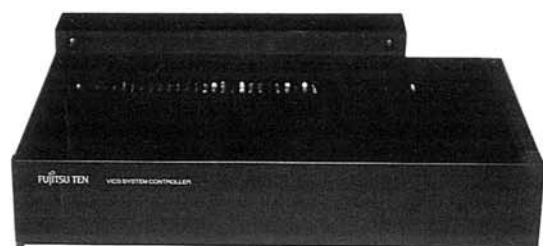


Figure 5. System controller

#### 4. System controller

The system controller consists of a CPU board with a microprocessor, ROM, and RAM mounted on it, an IF board that provides communication interfaces with external devices, and a power board that supplies power to each board. Figure 6 shows the system controller configuration.

##### 4.1 Functions of the system controller

- 1) Storing and displaying FM multiplex broadcast data  
The system controller updates and stores data sent from the FM multiplex broadcast receiver. It fetches the stored data and displays a simplified figure or characters.
- 2) Displaying locations based on beacon information  
The system controller receives current-location information when the vehicle passes under a beacon. It superposes received information on the area map received over FM multiplex broadcasting, and displays the result.
- 3) Voice user interface  
The system controller responds to voice commands and provides information using synthesized voices. The driver therefore receives information without lowering safety.

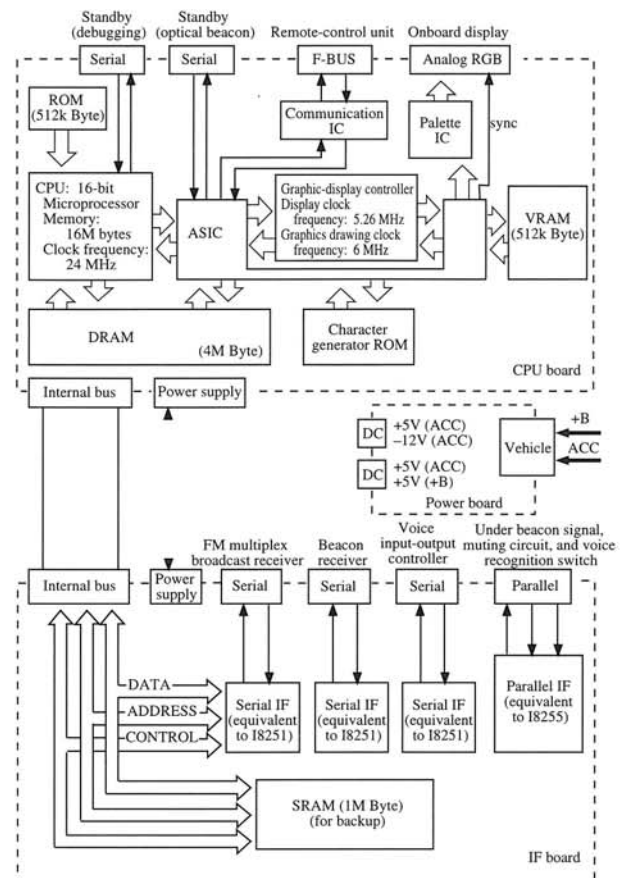


Figure 6. System controller configuration

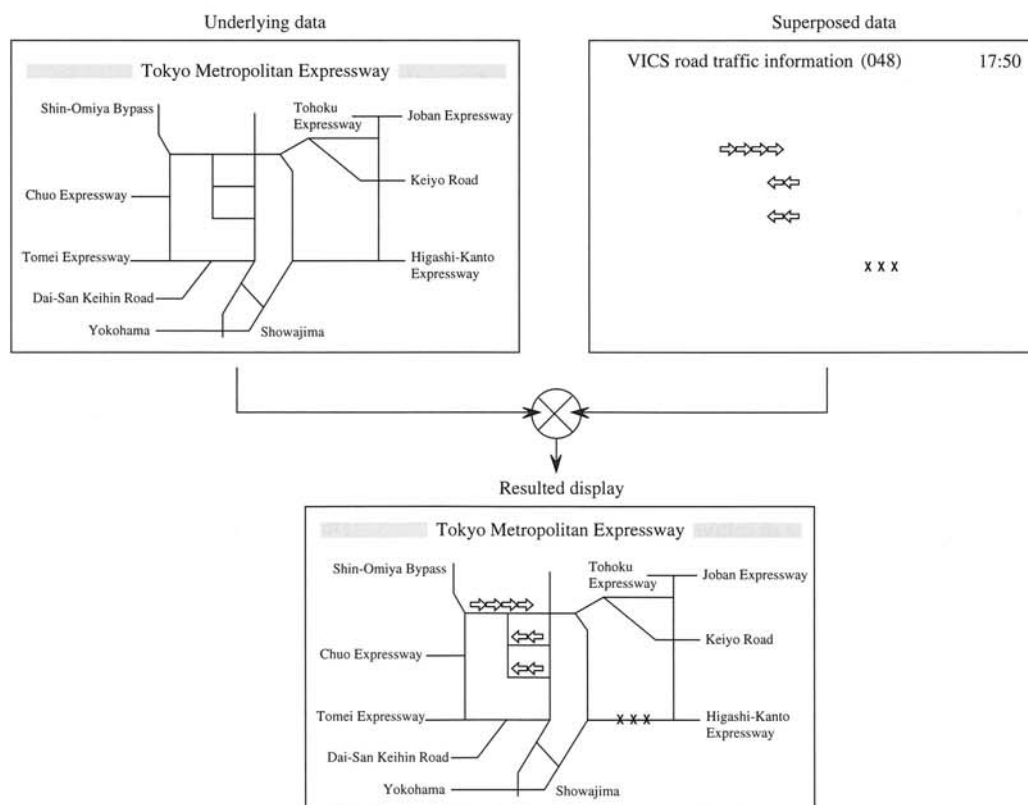


Figure 7. FM multiplexed broadcast information display

## 4.2 Displaying FM multiplex broadcast data

Road traffic information provided in a graphic form is separated into unchanged underlying-picture data for area maps and roads, and various superposed data that shows sections with congestion and accident locations. When information is displayed, superposed graphics are placed over underlying graphics (see Figs. 7 and 8).

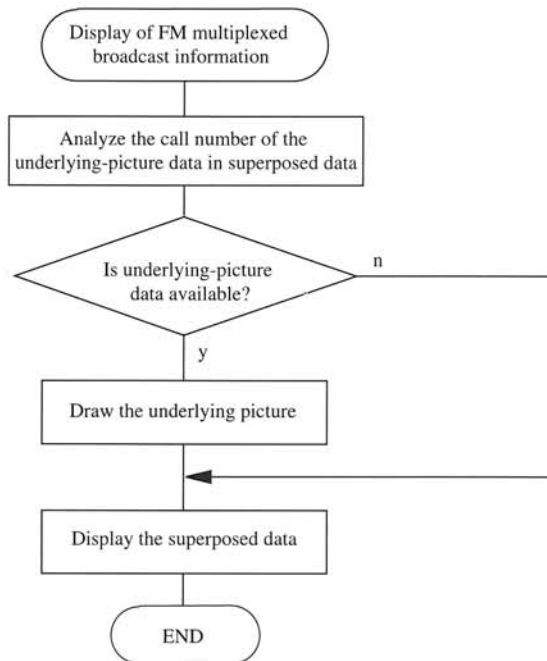


Figure 8. Display flow of FM multiplexed broadcast information

Superposed data and underlying-picture data are separated into blocks according to functions. Typical data blocks are as follows:

- 1) Data block that specifies palette colors for display screens
- 2) Data block that registers characters
- 3) Data block that displays characters, such as kanji and alphanumeric characters. This data block consists of commands and parameters that specify data such as character and background colors, display locations, character size, and characters to be displayed.
- 4) Data block to draw graphics such as lines, circles, and polygons (This data block consists of commands and parameters that specify data such as the graphic types to be displayed, drawing colors, and display locations determined by the starting and ending coordinates.)

The system controller performs processing shown in Figure 9 and displays selected FM multiplex broadcast data.

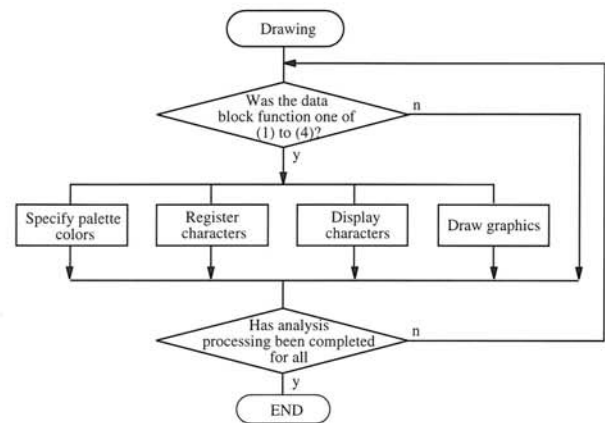


Figure 9. FM multiplexed broadcast data processing

## 4.3 Displaying locations based on beacon information

Table 4 lists the information provided by beacons.

The system controller displays the current-location information received when the car passes a beacon, simplified graphic information, which is dynamic information, and emergency messages. The display methods are described below.

### 1) Displaying current-location information

The system controller uses current-location information when it selects the related area map or performs arithmetic processing on the superposed and displayed location. It displays the location of the vehicle that is carrying the onboard system, which is determined from the location of the beacon under which the vehicle has passed (see Fig. 10).

### 2) Displaying simplified graphic information

The system controller processes simplified graphic information in the same way as it displays information sent by FM multiplexed broadcasting, displaying a simplified map (see Fig. 11).

Table 4. Beacon information

Information type	Information provided
Current-location information	Information such as absolute location of an installed beacon, place and road names of the installation location
Static information	Partially unchanged information, such as name and shape of the next intersection past a beacon installation location, names of roads intersecting at that intersection, and names of places those roads lead to
Dynamic information	Variable information such as an obstacles (e.g., traffic congestion or accidents) on the road near a beacon location, parking space availability, time required to travel, simplified graphic information, and emergency messages



## 3) Displaying emergency messages

The system controller automatically interrupts the current display to display an emergency message,

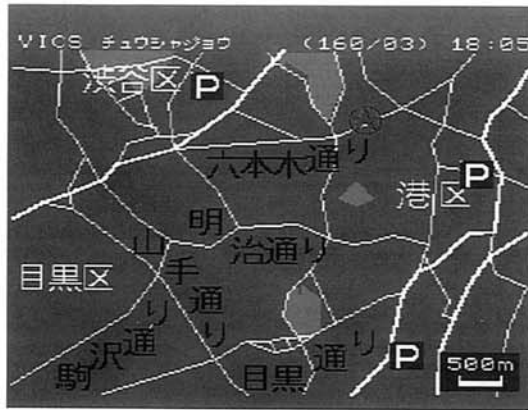


Figure 10. Positioning using road side beacon data

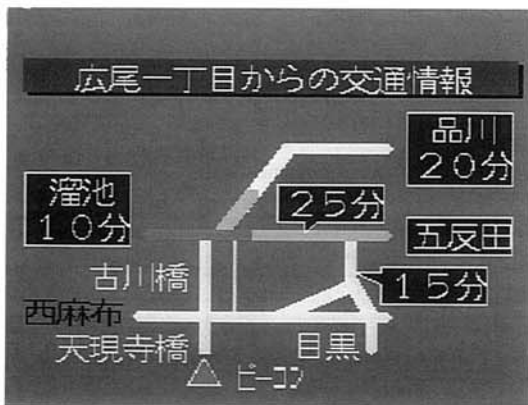


Figure 11. Simplified map display using road side beacon signals

regardless of the current display status. Emergency messages must be posted to car drivers quickly and securely to prevent accidents caused by, for example, road damage, bad weather, or an earthquake.

## 4.4 User interface using voice

If character information sent by FM multiplexed broadcasting or an emergency message sent from a beacon is selected, the system controller displays the information on the screen and outputs it in voice form.

The type of information and an area can be selected using the remote-control unit. They can also be selected using voice commands. The user speaks the number of the screen and the information to be displayed.

We are trying to make driving safer by using voice synthesis and voice recognition.

## 1) Voice system components

The voice system consists of a voice input-output controller, a voice synthesizer, a voice recognition unit, a voice recognition switch, and a microphone. The voice input-output controller has a dictionary for voice synthesis. It can encode data representing the results of voice recognition, and can communicate with the system controller.

## 2) Voice synthesis

The voice synthesizer used is an FMVS-101 made by Fujitsu Limited. The voice synthesis is based on synthesis-by-rule. In this method, the transitional state of one consonant (C) and one vowel (V) is

Table 5. Comparison of voice synthesis methods

	Voice segment recording and editing	Voice parametric representation	Voice synthesis by rules	Text-to-speech conversion
Outline	Many voice segments are recorded, and they are combined as required to produce speech.	Parameters which characterize voices are extracted, and speech is generated from these parameters.	Parameters of short voices are stored, and voices are produced from these voice parameters according to rules.	Voices are produced from voice parameters generated by language level processing, such as syntactic and semantic analyses.
Advantage	This method gives very high sound quality. It reproduces natural speech by using accent and intonation.	This method gives a relatively high sound quality, and achieves about 10 times as much information compression as voice segment recording and editing.	This method can synthesize voices for desired words and phrases.	This method can synthesize desired words and phrases, and uses an appropriate accent and intonation automatically.
Disadvantage	The number of words per unit memory capacity available through synthesis is very small. Voice segment recording and editing therefore require more memory than other methods.	A limited number of words per unit memory capacity are made available through synthesis. The sound quality is limited because part of voice information is removed.	The sound quality is poor (natural sound quality is not possible). Information on an accent and intonation must be provided externally.	The algorithm is complicated. The sound quality is poor at present.

referred to as a CVC, and the transitional states of consonants and vowels are saved in CVCs. The voice dictionary stored in the voice input-output controller contains about 70,000 basic words. Methods for synthesizing voices are compared in Table 5.

### 3) Voice recognition

The voice recognition unit recognizes words using a sound segment network, based on voice segment recognition. By using sound pattern models collected from many speakers, the system can recognize words spoken by a great diversity of speakers. The system takes less than 1 second to recognize each of 200 words. Figure 12 shows the system configuration.

First, the voice recognition system analyzes the spectrum of input voices, and identifies each voice segment by calculating the distance to the sound pattern models. It identifies words using the sound segment network and by applying the rules to determine voice intermittence time.

### 4) Communication method

The voice recognition sequence is as follows: First, the user places the voice recognition unit in the wait mode. Then, the user speaks. These steps improve the recognition rate. If voice synthesis is in progress, the voice recognition unit issues an interrupt message and stops voice synthesis, ensuring a good response characteristic. Figure 13 shows the voice recognition sequence.

Figure 14 is the state transition diagram that shows control of communication by the system controller for voice synthesis and voice recognition.

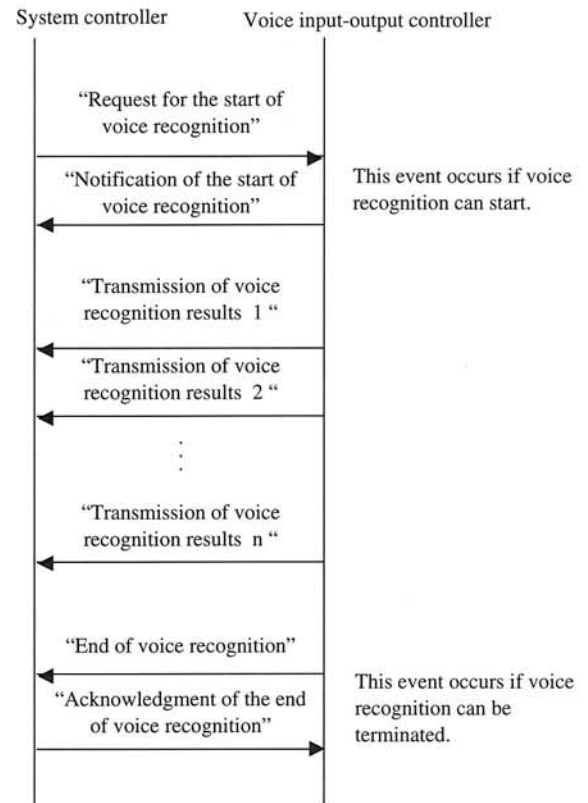
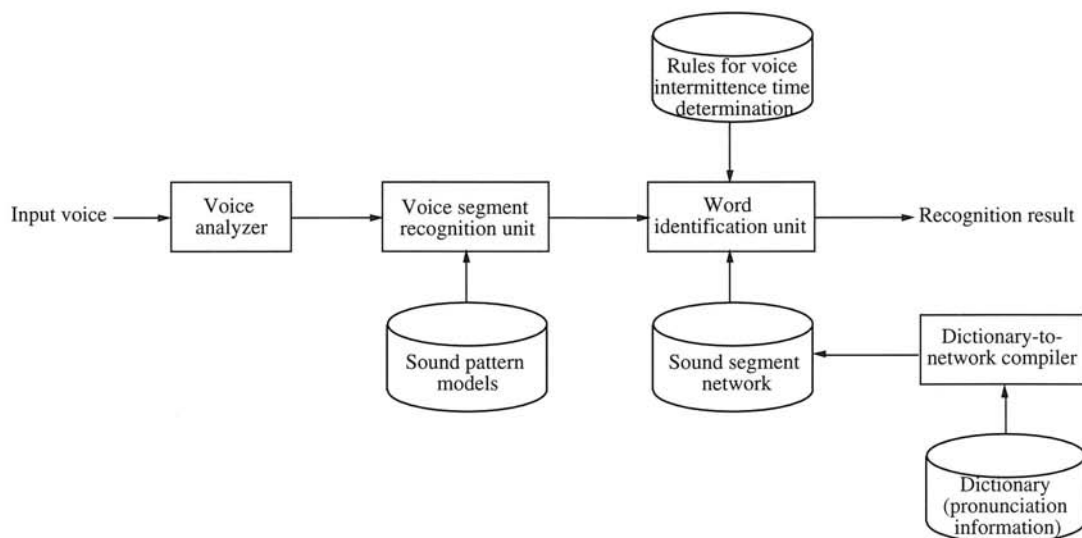


Figure 13. Voice recognition sequence



Voice analyzer: Analyses spectra of voices.

Voice segment recognition unit: Recognizes voice segments by calculating the distance to sound pattern models.

Word identification unit: Recognizes words using the sound segment network and rules for determining voice intermittence time.

Dictionary-to-network compiler: Converts pronunciation information into a dictionary for identification.

Figure 12. Voice recognition system construction

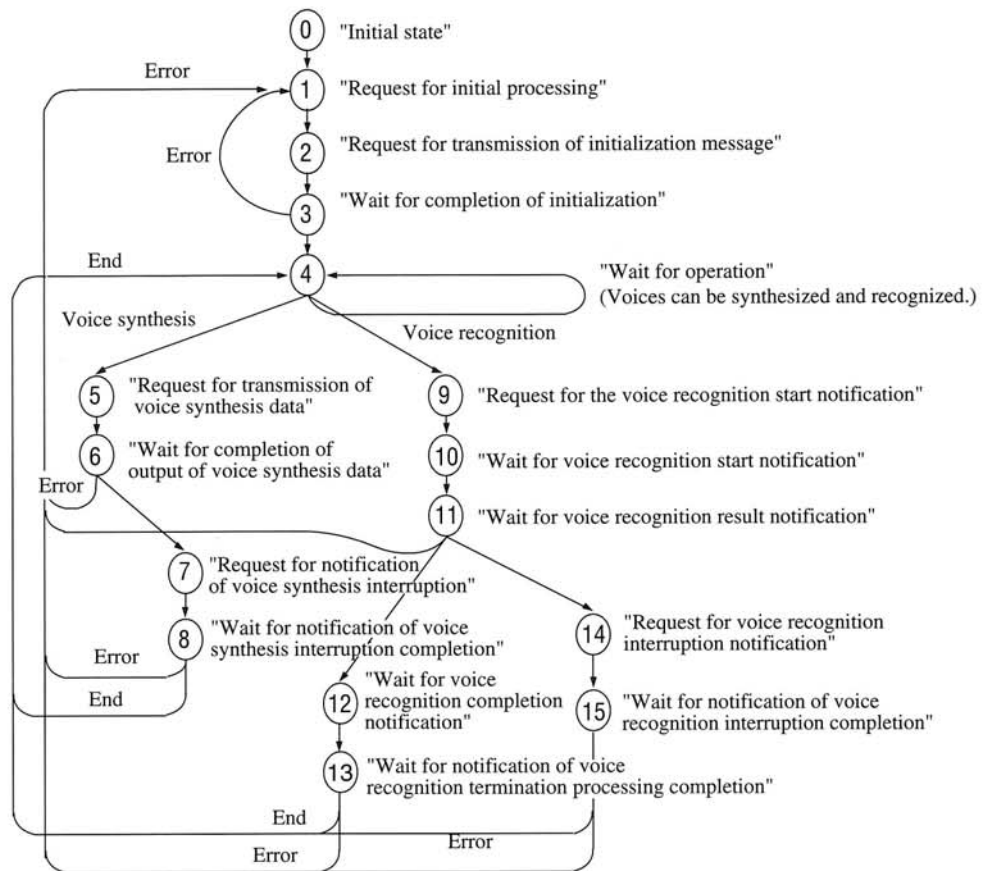


Figure 14. State transition diagram

## 5. Conclusion

Our experiments showed that the information distribution media using FM multiplex broadcasting and beacons can accurately transmit information sent from the VICS center (temporary name). We confirmed that information that helps car drivers select a route can be provided by onboard system devices that process received data.

Future study will include improving the user interface in a car based on our experimental results. Also, we will actively promote development in the fields of communication and control, which are Fujitsu TEN's strengths, to contribute to wider use of VICS.





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