● Technology Reports ●

FOMA In-vehicle Telematics Module and Addition of Network Functionality

In the expanding market for machine communications, NTT DOCOMO has developed the FOMA Telematics Module, for use in devices that require a high level of tolerance, such as passenger vehicles or heavy equipment. Various new functions have also been added to the network to increase usability and convenience for users in vehicles equipped with the module.

Ubiquitous Services Department   **Takaaki Izumi**[†1]

Kouki Tsutsumi

Communication Device Development Department   **Kazuhiko Takahashi**[†2]

Core Network Development Department   **Michiko Wakui**

1. Introduction

With the number of mobile phone subscribers exceeding 100 million in Japan the market for general mobile phones is reaching maturity, but demand is increasing rapidly in the machine-communication market, with applications like vending machines and payment terminals using built-in communications devices to implement functions like tele-metering.

In one segment of this market, the in-vehicle machine-communication market, use of communications in Intelligent Transport Systems (ITS)[*1] is increasing rapidly. Passenger vehicles as well as trucks, heavy equipment and other commercial vehicles are being equipped with in-vehicle communica-

tions devices and functions. These are used to provide safe and secure services like accident mitigation and avoiding traffic-congestion, in-car multimedia systems linked to a Car Navigation systems (hereinafter reffered to as "Car-Navi"), and other services like trip-management, or remote monitoring.

In order to meet this demand in the

in-vehicle machine-communication market, to further expand use of ITS, and to develop new business opportunities, NTT DOCOMO has developed the TM01-SA FOMA Telematics Module (hereinafter reffered to as "Telematics Module"). This is the first device of its kind from NTT DOCOMO (**Photo 1**).

The safe and secure requirements in
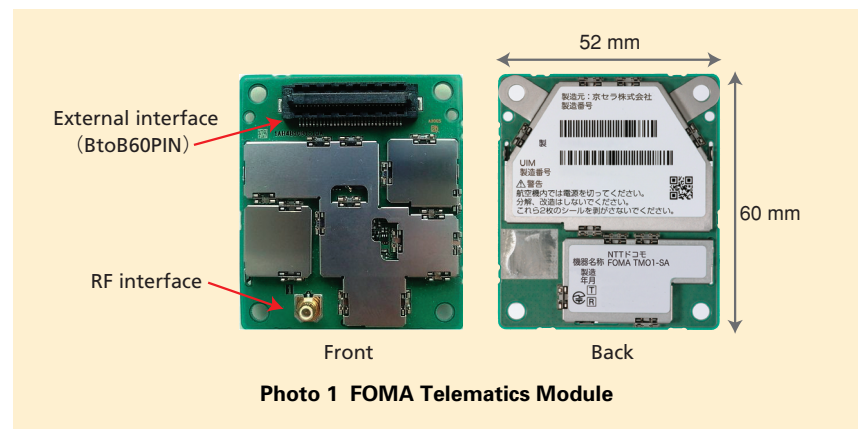
Photo 1 FOMA Telematics Module

---

*1 **ITS**: An overall name for transportation systems using communications technology to improve vehicle management, traffic flow or other issues.

a vehicle environment are very strict and problem-free operation is required under severe conditions, so extremely-high tolerance and reliability is required for the device.

Two major features of the Telematics Module that distinguish it from regular mobile terminals or the FOMA Ubiquitous Module (hereinafter refferd to as "Ubiquitous Module") are that it has been adapted to these severe conditions, and that it has an interface to the vehicle's Electronic Control Unit (ECU)[*2], allowing vehicle-control functions to be provided.

The Ubiquitous Module is an embeddable packet-communications module from NTT DOCOMO that is already being used in the machine-communications market. In addition to this sort of packet communications function, the Telematics Module also includes hands-free voice functions, and voice-calling functions that can be used like a regular telephone when installed in a vehicle or other device. It also includes a videophone function that can be used to remotely monitor the interior or exterior of the vehicle, or provide alcohol-check or other services that use video. Examples of the range of possible applications in the module market are shown in **Figure 1**.

In this article, we first give an overview of the Telematics Module. Then, we describe one of the new network functions, the Self Activation function, which makes it possible to

handle the sale and distribution of vehicles smoothly, particularly in the used-car market. With the introduction of this function, various operational issues can be handled flexibly according to user needs, such as changing modules, having repairs done, purchasing a new car, or initiating use of services and fee payment for products using the Telematics Module.

2. FOMA Telematics Module

2.1 Functional Overview

The Telematics Module is the first communications module to be developed by NTT DOCOMO for use in-vehicles, and its main specifications are shown in **Table 1**. The communication bearer supports voice, video call, packet
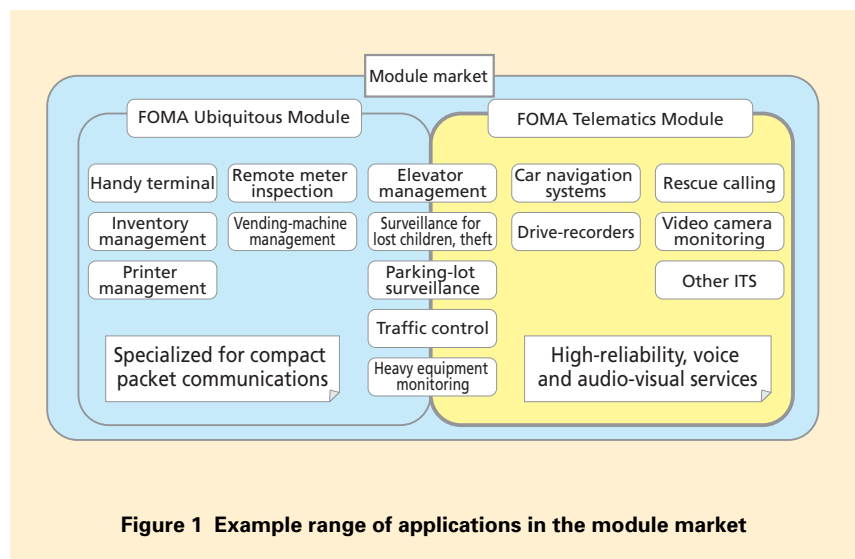

Figure 1 Example range of applications in the module market

Table 1 Major specifications

Item	Detail	Notes
Bearer	・ Voice ・ Videophone (AV64 kbit/s) ・ Packet communications (downlink 384 kbit/s, uplink 64 kbit/s) ・ SMS (vehicle-control SMS receiver only)	Supports multi-access
Frequencies	3GPP Band I (2 GHz band), Band VI (800 MHz band)	
Environmental requirements	・ Operating temperature: – 30 ℃ - +70 ℃ (ambient) ・ Preserving temperature: – 40 ℃ - +85 ℃ (ambient) ・ Operating humidity: 95% RH or less	
Size	Approx. 52.0 (W) × 60.0 (D) × 8.6 (H) mm	Height not including protruding parts of external connectors
Weight	Approx. 29 g	
Power	DC5.0 V	
Main power supply current	・ While communications: 700 mA or less. ・ While in stand-by: 1.5 mA or less (in power-saving mode) 80 mA or less (regular mode, not transmitting)	

*2 **ECU**: A microcomputer unit for controlling automobiles.

communications and Short Message Service (SMS) (although it can only receive vehicle-control SMS). Since it also supports multi-access functionality, it can perform functions like accessing information using the CarNavi browser while the user is talking on the phone. In the vehicle environment where hands-free calling is assumed, this functionality is far superior to the using a regular handset-style mobile terminal.

The module supports the 2 GHz and 800 MHz bands, which includes the FOMA Plus Area[*3], so it can be used over a wide area even in the vehicle mobility environment. The external antenna can be used to ensure that the FOMA terminal delivers good performance while installed in the vehicle by working with the automobile manufacturer during design, development and testing.

The temperature ranges for both guaranteed operation and preservation are extremely important for tolerance and reliability—key features of the Telematics Module as mentioned above. Accordingly, the module operating range is from −30 ℃ to +70 ℃, and the preserving range is from −40 ℃ to +85 ℃, sufficient for in-vehicle use. Note that general temperature ranges as regulated by 3rd Generation Partnership Project (3GPP) standard specifications are from +15 ℃ to +35 ℃ or −10 ℃ to +55 ℃ [1]. The Telematics Module is guaranteed to operate within this temperature range, due to measures starting with careful selection of parts at the design stage, through to reliability testing and inspection during the production process.

2.2 Device Configuration

The Telematics Module has been designed to be used in various configurations. The structure of one example configuration, installed in a vehicle together with a CarNavi system, is shown in **Figure 2**. The vehicle is equipped with various devices such as
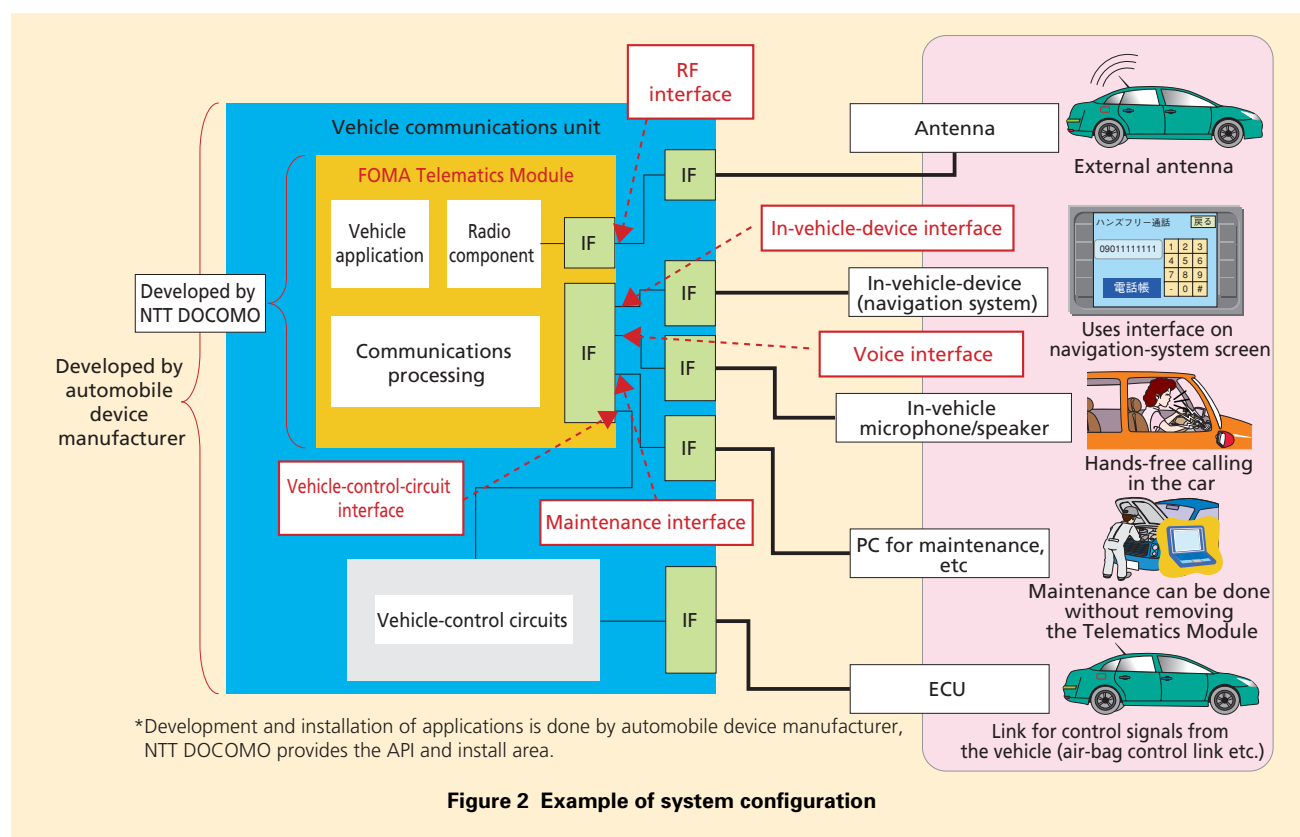

*Development and installation of applications is done by automobile device manufacturer, NTT DOCOMO provides the API and install area.

Figure 2 Example of system configuration

antenna, microphone and speakers on the production line, and these are connected to the Telematics Module, which is embedded in the in-vehicle communication unit by the device manufacturer, through the Radio Frequency (RF) interface[*4], and voice interfaces[*5]. It is also connected to an in-vehicle device (CarNavi) through the in-vehicle-device interface, which is a Universal Serial Bus (USB) interface. Through this interface and using the in-vehicle-device's screen operations, AT commands[*6] can be sent and received through the Telematics Module, which acts as a modem. Finally, the unit is also connected to the ECU, which controls various sensors and other devices in the vehicle, through the vehicle-control-circuit interface, allowing it to collect vehicle data and send control commands to vehicle mechanisms. The module also has a Universal Asynchronous Receiver Transmitter (UART)[*7] maintenance interface allowing maintenance functions such as after-sale software updates.

In addition to the external interfaces described above, the Telematics Module reserves internal memory area for storing vehicle applications, so that in-vehicle device manufacturers can include applications from the various service providers, such as automobile manufacturers, when they incorporate this unit into a product. Whether such applications are included, and what sort of application can be decided based on the particular application.

2.3 Reliability Test Item

In order to ensure the tolerance and reliability characteristics of the Telematics Module, various reliability tests were conducted (**Table 2**). Compared to environmental testing for ordinary, handset-type mobile terminals, very harsh test conditions were used. A level of quality able to withstand in-vehicle use was achieved by repeatedly testing and feeding-back test results into the design. Hardware is particularly susceptible to high and low temperatures and thermal shock, so the layout of parts, circuit-board pattern, soldering conditions and other aspects of Telematics Module were optimized from the design stages to ensure that no defects or operating faults were introduced. Finally, in the production process, from management of parts through to screening inspection work after production, measures are taken to ensure the reliability required for vehicle use and decrease failure rates.

2.4 Other Significant Functions

1) Internal UIM

Due to the temperature and vibration conditions in a vehicle environment, the Telematics Module can not use a FOMA card, so User Identity Module (UIM)[*8] functions such as storing the subscriber information are provided internally.

2) Vehicle-control SMS

The Telematics Module is able to receive vehicle-control SMS messages. When an SMS message with a vehicle-control header is received, an installed application is notified, and actions are taken as required, such as accessing the vehicle-control circuits or creating a packet connection to transmit relevant information.

3) Power-saving Mode

The Telematics Module also has a

Table 2 Reliability test items

Item	Test conditions	Reference specifications (though test parameters vary)
Temperature characteristic test	T=−30℃ - +70℃	JASO D001-94 5.11
Low temperature shelf test	T=−40℃，Fixed time	JASO D001-94 5.12
Low temperature operate test	T=−30℃，Fixed time	JASO D001-94 5.13
High temperature shelf test	T=+85℃，Fixed time	JASO D001-94 5.14
High temperature operate test	T=+70℃，Fixed time	JASO D001-94 5.15
Temperature cycle test	T=−30℃ ←→ +70℃，Fixed cycle	JASO D001-94 5.16
Heat-shock test	T=−30℃ ←→ +80℃，Fixed cycle	JASO D001-94 5.17
Fixed-humidity test	Fixed conditions	JASO D001-94 5.19
Vibration test	Fixed conditions	JASO D001-94 5.23
Static electricity test	Fixed conditions	JASO D001-94 5.8

Japan Automobile Standards Organization (JASO) Standards: Standards from the Society of Automotive Engineers of Japan

---

*4 **RF interface**: Antenna connection point on the Telematics Module.

*5 **Voice interface**: External speaker and microphone connection point for the analog voice signal used in the Telematics Module.

*6 **AT Command**: A command system for communications with the modem.

*7 **UART**: An interface circuit for converting between serial and parallel signals.

*8 **UIM**: An IC card which stores subscriber information including the phone number. Inserted it into the mobile terminal and used to identify the user.

power-saving mode, so that it can operate continuously at low power consumption for applications such as vehicle monitoring, which keep the Telematics Module in standby mode even while the engine is shut off.

4) GPS Functions

The Telematics Module also incorporates a Global Positioning System (GPS) function that supports both the basic positioning method as well as Assisted-GPS (A-GPS) [2]. A-GPS uses supporting data delivered through the FOMA network. The user can also obtain the current location with an installed application that uses the Mobile Originated-Location Request (MO-LR)[*9] procedure [3] as specified by the 3GPP. This function can be used

to offer services such as theft notification, or location notifications in case of accident.

2.5 Service Application Example

The Telematics Module provides more than simple voice and data communications. Through use of installed applications and linkage to the ECU, various services as desired by service providers or automobile manufacturers are anticipated. One example of such a service application is shown in **Figure 3**, in which a user is able to turn off the vehicle lights remotely using his or her mobile terminal. This is just one possible use-case, and we expect that many new types of service not seen before

will be created.

3. Self Activation Function

The International Mobile Subscriber Identity (IMSI)[*10], which identifies the user of the Telematics Module, is only set when the module is first shipped, and after that the Mobile Subscriber ISDN Number (MSISDN)[*11], or phone number, can be registered or changed without changing modules. This allows sale or distribution of vehicles (especially on the used-car market) to be handled smoothly.

As an example, the chain of events from shipping of the Telematics Module, to installation in a vehicle and delivery to the user is shown in **Figure 4**,
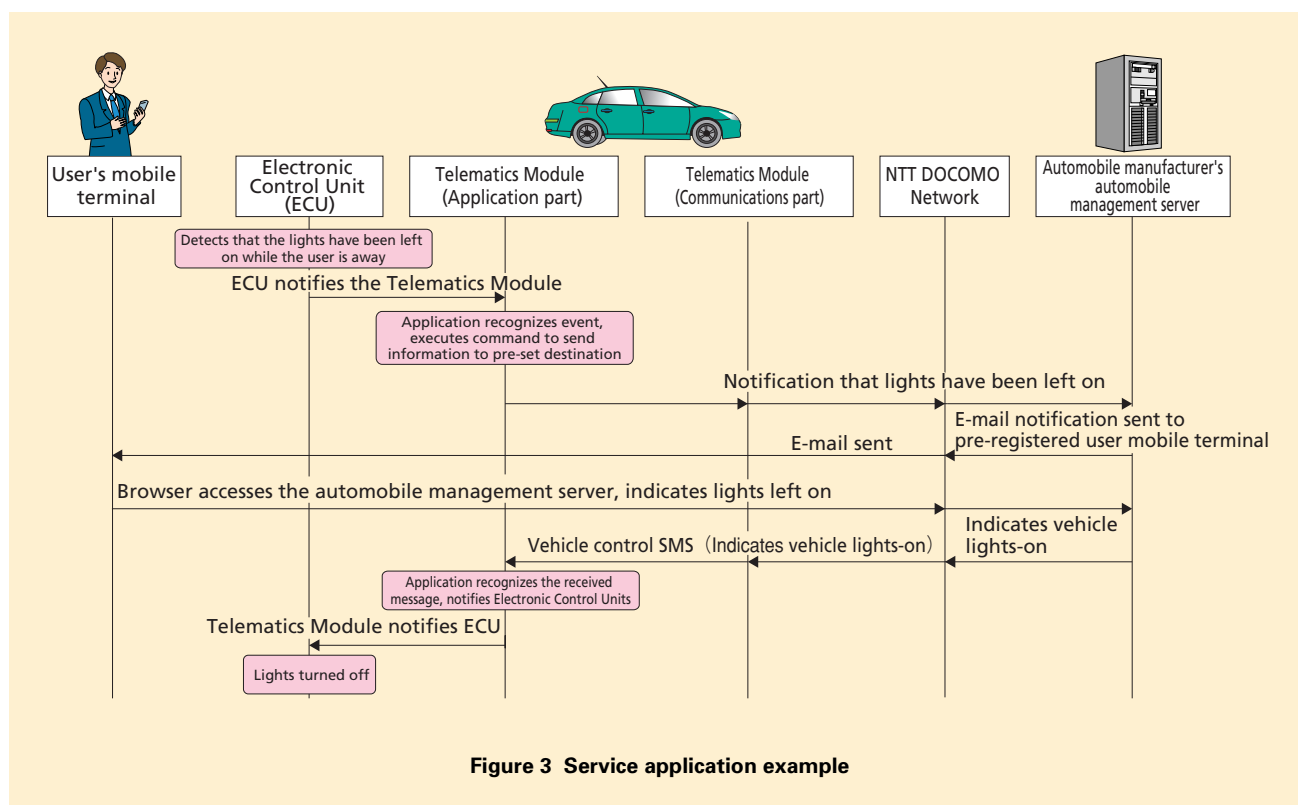

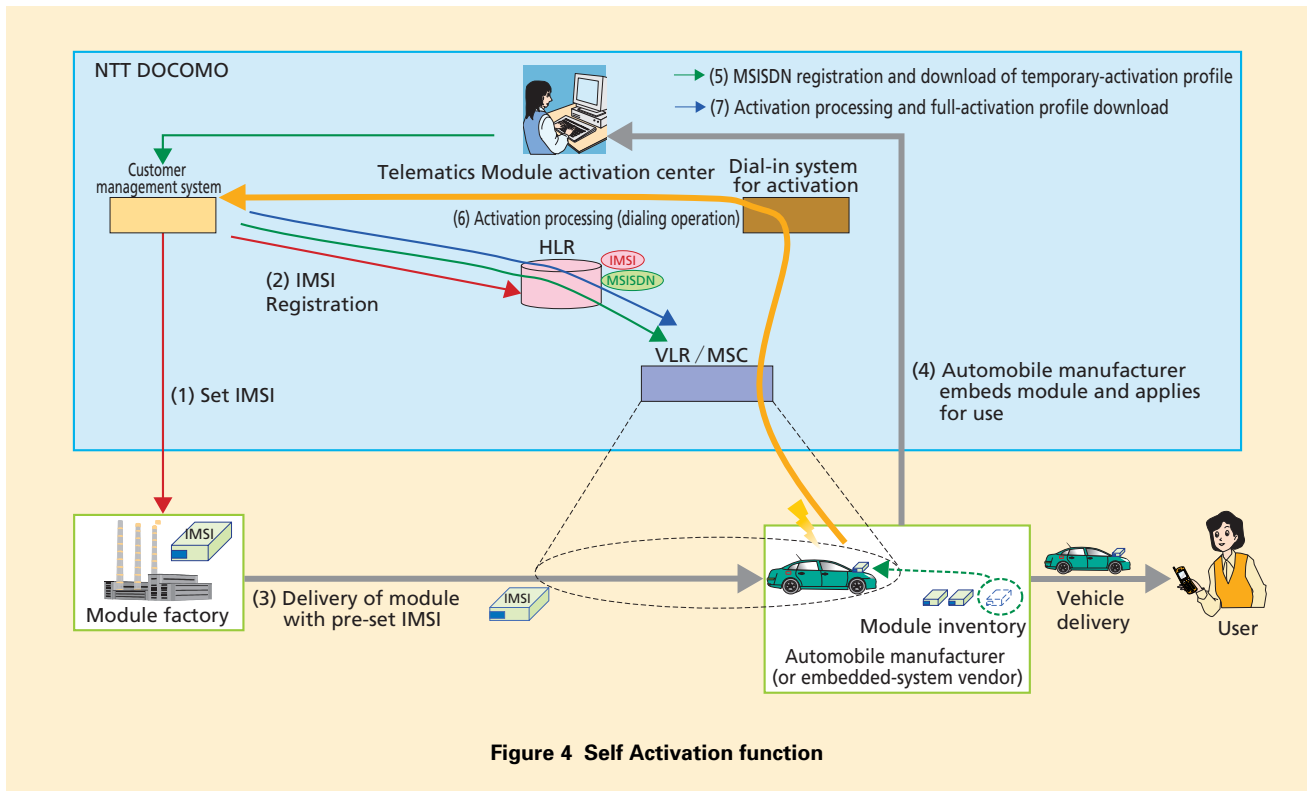**Figure 3 Service application example**

Figure 4 Self Activation function

with details given below.

When the Telematics Module is initially shipped, the IMSI is written to the module (Fig. 4(1)) and registered in the Home Location Register (HLR)[*12] (Fig. 4. (2)) and the module is delivered to the automobile manufacturer's managed inventory (Fig. 4(3)). The module can then be activated at any time.

At the automobile manufacturer, which is also a service provider, if a user would like to use a telematics service[*13], application to use it is submitted at the same time as the NTT DOCOMO Telematics Module is installed and activated (Fig. 4 (4)).

When the Telematics Module is activated, a phone number for the module is allocated through the subscriber-management system.

The subscriber-management system assigns the MSISDN being activated to the IMSI registered in the HLR and the HLR sends a temporary-activation profile for the appropriate phone number to the Visitor Location Register (VLR)[*14] and Mobile Switching Center (MSC)[*15] (Fig. 4 (5)). In this way, a temporary-activation state is created, and the Telematics Module is able to call only to the activation phone number (calls to any other number, receiving calls, and all other services are restricted).

Then, when the vehicle is delivered to the user, the activation number is called (Fig. 4 (6)), and a full-activation request is sent to the HLR through the subscriber management system. The

HLR changes the temporary-activation state[*16] to a full-activation state[*17] for the appropriate MSISDN, and sends control-profile information to the VLR/MSC that will allow the Telematics Module to be used (Fig. 4 (7)). This removes the restriction to calling only the activation number, allowing calls to other numbers and use of the telematics services. The basic usage fee for the Telematics Module is also charged starting when the activation number is called.

By using this sort of Self-Activation function, the user-registration process on the NTT DOCOMO side need not be synchronized with the start of service-provision, allowing the activation timing at the automobile manufacturer

---

*12 **HLR**: A logical node defined by the 3GPP with functions for managing subscriber information and call processing.
*13 **Telematics service**: Any of a variety of types of original service offered by service providers which use the Telematics Module.

*14 **VLR**: A logical node defined by the 3GPP with functions for managing network-location information for subscribers.
*15 **MSC**: A logical node defined by the 3GPP with functions for switching.

*16 **Temporary-activation state**: In this article, indicates a state where the Telematics Module may only communicate with the telematics-service activation number.
*17 **Full-activation state**: In this article, indicates a state where the telematics services can be used.

to be adjusted freely. Service start times can also be adjusted flexibly in cases such as if, after applying for the service with NTT DOCOMO, there are delays in delivery from the factory.

There is also no need to change the module when changing phone numbers, so no labor is required when vehicles using telematics services are bought and sold, or enter the used-car market. The phone number can be assigned freely, so buying and selling can be carried out efficiently.

4. Conclusion

In this article, we have introduced a communications module oriented to the machine communications market, for use in vehicles and designed to operate in harsh environments. In the ITS field, where demand has been increasing rapidly in recent years, we hope to improve user convenience, and expand the range of applications available. This will include providing support for safe and comfortable vehicle operation while providing rich, in-vehicle entertainment, through new services linked to the vehicle's ECU.

We intend to continue active development of communications modules and expansion of network-infrastructure functions to further develop the ITS market as communications technology and functionality progresses, and to strengthen our position with respect to our competitors.

REFERENCES

[1] 3GPP TS25.101: "Technical Specification Group Radio Access Network; User Equipment (UE) radio transmission and reception (FDD)."

[2] Asai et. al, "Location Information Functions for FOMA Terminals—Location Positioning Function—, " NTT DoCoMo Technical Journal, Vol. 7, No. 4, pp. 13-19, Mar. 2006.

[3] 3GPP TS23.271: "Technical Specification Group Services and System Aspects; Functional stage 2 description of Location Services (LCS)."