Technology Reports

FOMA Ubiquitous Module and Addition of Network Functions

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A FOMA Ubiquitous Module has been developed to satisfy demand in the machine communication market. Moreover, user-friendliness has been improved by adding functions to the FOMA network.

1. Introduction

The demand in the machine communication market where data communication is realized with machines, such as product purchases from vending machines using electronic money, the payment of taxi fares by credit card, the remote checking of gas meters or electric power meters, and location information management of trucks and taxis, has increased more than ever. In such an environment, a FOMA Ubiquitous Module and relevant network functions have been developed.

When a product is purchased from a vending machine by utilizing electronic money, a system is required whereby a mobile terminal mounted on the vending machine performs authentication, inquires about the user's balance and other information through a center side server, and then concludes a settlement. In this case, every time electronic money is used, communications between the mobile terminal and center side server are required. However, payment processing operation must be performed quickly to improve user-friendliness for the vending machine user. Particularly, reduction of connection time is an important issue. Likewise, when payment is made for a taxi fare by credit card through a mobile payment terminal, reduction of connection time is required to improve user-friendliness for the taxi user.

When a corporate user introduces a system as described

above, DoCoMo supplies a large number of User Identity Modules (UIMs)[*1] and FOMA Ubiquitous Modules to the corporate user, who then conducts an end-to-end test[*2] to verify successful system integration and correct system operation. The FOMA Ubiquitous Module (hereinafter referred to as a "FOMA module") is a small mobile terminal dedicated to FOMA packet communication, and suitable for integration into such equipment as vending machines (**Photo 1**). Conventionally, a basic charge was applied before a corporate user actually begins to use a system as a service. In this case, since there are a large number of test items and UIMs, the user is billed for expensive basic charges. Consequently, users have requested that the basic charge starting time correspond with the time when actual system utilization begins.

Furthermore, since the needs for high-speed, high-capacity data communications have increased in machine communication applications, users are requesting a smooth transition from existing Personal Digital Cellular (PDC)[*3] terminals to FOMA terminals.

The widespread use of FOMA packet communication in the machine communication market is being promoted by providing a function equivalent to continuous connection (hereinafter referred to as an "instant connection function") with respect to the request for reduction of connection time described above, and an automatic circuit activation function with respect to the request for the start time of the basic charge to correspond with the start time of actual use.

Photo 1 External view of FOMA ubiquitous module

2. Instant Connection Function

2.1 Radio Network Function

Reducing the connection time has been requested to improve user-friendliness for machine communication users. In order to connect a call, the Radio Network Controller (RNC)[*4] must establish a radio circuit as well as a core network connection, with the steps for authentication, ciphering, and other operations being performed between a mobile terminal and the core network. However, the actual situation has been that the time necessary for such operations has not satisfied the connection time required in terms of business requirements. This can be solved by continuous connection where a full connection is established in advance and all connections are maintained. However, since traffic is rarely generated continuously in machine communications, applying a continuous connection results in inefficient maintaining of resources. In particular, the inefficient maintaining of a radio resource[*5] which is difficult to add or increase, significantly reduces the connection quality. Consequently, a method has been adopted whereby instant connection is made for reducing the connection time by releasing only the radio circuit (**Figure 1**).

In this method, when there is no communication traffic for a predetermined time period, the RNC gives an instruction to a FOMA module targeted for instant connection, thus placing the module into the Cell_PCH[*6] state. Since a radio circuit for communications is released in the Cell_PCH state, data cannot be sent or received. However, since the connection between the FOMA module and network is maintained, the steps for authentication, ciphering, and establishing a connection between the RNC and the core network are not required during transition from the Cell_PCH state to a state where data communications can be performed. As a result, it is possible to make a connection in a shorter period of time than with a normal call connection (**Figure 2**).

Meanwhile, since a large volume of traffic is rarely generated in machine communications due to the intended use of the FOMA module, radio resources occupied in the data communication state are also efficiently managed by limiting the maxi-

*1 UIM: A smart card that stores subscriber information such as a telephone number. It is inserted into the mobile terminal to identify the user. A FOMA card is an example of UIM.
*2 End-to-end test: A comprehensive test conducted by utilizing a mobile terminal, radio network, core network, and center side server, while assuming the actual use of services by a user.
*3 PDC: A Second-Generation mobile communication system widely used in Japan, adopted by DoCoMo and others.
*4 RNC: A device defined by the 3GPP for performing radio circuit control and mobility control in the FOMA network.

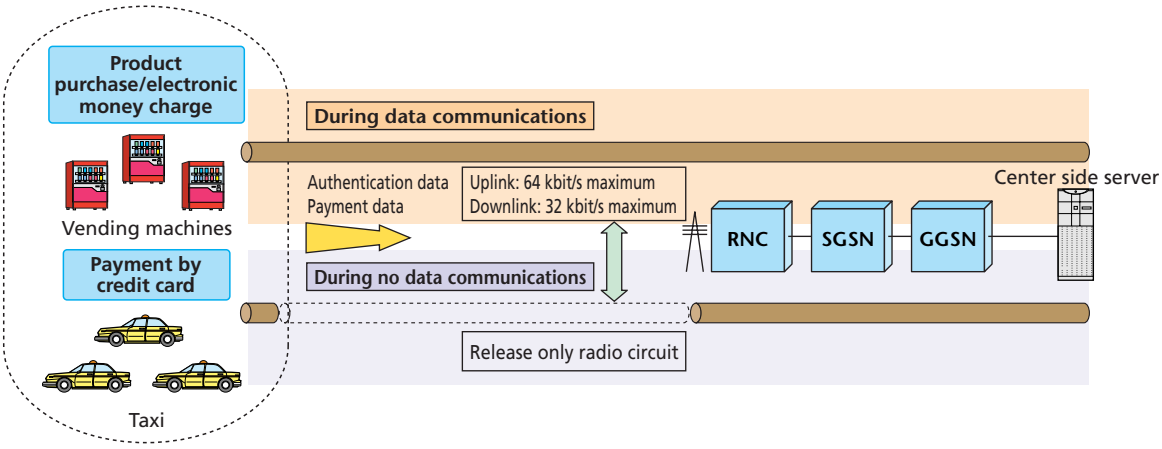
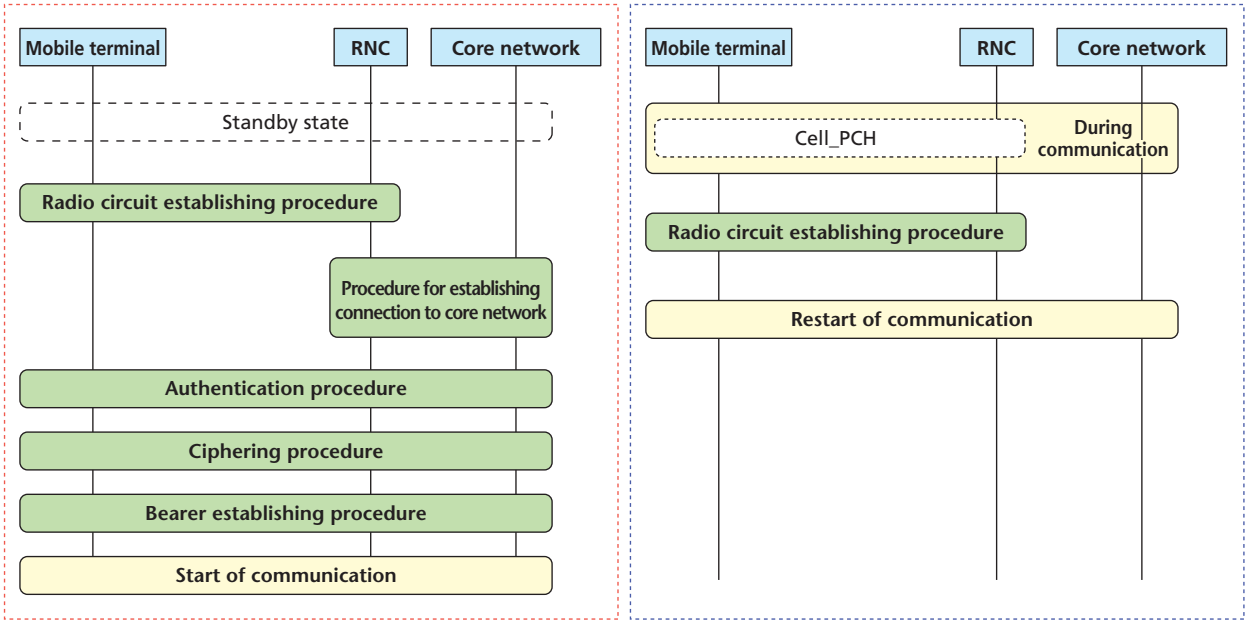


Figure 1 Instant connection service



(a) From call connection to start of communication **(b) From Cell_PCH to restart of communication**

"Bearer" refers to a communication circuit for transmitting information.

Figure 2 Communication starting procedure

mum communication speeds to 64 kbit/s for uplink and 32 kbit/s for downlink, respectively.

2.2 Core Network Function

In order to determine whether control for an instant connection is required when starting communication from a standby state, an instant connection contract state (on the mobile terminal side) is maintained as subscriber information in the Serving General packet radio service Support Node (SGSN)[*7]. In addition, an instant connection contract state (on the Access Point Name (APN)[*8] side) is maintained as an attribute for each APN in the Gateway General packet radio service Support Node (GGSN)[*9]. When an instant connection contract (on the mobile terminal side) exists upon receiving a communication start

*5 Radio resource: A channelization code which is a spreading code utilized to discriminate physical channel in the CDMA system, downlink total transmission power and such.
*6 Cell_PCH: A communicating state as defined by the 3GPP. This is defined to utilize radio circuit resources efficiently and reduce power consumption by a mobile terminal, when no state of communication can exist such as in packet communication.
*7 SGSN: A switching system at the subscriber level as defined by the 3GPP. In the DoCoMo network, the SGSN functions are realized as a part of the xGSN device.
*8 APN: Access point name in a network provided as a point to be connected by a corporate user.

request signal from a FOMA module, the SGSN sends a connection establishment request signal to the RNC by setting an element indicating an instant connection. At the same time, the SGSN also sends a connection establishment request signal to the GGSN by setting an element indicating an instant connection. When an instant connection contract (on the APN side) exists for the APN, the GGSN allows the steps for establishing a connection to continue. Conversely, when no instant connection contract (on the APN side) exists for the APN, the GGSN sends back a connection establishment reject signal to the SGSN, which subsequently terminates communication by sending a communication start reject signal, and a connection release request signal to the FOMA module and RNC.

By performing the verification processing of instant connection contracts for the mobile terminal side and APN side in this way, it is possible to reject a request for instant connection to the APN, which does not consider connection from a FOMA module having an instant connection contract. Therefore, it is possible to prevent resources (such as the number of simultaneous connections) for each APN from being depleted.

2.3 Mobile Terminal Function

A FOMA module is a FOMA terminal capable of handling an instant connection function for use in machine communications, and which can operate in the Cell_PCH state in compliance with 3rd Generation Partnership Project Release 99 (3GPP R99)[*10]. It is possible to maintain a Point to Point Protocol (PPP)[*11] connection established with user equipment by linking the radio network and the core network functions as described above, and when data is generated, it can be sent or received by simply reestablishing a radio circuit from the FOMA module.

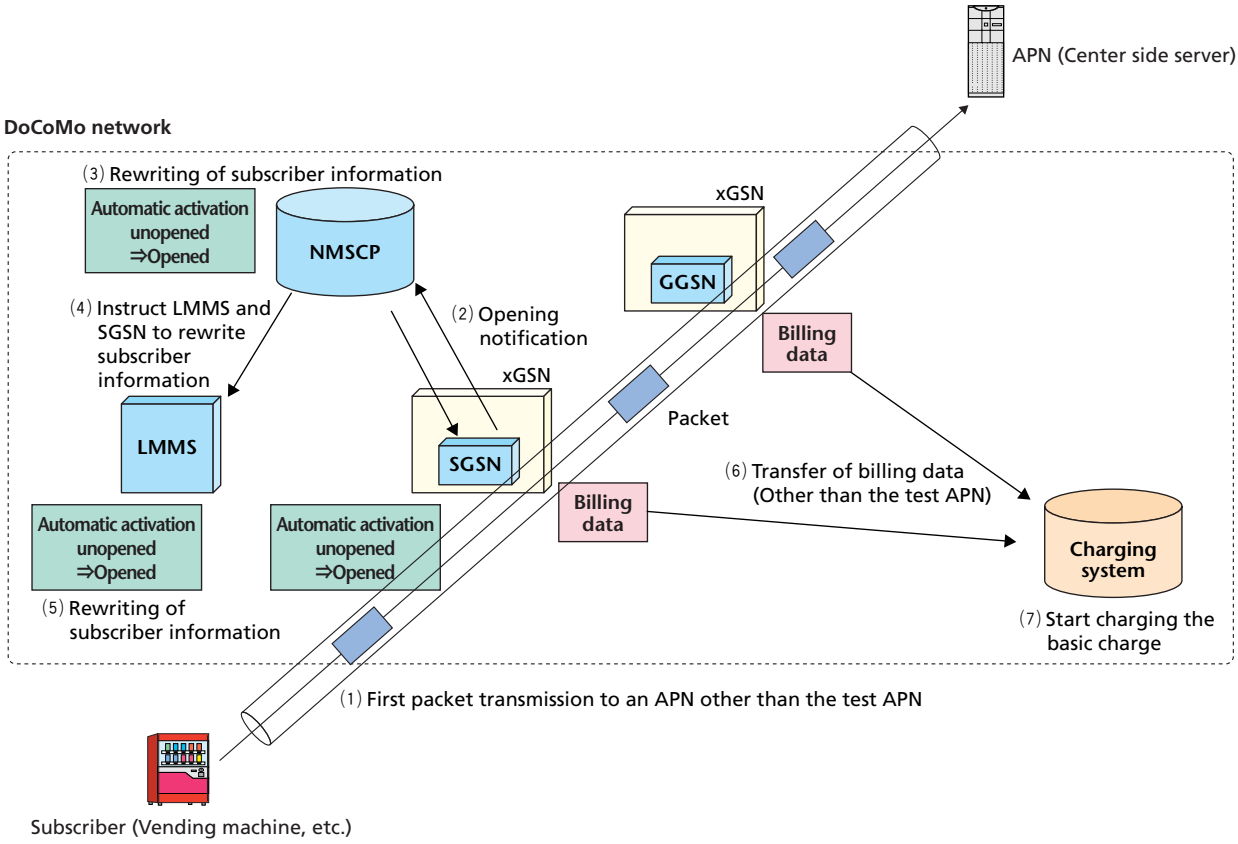
Furthermore, since the DoPa Ubiquitous Module[*12] and DoPa Mobile Ark[*13] are currently provided in PDC, the specifications of a FOMA module are defined in consideration of a future transition from PDC to FOMA. This module is a mobile terminal dedicated to packet communication similar to the DoPa Ubiquitous Module and DoPa Mobile Ark, and can handle dual band frequencies of 2G/800 MHz and packet communication at speeds of 64/384 kbit/s like a typical FOMA terminal, at which speeds a user not applicable to instant connection service by type of contract can communicate. On the other hand, with a type of contract having an instant connection service, the maximum communication circuit speed is limited to 64/32 kbit/s. With respect to transition from the DoPa Ubiquitous Module, the specifications are defined to be compatible in terms of mobile terminal shape, environmental conditions, the serial interface, the AT command[*14], and other factors. Regarding transition from the DoPa Mobile Ark, the compatibilities of the shape and serial interface are considered by specifying an optional interface conversion adapter having a shape similar to that of the DoPa Mobile Ark 9601D[*15].

3. Automatic Circuit Activation Function

It is desirable to apply a basic charge starting from the date when service is actually provided in such markets as the machine communication market, where a certain time period is necessary from when a FOMA module is integrated into user equipment to when service actually begins. In order to verify that a FOMA module is correctly integrated in the user equipment, an end-to-end test must be conducted. At such time, to allow a call origination test from the FOMA module under the condition that a basic charge is not applied (hereinafter referred to as an "automatic activation unopened state") , an automatic activation test APN (hereinafter referred to as a "test APN") is implemented as a destination APN. The GGSN maintains information for each APN to determine whether the APN is a test APN. In addition, in order to reject a connection other than a packet call origination under the automatic activation unopened state, this state is maintained in the SGSN, the Local Mobile Multimedia switching System (LMMS)[*16], and the New Mobile Service Control Point (NMSCP)[*17]. **Figure 3** shows the procedure for connecting a mobile terminal to a general APN under the automatic activation unopened state.

When a general APN other than a test APN is connected under the automatic activation unopened state, both the SGSN and GGSN create billing data triggered by a packet call origination ((1) in Fig. 3) and the SGSN simultaneously sends an opening notification to the NMSCP ((2) in Fig. 3). By using this as a

*9 GGSN: A switching system at the gateway level as defined by the 3GPP. In the DoCoMo network, the GGSN functions are realized as a part of the xGSN device.
*10 3GPP R99: Recommendations (1999 version) by the standardization project for Third-Generation (3G) mobile communication systems.
*11 PPP: A protocol for connecting a computer to a network through a telephone line, used frequently in dial-up connection.
*12 DoPa Ubiquitous Module: A small mobile terminal, sold by DoCoMo, dedicated to packet communication using the PDC system, considered for integration into such equipment as handy terminals.
*13 DoPa Mobile Ark: A mobile terminal, sold by DoCoMo, dedicated to packet communication using the PDC system, considered for integration into such equipment as vending machines.



xGSN (serving/gateway General packet radio service Support Node): A packet communication processing device in the FOMA network, equipped with both the SGSN function and GGSN function defined by the 3GPP.

Figure 3 Opening procedure for automatic activation

triggering point, the NMSCP initiates deletion of the automatic activation unopened state in the SGSN, the LMMS, and the NMSCP to enable transition to a normal opened state ((3) through (5) in Fig. 3). After this, the basic charge is applied by the SGSN and GGSN by transferring the billing data to a charging system ((6) and (7) in Fig. 3). Conversely, when a test APN is connected, the basic charge is not applied because the test APN is distinguished from another general APN by setting an element indicating connection to the test APN in the billing data created by the GGSN.

By using this mechanism, it is possible to provide service based on the type of contract with the start of the basic charge.

4. Conclusion

This article described a newly developed instant connection function and an automatic circuit activation function. However, these functions only represent the first step toward improving user-friendliness for users in the machine communication market.

From now on, competition in the machine communication market will possibly intensify with the entry of other telecommunication companies. We accordingly intend to develop FOMA ubiquitous modules with higher cost performance and more improved functions, and also intend to expand basic network functions that can be commonly utilized in various services in the future by utilizing ubiquitous modules.

*14 AT command: In this article, a means of control for performing an operation to set up or change functions of a mobile terminal through a personal computer, etc.
*15 DoPa Mobile Ark 9601D: A product name of DoPa Mobile Ark sold by DoCoMo.
*16 LMMS: A switching system at the subscriber level for circuit-switching communication in the FOMA network.
*17 NMSCP: A large-capacity mobile communication service controller in the FOMA network/PDC network. Subscriber information is maintained.