Overview of Mobile Network Services and Service Control Technologies for Future Enhancements of IMT-2000

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This paper looks at the trends in mobile communication services in Japan and proposes several service control technologies of Fujitsu and an example service for mobile users. In Japan, some of the major mobile network operators have launched IMT-2000 (Third-generation mobile) services. These services provide users with phone services having superior voice quality and faster data communications than existing second-generation infrastructures. This paper introduces services and products that exploit the capabilities of IMT-2000 and looks at the activities of network operators and service providers. This paper also proposes several of Fujitsu's service control technologies for future mobile communication systems and a service that uses these technologies to provide company users with a secure network access service over a VPN (Virtual Private Network).

1. Introduction

Several major network operators in Japan have launched IMT-2000 wireless services. NTT DoCoMo, Inc., which is the largest mobile network communications company in Japan, launched an IMT-2000 wireless mobile service called FOMA™ note 1) (Freedom Of Mobile multimedia Access)[1)] in October 2001. FOMA operates on the W-CDMA (Wideband Code Division Multiple Access) mobile communication system. NTT DoCoMo has been expanding the service area so that the service will cover 90% of the nationwide population by the end of March 2003.

Also, in April 2002, KDDI Corp. launched its own IMT-2000 cellular phone service. This new service, which is called CDMA2000 1x, is expected to cover 90% of the nationwide population by March 2003. Moreover, J-phone Co., Ltd. launched a W-CDMA-based service in 2002 and is currently conducting trials for an IMT-2000 service that will be commercialized by December 2002.

The Japanese market for mobile communication services in Japan will be a touchstone of the ability of IMT-2000. This paper describes some typical IMT-2000 mobile multimedia services that are available in Japan, for example, visual communications and multimedia Internet services. These services are forerunners of the next-generation wireless mobile communication services that will become available worldwide.

Against this background, Fujitsu has developed several core technologies for developing the services and capabilities of IMT-2000 networks. This paper introduces two core technologies. One is an intelligent Network Middleware for realizing roaming access between heterogeneous networks. The other is the Unified IP service architecture, which is a network-side capability for realizing user-customized network services. Finally, this paper describes a mobile service for

note 1) FOMA is a trademark of NTT DoCoMo,Inc.

company mobile users that employs these two technologies.

2. Trends of IMT-2000 services in Japan[2)]

2.1 Visual communication services

One of the most popular IMT-2000 data services is visual communication.

Some of NTT DoCoMo's FOMA handset models have built-in digital cameras.[1),3)] The first-generation model has a camera with a 110 000-pixel resolution and a 200% zoom. The second-generation models have two cameras, one on the front and another on the top. These handsets can transmit voice and real-time video simultaneously, so users can communicate with each other "face-to-face" via cellular phone. A trial multicast video streaming service has also been launched. The video content can be transmitted in RTP (Real-time Transport Protocol)[4)] packets.

In March 2002, KDDI also launched its CDMA2000 service and released a handset terminal that has a built-in 350 000-pixel digital camera.[5)] With this handset, users can capture high-quality still pictures and share them with other subscribers. The camera view is shown on a 2-inch LCD that can display a maximum of 260 000 colors. The handset also has a GPS (Global Positioning System) function that indicates the user's location.

Users can also enjoy their cameras more by using various entertainment functions. One of the most attractive of these is the "frame stamp" function, which enables users to freely decorate their photographs with several types of frame-shaped image. Users can download their favorite frame from the service provider's Web sites. These kinds of imaging functions are very popular, especially among young people in Japan.

The visual communication service is expected to be an important source of earnings among the IMT-2000 services.

2.2 Mobile multimedia Internet service

2.2.1 IMT-2000 services from Japan

NTT DoCoMo's i-mode is one of the most successful mobile Internet services in the world. The number of i-mode-compliant sites has been growing rapidly, not only in Japan, but also around the world. In April 2002 in the U.S., AT&T Wireless Services, Inc. launched a wireless data service called mMode based on i-mode. The service offers compatibility with i-mode services. mMode users can access i-mode sites from their handsets. In addition, AT&T has linked the service with America Online, Inc. (AOL) so that AOL's e-mail and Instant Messenger services are available through mMode. In Europe, German operator E-Plus launched an i-mode service in March 2002.

2.2.2 Benefits of high-speed bearer of FOMA

At the launch of IMT-2000, more than 60 content providers offered over 500 contents. IMT-2000 makes these kind of services more comfortable and convenient. For instance, thanks to FOMA's high-speed packet transmission at receiving speeds up to 384 kb/s, access to i-mode sites and reception of e-mail-attached multimedia data are much faster. Users can easily exchange e-mail with still pictures and music data via i-mode. E-mail can also be exchanged between a FOMA handset and a PC via the Internet, so attached multimedia data can be processed as required on a PC. For example, users can take still pictures using the built-in camera of a FOMA handset and send it to a PC via the Internet, where it can be edited.

A number of ISPs (Internet Service Providers) provide a connection service and content delivery services with i-mode on FOMA. For instance, Fujitsu's @nifty, which is the largest ISP in Japan, is managing a portal site, mobile@nifty, that is specialized for mobile devices (e.g., browser-phones and PDAs). The site has a wide range of contents for mobile communication devices, for example, business information, sports news, music charts, and travel information. The wide spread of IMT-2000

handsets will stimulate these sites to deliver more competitive contents by using multimedia functionalities.

2.2.3 Downloadable Java application support

Most of the IMT-2000 handsets in use in Japan also support Java-based applications that the user can download from a content provider's site. Users can enjoy high-quality video games and information delivery services with a sophisticated user interface. At the early stage of i-mode, Java-based applications mainly focused on the entertainment area, for example, games. However, the high-speed transmission capabilities of IMT-2000 and the larger capacities of terminals has made it possible to use more complex and intelligent Java-based applications. A number of content providers are planning to develop and deliver not only existing entertainment applications, but also business applications.

2.2.4 An example motion imaging service: i-motion™ note 2)

NTT DoCoMo has launched a new Internet service called i-motion that allows users to download audio and video files from i-mode sites to their handset. Users can easily access video content, including news footage, video clips from movies, sample audio files from music CDs, and so on. It is also quite easy for content providers to deliver their content through i-motion. All users have to do is visit their Web sites. Contents such as audio and video files are sent to and stored in the i-motion center operated by NTT DoCoMo via the Internet. Then, the i-motion center sends the contents to FOMA handsets as requested by the users with high-speed packet transmission at up to 384 kb/s. The configuration of the IMT-2000 network including i-motion functions and terminals is shown in **Figure 1**. The data types that are supported are MPEG4 video files and AMR (Adaptive Multi-Rate) audio files. Thanks to the easy content creation environment and delivery capabilities, the number of content providers and their contents are growing rapidly.

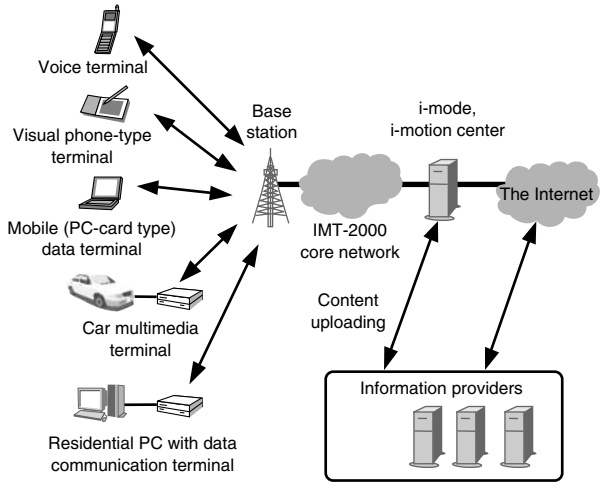

Figure 1
Configuration of IMT-2000 network and terminals.

note 2) i-motion is a trademark of NTT DoCoMo,Inc.

2.3 Multimedia terminals

The latest line-ups of IMT-2000 terminals have a wide range of functions and visual designs to suit the users' life styles. At the first stage of IMT-2000 in Japan, most of the terminals were handsets similar in appearance to 2G handsets. On the other hand, the terminals in the new categories that are specialized for data services are expected to create new market segments in IMT-2000, for example, car-multimedia and indoor high-speed data communication.

An example of these new terminals in Japan is NTT DoCoMo's PC-card (PCMCIA) type FOMA terminal, which offers a downlink speed of up to 384 kb/s and an uplink speed of up to 64 kb/s. These new terminals will enable users to enjoy high-quality mobile computing.

Some of the terminals specialized for indoor data communications can configure small-scale LANs (Local Area Networks), for example, inside a house or small office. One such terminal is a portable FOMA terminal manufactured by Fujitsu that offers a unique mobile communication style. This terminal consists of

a main unit and a wireless handset and looks like a wireless telephone set for PSTN voice services. The two-piece design of this terminal is an outstanding feature of this lineup of FOMA terminals.

The main unit of this terminal contains a FOMA radio module (air interface), an antenna, and a router with four RJ-45 (10BASE-T) ports. The main unit and handset are linked together via Bluetooth™, which is a low-power, personal-area wireless system for connecting various types of peripherals and home appliances. With this model, a user can conduct a telephone conversation and simultaneously perform data communication at up to 384 kb/s in the downlink and up to 64 kb/s in the uplink.

The unique features of models of this type give them the potential of creating new market segments. This type of product suits "nomadic" users who access networks from, for example, temporary offices or vehicles. The basic requirements for using existing broadband services such as DSL (Digital Subscriber Line) or CATV (cable TV) are that the access point is wired and residential. However, because of its portability with routing capabilities and high-speed wireless access, this model overcomes these restrictions.

3. Future enhancements of IMT-2000

3.1 Network architecture

As mentioned above, the current trends in IMT-2000 wireless services have been mainly driven by the entertainment field, especially for individual users. On the other hand, company users are main contributors to the revenues of IMT-2000 network operators. As with the services for individual users, emerging network services for cooperate users are expected to increase the service revenue of network operators. It is said that the emerging wireless services (e.g., wireless LAN services) will be formidable competitors to IMT-2000. In relation to this competition, the authors expect IMT-2000 service providers to take the lead in the wireless services market by strategically installing new technologies that will restrict the development of the emerging wireless services.

Figure 2 shows an example of a network convergence utilizing seamless roaming services that will be realized in the near future. In this figure, IMT-2000 network operators are assumed to handle the emerging wireless technologies by inter-working them with IMT-2000 as supplemental services. The authors expect that this service strategy will increase user-convenience.

3.2 Two key-technologies in IMT-2000 wireless

Predicting the key feature of mobile services in the near future is difficult and requires careful consideration. Various types of solutions for enhancing IMT-2000 services are possible. In this section, the authors describe some of their expectations regarding two key-technologies.

3.2.1 The background: High-speed bearer service

This is already offered by most of the IMT-2000 network operators as a main feature. It promotes a new category of services, for example, high-speed data bearer with handover capability.

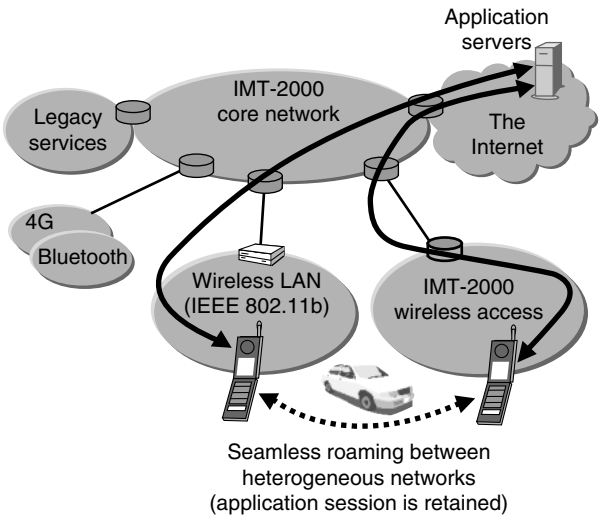

Figure 2
An example of seamless service.

3.2.2 The first key-technology: Collaboration of heterogeneous networks

This is a service capability that combines different types of bearer capabilities (e.g., bearer speeds and operation costs). The authors expect that this will be the key to promoting collaboration of IMT-2000 and emerging wireless technologies that create new market segments.

For example, wireless LAN (e.g., IEEE 802.11 series) access technologies enable network operators to build "hot-spot" services that can quickly provide cost-effective and high-speed (e.g., 11 Mb/s in the case of 802.11b) network access. The capabilities of a wireless LAN are different from those of IMT-2000 wireless services. IMT-2000 is superior in terms of its population coverage and handover mechanism. On the other hand, a wireless LAN can handle more data than IMT-2000. The combination of these two access technologies will enable service providers and network operators to create new types of network services that complement each other.

3.2.3 The second key-technology: User-by-user-based service control

This is a set of capabilities that are deployed in IP core networks. Cellular phones and similar mobile communications devices are currently dominant in the communications terminal markets. However, to catch up with the diversity of services, the physical shapes and the functionalities of mobile terminals will become increasingly diversified. Also, network intelligence will be essential for adapting the services to the users' environments.

Fujitsu has developed a network-side technology and a terminal-side technology to enhance the existing IMT-2000 network architecture and services based on the strategy of collaborating with heterogeneous wireless services.

3.3 Network Middleware

This is an answer for the first key. Fujitsu Laboratories has released a network technology that enables mobile users to access multiple types of heterogeneous wireless networks utilizing seamless roaming.[6)]

The middleware in a user's terminal monitors the network status (field strength at available air-interfaces) and automatically switches to the appropriate bearer without the user being aware of it. The bearer-selection rules are specified in the user's preferences and referenced by application programs. With this middleware technology, mobile users can access a network without needing to select a bearer.

3.4 Unified IP service control architecture

This is a solution for the second key. To provide a user-by-user-based service control, Fujitsu Laboratories has also developed the Unified IP service control architecture.[7)] **Figure 3** shows a

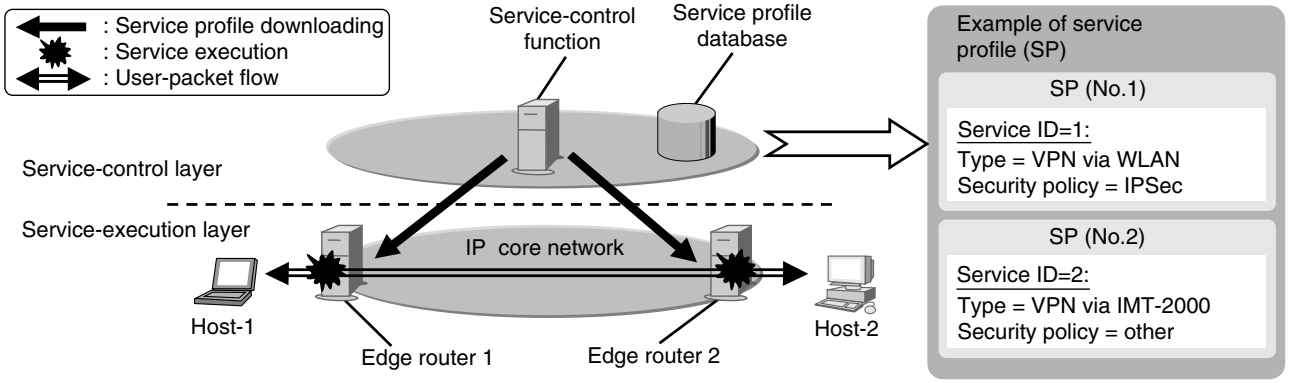

Figure 3
Conceptual network model and service profile.

conceptual network model and service profile of the architecture.

The architecture provides users' mobile hosts with customized network services. In a mobile network for commercial use, it is assumed that each mobile host executes the location registration procedure to notify the network of its current location (e.g., at an edge router that accommodates the mobile host) in the network. In the registration procedure, the network authenticates and validates the mobile host to permit network access. The architecture uses this procedure to distribute the service profile (SP), which specifies the user's service details, to the edge node where the mobile host is currently accommodated. The SP is then distributed to the edge routers in messages that are sent in response to registration requests.

The edge routers then adopt the behavior specified in the SP for the mobile host.

4. An example of Fujitsu's service scenario; Mobile IP-based VPN service

4.1 Overview

This section outlines a solution for a mobile network service that uses the key Fujitsu technologies mentioned above. Fujitsu Laboratories has also developed the Mobile IP-based VPN (Virtual Private Network) service capabilities based on the proposed technologies (Network Middleware and Unified IP service control architecture).

Recently, company users have been interested in network access solutions that are focused on mobile users. One of the most popular applications for company users is the secure mobile-access service. This service offers connectivity to an office network from an external (visiting) network by utilizing mobile-devices such as PCs, PDAs, and browser phones over a secure connection on a VPN. Several network vendors and system integrators have released equipment with VPN functionalities (clients and gateways) for this area of the market.

However, we investigated the existing VPN-access services for mobile users and found two fundamental problems: 1) users must manually switch the network parameters and 2) few VPNs support fast handover. These problems and proposed solutions are described below.

4.2 Automatic bearer selection

4.2.1 Problem 1: Manual switching of network parameters

Mobile users must know their current position in the network environment both inside and outside the company network, and the conditions of the networks that are available depend on the strength of the airwaves. Therefore, users have to switch the network-related parameters in the mobile host before starting to connect, which might be a difficult task for most users.

4.2.2 Solution: Automatic bearer selection by Network Middleware

This problem can be solved by using the first key, Network Middleware, so that mobile users do not need to adjust the network parameters on starting the connection procedure. With this solution, users can access the network without having to consider bearer selection.

4.3 Seamless roaming support for VPN

4.3.1 Problem 2: VPN with fast handover capabilities

In relation to the previous item, most of the recent, major VPNs, which use the IPsec (IP security protocol), do not support high-speed handover. **Figure 4** shows a conventional mobile VPN that uses the IKE (Internet Key Exchange) procedure. When a mobile host roams into a wireless service area, it initiates IKE between itself and the VPN gateway in the office network. After the completion of IKE, the mobile host executes the location registration procedure to enable the other host to send packets to the registered mobile host.

In the conventional procedure, several mes-

sage exchanges are needed to establish VPN paths and complete the Mobile IP registrations. This affects the length of the registration time at handover.

4.3.2 Solution: Seamless roaming support by Unified IP service control architecture

This solution supports seamless handover between different types of bearers by using the Unified IP service control architecture, which is the second key. The architecture uses the Mobile IP[8),9)] protocol, which provides mobility capabilities in an IP network, to distribute VPN keys to mobile hosts.

Figure 5 outlines the configuration and procedure of the proposed service. The network mainly consists of three parts: an application server, a VPN gateway, and a Mobile VPN server. The application server is located inside the company network and provides various services such as e-mail and Web access. The VPN gateway is located on the edge of the company network and terminates the VPN path to the Mobile VPN server. The Mobile VPN server is the core part of the service and provides two main capabilities. One is to retain the static VPN paths to the VPN gateways of company users. (The static VPN tunnel is generated according to a contract between the enterprise users and the network operator.) The other function is to generate dynamic VPN paths to the mobile host, depending on the security level of the wireless access services where the mobile host is located.

The operation procedures are as follows. When a mobile host moves into a wireless area, it first initiates the Mobile IP registration procedure. A registration-request message is sent to the VPN server, which has the Home Agent capability of Mobile IP. The VPN server prepares a VPN key for the user and stores it in the service profile, which specifies the user's service conditions based on the user's contract. The service profile (including the VPN key) is sent to the user's host by including it in a Mobile IP registration-reply message. Then, the VPN key is distributed in the Mobile IP registration procedure. This procedure shortens the time needed to establish a VPN path at handover.

This procedure also makes it possible to establish VPN paths with different schemes, according to the security level of the access network.

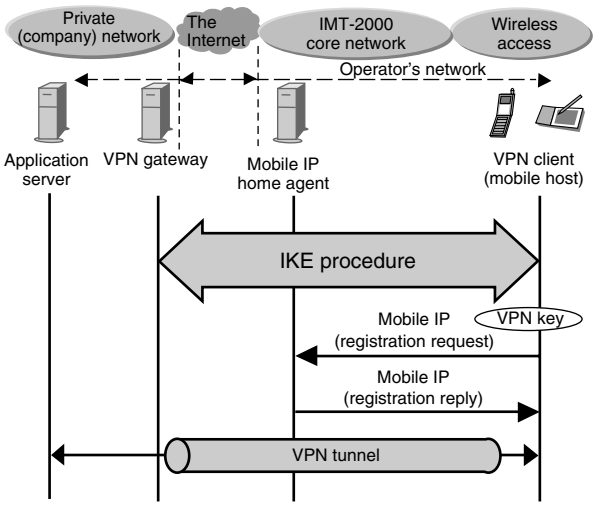

Figure 4
Conventional IKE-based VPN for mobile hosts.

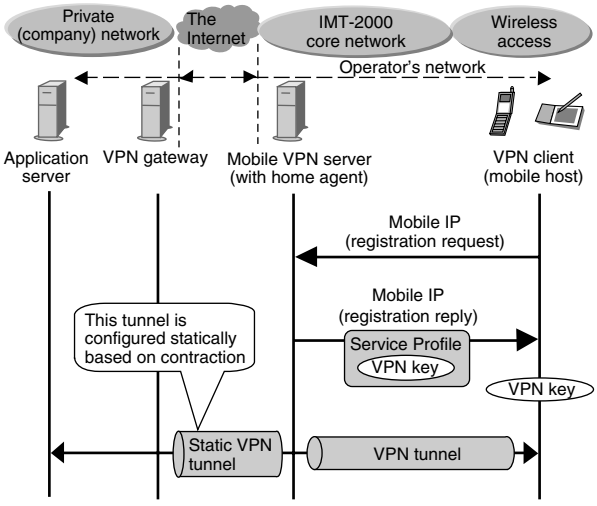

Figure 5
Proposed Mobile IP-based VPN service.

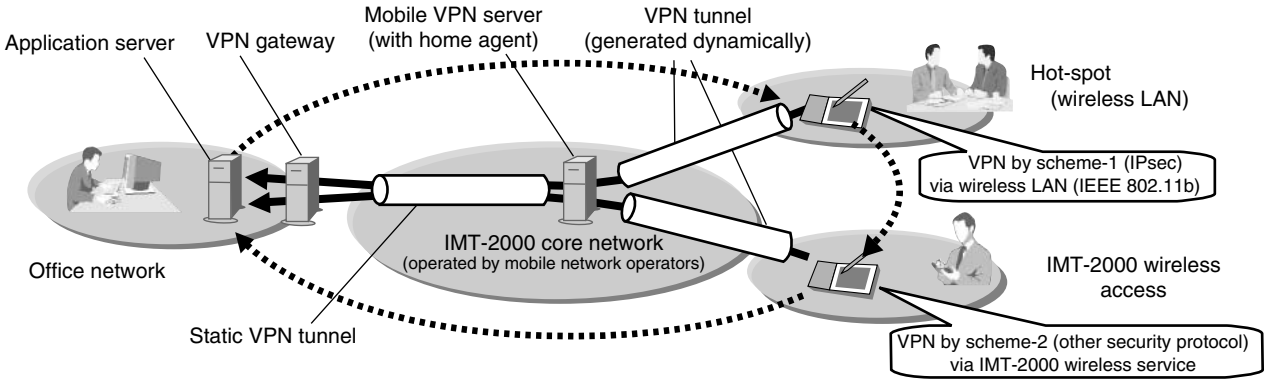

Figure 6
Image of proposed Mobile IP-based VPN service.

4.4 Service description

This section gives a detailed description of the Mobile IP-based VPN service (**Figure 6**):

The service enables a company-user's mobile host to access the company's private network from an outside network (also called a visiting network) while retaining a private IP address assigned in the private network. The main target customers of the service are companies that want to provide their employees with network-access services over a VPN that provides secure communications between mobile hosts (employees) and VPN gateways located at the edges of the companies' private networks.

An example service scenario that involves three different network environments is given below.

4.4.1 Environment 1: The office network

A company employee connects to the office network using a PC and is assigned a private IP address.

4.4.2 Environment 2: A hot-spot (wireless LAN)

The user goes out of the office to meet clients. The meeting venue provides a hotspot (wireless LAN) access service. In this environment, the user can connect to the office network by starting a connection wizard without needing to consider what type of wireless service is being used. Then, the user's mobile host (PC) starts to connect to the office network using an automatically detected and selected bearer as specified in the user's preferences. The mobile host senses the wireless LAN access, and a VPN path to the user's office network is prepared using an IPsec-based VPN.

4.4.3 Environment 3: An IMT-2000 wireless network service

On the way back to the office, the user moves to another environment while maintaining the VPN session with the office network that was established in Environment 2.

There is no wireless LAN in this environment, but an IMT-2000-wireless service is available. In this situation, the Network Middleware in the wireless module automatically seeks and switches to the available IMT-2000 wireless service and generates a VPN path to the office network by initiating the Mobile IP registration procedure. The user's application then continues to operate over the new VPN path without interruption.

The Mobile IP-based service functionality also enables the mobile host to receive messages in real-time like an inward call of a VoIP (Voice over IP) service.

5. Conclusion

This paper looked at the trends in IMT-2000 services in Japan and introduced some of Fujitsu's service control technologies for future IMT-2000 wireless services.

Regarding recent trends in IMT-2000 wireless services, visual communication and Internet access services are popular. These services are expected to be the major forces behind future expansions in the IMT-2000 service market.

Several IMT-2000 terminals with new features have been released to create and support a new style of use for mobile users. Terminals specialized for data communications are coming onto market and are expected to occupy a growing place in the IMT-2000 terminals market.

IMT-2000 services can be advanced by considering other wireless technologies. Several new wireless services (e.g., IEEE 802.11 series of wireless LANs) have become popular because of their cost-effectiveness and high-speed data rate. Some of these new services compete with existing IMT-2000 services, but others are expected to collaborate with IMT-2000 wireless infrastructures.

Fujitsu Laboratories has proposed two key technologies for service control to promote collaboration with heterogeneous wireless technologies. When combined with Fujitsu's strategy of "Customer Focus," these network technologies are expected to increase the market value of our IMT-2000 services.

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