Next-generation Mobile-access IP Network

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OVERVIEW: The recent growth in the use of the Internet and mobile communications is remarkable. It has resulted in Internet access using mobile communications being positioned to overtake fixed network access. However, the data-transfer capabilities of current mobile communications, which is based mainly on circuit switching for voice, are insufficient for implementing systems to distribute music and maps and particularly for distributing movies, which require higher speed data transfer. The next-generation of mobile communications now being standardized thus takes into account the need for high-speed data transfer. Practical implementation is targeted for 2001. This paper describes an IP access network system that enables high-speed data transfer suitable for the next-generation mobile-communication IP network and that will enable mobile application of push-type services.

INTRODUCTION

SINCE 1995, the number of mobile communication users and the number of Internet users in Japan have been increasing. Mobile communications in the beginning was aimed at "placing a call from any place, at any time," but it was only an extension of existing fixed-telephone communications, mainly voice communication. And in Japan, those accessing the Internet have mostly been in industry, academia, and public organizations.

However, the advent of services enabling the mobile terminal to easily access the Internet in February 1999 enabled the provision of net business services. Service providers rapidly acquired users who had not previously accessed the Internet. The number of Internet users using mobile communications exceeded ten million in May 2000[1)].

The existing mobile access systems, used mainly for voice communication, use transmission speeds of 9,600 bit/s, 32 kbit/s, or 64 kbit/s depending on the type of communication. With these low speeds, it is difficult for existing systems to distribute complex contents such as music and dynamic images, which are considered to be the mainstream of Internet business in the future. From this background, the development of "IMT-2000," the next-generation multimedia mobile communication system, has started worldwide.

This paper describes an IP (Internet protocol) access network system that enables high-speed data transfer suitable for next-generation mobile-communication IP networks, and that will enable mobile application of push-type services.

NEXT-GENERATION MOBILE ACCESS IP NETWORK

Network Configuration

The configuration of next-generation high-speed mobile-access IP networks was standardized by the 3rd Generation Partnership Project 2, an international standardization organization. As shown in Fig. 1, the network components are arranged to connect a mobile station, to an access point (AP), to a consolidation router (CR), to a packet data serving node (PDSN), and finally to a home agent (HA).

The access point (AP) has the functions of existing base stations and base station controllers; it performs radio resource control and mobile station position control, including data transfer rate adjustment and dormant control according to the conditions of the radio section.

The consolidation router (CR), which connects with multiple APs, routes data from each AP to the PDSN assigned to that AP, and concentrates the physical lines.

Mobile Station Position Control

The mobile station position control uses mobile IP and is provided by the foreign agent (FA) installed in the PDSN. Mobile IP technology enables the same IP address to be used as the mobile station moves from

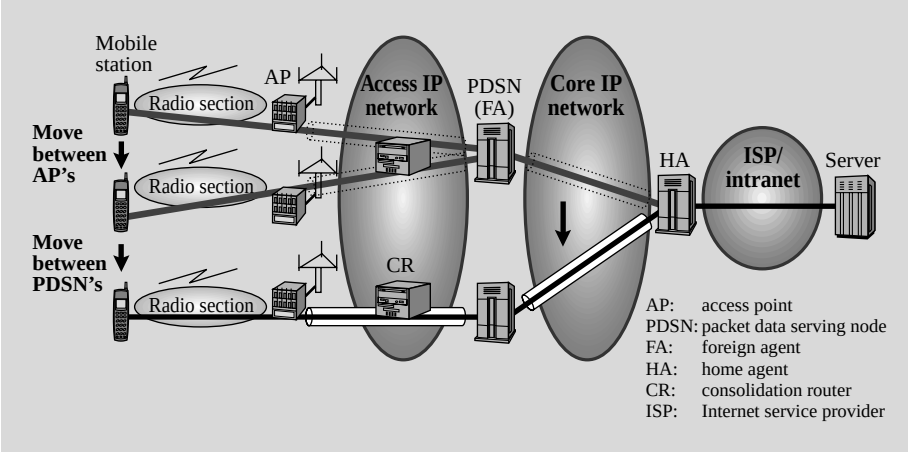

Fig. 1—Configration and Mobility Management Mechanism of Next-generation High-speed Mobile-access IP Network.

AP to AP. The home agent seizes packets sent to the mobile station's home IP address, and then by encapsulating the packets (called "IP in IP"), transfers them to the PDSN (FA) to which the mobile station currently belongs.

A similar feature is provided in the section between an AP and PDSN. The PDSN can identify the destination AP for data because a new registration is processed between the AP and PDSN when the mobile station moves to another AP.

IMPLEMENTATION OF PUSH-TYPE SERVICE ON NEXT-GENERATION MOBILE-ACCESS IP NETWORKS

New Push-type Services

The next-generation high-speed mobile-access IP network system is intended to implement not only high-speed mobile-access services but also constant radio-connection services. The creation of new radio applications is expected as vehicle-mounted PCs become used as mobile stations because there will be no battery consumption problems, thus enabling constant radio connection. For example, "mobile server service" using a mobile station as the server can be implemented; this push-type service is not available with current networks.

Example Push-type Services and Problems to Be Solved

Table 1 lists examples of new push-type information-distribution services. The core of these services is items #1 to #3; the others can be classified as pseudo push-type services. For radio advertisement (#1) and emergency information (#2) services, which need real-time communication, the key concept is the continuous transfer of contents to a moving terminal. This requires the development of a method for continuously distributing contents to a moving terminal.

The mobile server service (#3) could be implemented by assigning IPv4 global addresses, now scarce in number, to public transportation vehicles

TABLE 1. Example Push-type Information-distribution Services

#	Service	Type	Problems to be solved
1	Radio advertisement	Push service from station server to mobile server	Realization of push-type contents distribution method according to the geographical position of mobile terminals
2	Emergency information		
3	Mobile server service	Push service from mobile server	Exhaustion of IPv4 global addresses
4	Auction and stock trading	Push service with conditions from station server to mobile server that can be dynamically specified by users	Realization of high-speed and effective push-type information-distributing system and push-type information-distributing system with address-conversion function other than notification by e-mail
5	Traffic information		
6	Map-distribution-type car navigation system		
7	Transport car management		

including buses and trains, and business vehicles including taxis. There are, however, not enough IPv4 global addresses for millions of mobile stations. Hitachi has thus developed network address translation-protocol translation (NAT-PT) to implement push-type services from the network side by using IPv4 private addresses assigned to general vehicles, mobile terminals, and PCs on a per session basis. In this concept, the problem to be solved is how to implement a function for assigning global addresses.

IMPLEMENTATION OF NEW PUSH-TYPE SERVICE

Implementation Using Existing Method

Internet access services using the wireless application protocol are implemented by converting the private IP address dynamically assigned to a mobile station into a global IP address by using the network address translation feature of the NAT gateway (GW)[2].

A translation system using this feature usually implements a pull-type service using a private IP address by converting the IPv4 private address of a mobile station into the IPv4 global address of the NAT gateway when a packet forwarded to the Internet arrives at the gateway. The system performs a reverse conversion when a response from the Internet arrives at the gateway.

Implementation Using Hitachi's Method

In next-generation high-speed mobile-access IP networks, push-type services will require the conversion of an IPv4 global address into an IPv4 private address. This conversion can be implemented by additionally installing the multicast-to-unicast conversion feature on a NAT gateway to convert IPv4 multicast addresses into IPv4 private addresses.

Moreover, in combination with the contents server, the position-dependent entity that maintains the mobile station's geographical position data can "push" the specified information to several mobile stations located at the same position. Such area-limited push-type services are considered particularly effective for implementing radio advertisement and emergency information services. Fig. 2 illustrates the NAT gateway system configuration for providing area-limited push-type services.

For area-limited services, the contents server may push different services to different multicast addresses or push all the information to a NAT gateway in advance. When a contents server pushes information in advance, information distribution is performed by converting the multicast information into unicast information by filtering for information cached at the gateway.

The services can be implemented without installing the multicast feature in mobile stations, if a gateway joins the IP multicast group on behalf of the mobile stations, as determined by the network address identifier of each mobile station. As mentioned, push-type services can be implemented without modifying the mobile stations if conversion of addresses and contents is performed using information about the users and their service contracts stored at the gateway.

Here we assume that both the contents push server

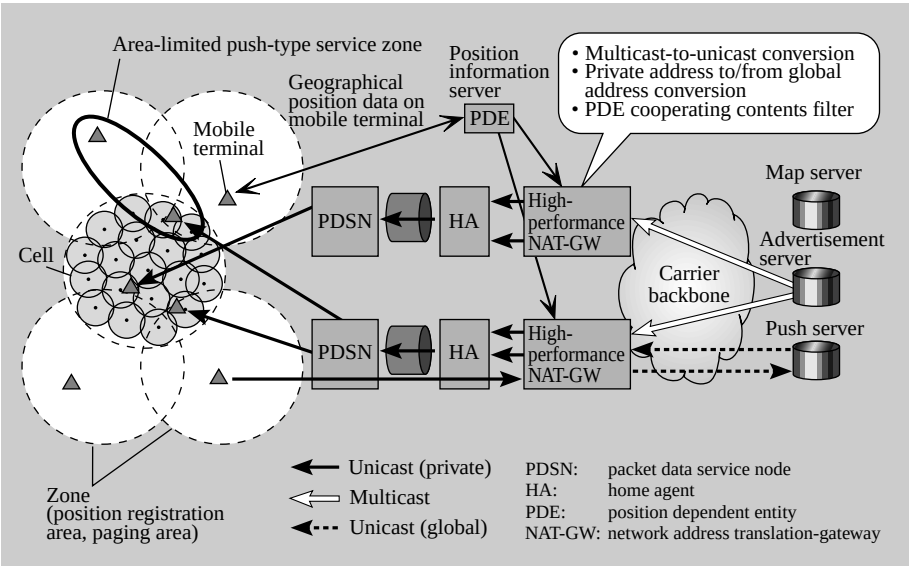

Fig. 2—NAT Gateway System Configuration.

and the mobile station are IPv4 countable. Address conversion by NAT-PT at a NAT gateway will still be required even if the mobile station is changed to be IPv6 compatible. If the contents push server is changed to be IPv6 compatible, it will not be required. However, high-level NAT gateway features like contents conversion will be essential for many services.

CONCLUSIONS

The next-generation high-speed mobile-access IP network system discussed so far ensures the high-speed data transfer with radio characteristics without spoiling the mobility inherent in mobile stations. Hitachi anticipates that the network system will implement the following services at "any time, any place, conveniently," utilizing the advantages of the mobile access network system.

(1) Distribution of large volumes of data such as for movies, music CDs, and electronic books.
(2) High-speed virtual private network services connecting office and home and headquarters and satellite offices.
(3) Instant unified messaging.

Furthermore, different types of mobile contents distribution are expected to emerge along with the proliferation of high-speed mobile-access IP network systems including those discussed here. It is also expected that the newest technologies including IPv6 will be introduced and that all IP networking services including voice will be implemented[3].

REFERENCES

(1) Report of the Telecommunications Carriers Association of Japan (Aug. 2000).
(2) Y. Takeda et al., "VPN Configuration Using Dynamic DNS," IEICE SSE99-184 (Mar. 2000).
(3) T. Oishi et al., "Mobile Network with IP Technology," IEICE No. 146 (Feb. 2000).

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