Seamless Access to Multiple Networks Using Domain Name Resolution

Akihiro Otaka†, Morimichi Hirahashi, and Masahide Migita

Abstract

We have developed a new method of achieving seamless access to multiple networks, such as the Internet and a content delivery network (CDN), based on domain name resolution with a novel concept of network priority. It lets users access to a CDN without manually switching network connections.

1. Seamless access to multiple networks

Communication technologies related to the Internet protocol (IP) have been developed mainly for communication between computers. Today, however, many other types of IP-based services, such as video distribution and IP telephony, are under development. In these situations, IP networks will be constructed according to the specifications for each service. For example, a content delivery network (CDN) could be developed to facilitate a high-quality video distribution service, providing higher quality than could be achieved with the Internet. It would be constructed as a separate network, independent of the Internet. However, it would be inconvenient for users to have to reconfigure their computers whenever they want to change access networks. Therefore, seamless multiple-network access will be important.

2. DNS-based seamless access method

In this article, we propose a new method of seamless access to multiple networks, based on domain name resolution with a novel concept of network priority. Our method provides seamless access by utilizing the domain name system (DNS) in an environment consisting of multiple network connections. DNS is a technology used to translate a domain name, such as "ansl.com" that one might input into a web browser, into an IP address. In our method, the terminal of a user who wants to access a server while connected to multiple networks sends DNS query packets to each network. If the terminal receives more than one DNS response packet, an optimum network is selected according to network priority. This new concept of network priority with DNS facilitates a new domain name space that is independent of the Internet. **Figure 1** shows an example of a new mirror service[*1] using this method. In this case, two different IP addresses in the CDN and the Internet are used for the same domain name. The DNS server in the Internet and that in the CDN respond to different IP addresses as a result of queries for the same domain name. Thus, the Internet access user accesses the Internet-based server by using the conventional DNS sequence, while the CDN user accesses the CDN-based server with high-quality contents automatically by using this new access method.

We have implemented our new method in an environment with simultaneous connections to a PPP-based access network (PPP: point-to-point protocol) and a native IP-based CDN. In this article, we illustrate two types of access based on this method: the

† NTT Access Network Service Systems Laboratories
Chiba-shi, 261-0023 Japan
E-mail: ootaka@ansl.ntt.co.jp

*1 Mirror service: One of the network services for contents holders. Using this service, one can deliver contents smoothly using multiple servers. Content in an original server is copied to some "mirror" servers and users can access the most convenient server automatically. In this article, the word "mirror service" includes the case where a copy of higher quality than the original one is put on mirror servers.

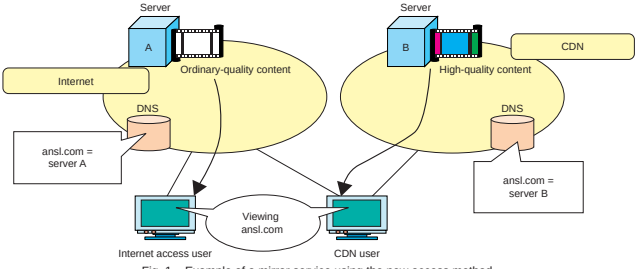

Fig. 1. Example of a mirror service using the new access method.

user-terminal-type method and the network-type method. First, we examine the user-terminal type, which is designed for user PCs connected to two networks, with the seamless access functions implemented as software on the PCs. Then, we discuss some limitations of the user-terminal-type method and show how the network-type method can provide greater convenience.

3. User-terminal-type access method

Figure 2 illustrates the user-terminal-type seamless access method. In this figure, a user PC is connected to two networks. One is a PPP-based access network, through which the PC accesses the Internet by using PPPoE (PPP over Ethernet). The other is a CDN, through which the PC accesses a content server storing high-quality contents by using native IP. The PC is assigned two IP addresses, one by each network. Both the Internet and the CDN include DNS servers, whose IP addresses are configured on the PC in advance. The Internet and the CDN also both include content servers, with low-bit-rate sample contents on the Internet server and high-quality original contents on the CDN server. In this situation, the PC is a splitting point with respect to the two networks, so it must have a function for selecting the more suitable network and content server in a given situation.

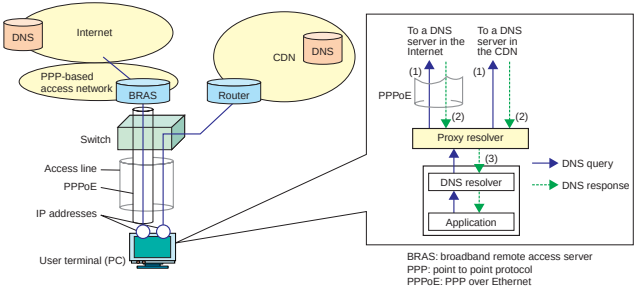

Fig. 2. DNS-based seamless access method: user-terminal type.

We have implemented the DNS-based access method as software, called a proxy resolver, running on the Windows operating system. This enables us to add this new function without changing the existing DNS resolver in Windows.

Figure 2 shows a schematic view of this approach. First, an application on the PC asks the proxy resolver for the IP address of the content server. The proxy resolver sends DNS query packets to the Internet DNS server and the CDN DNS server simultaneously (step (1) in the figure). Each DNS server replies with a DNS response packet (step (2)). The proxy resolver receives these packets and chooses the optimum DNS response as the result of name resolution according to the network priority. It then sends the result to the application through the DNS resolver (step (3)). As a result of this sequence, if the domain name is resolved in the CDN, the application can access the CDN server, while if it is not resolved in the CDN, the application accesses the Internet server. Because the PC cannot know in advance which response it will receive first, the proxy resolver waits for the DNS response packet from the CDN for a certain time. If this DNS response packet does not arrive within this time, the proxy resolver sends the results from the Internet to the application. This waiting step enables the DNS response from the CDN to be handled with the appropriate priority.

In this method, the DNS server and content servers in the Internet do not have to make any changes. Therefore, the user can continue to access the Internet server as normal through the PPP-based access network. On the other hand, the DNS server in the CDN does not reply to queries intended for the Internet-based DNS server, so it does not have to register any Internet servers. This ensures that the CDN can be constructed independently from the Internet domain.

There are two major issues with applying the user-terminal-type access method. First, this approach performs network selection only for domain name resolution, and the IP routing for the server should be determined independently from the name resolution. This means that although the PC can obtain a suitable IP address with this method, it will not know which network the address belongs to. Therefore, the IP routing table for the PC has to be configured some other way.

The second issue is that the DNS response from the Internet must be stored by the proxy resolver for some time, called the "waiting time". This means that the Internet domain name resolution cannot take less time than this waiting time. However, we think that the waiting time can be reduced sufficiently to prevent any inconvenience to users during typical usage, such as Web access, because the only requirement for the waiting time is that it should be longer than the DNS response time from the CDN.

4. Network-type access method

To resolve the problems with the user-terminal-type approach, we developed the network-type seamless access method (**Fig. 3**). The PC is connected only to the Internet, through the PPP-based access network by PPPoE. This means that only one IP address and the DNS server's address are assigned to the PC from

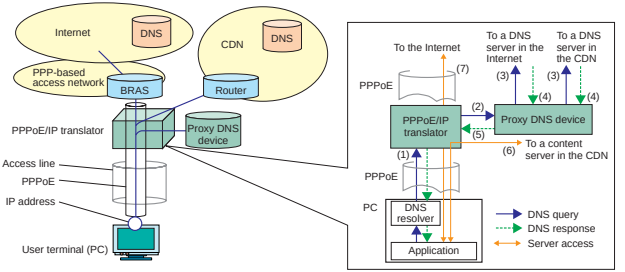

Fig. 3. DNS-based seamless access method: network type.

the Internet. Any IP addresses related to the CDN, such as a default gateway address or a DNS address, are not configured on the PC. Instead, the PC can access the CDN through a PPPoE/IP translator and proxy DNS device. These technologies facilitate DNS-based seamless access and IP routing to communicate with the CDN content server. Thus, as with the user-terminal-type method, DNS and content servers are located in both the CDN and the Internet.

In the first step of the network-type method, as illustrated in Fig. 3, the PC sends a DNS query packet to the network (step (1) in the figure). The PC is only connected to the Internet through the PPP-based access network, so the destination IP address of the DNS query packet is the DNS server in the Internet, and the packet is encapsulated by PPPoE. The PPPoE/IP translator detects the DNS query packet, removes the PPPoE header, and sends it to the proxy DNS device as an IP packet (step (2)). The proxy DNS device receives the packet and resolves the domain name as a proxy for the PC. It then sends DNS query packets to the Internet DNS server and the CDN DNS server simultaneously (step (3)), in the same manner as for the user-terminal-type access method. The DNS servers reply with DNS response packets (step (4)). The proxy DNS device receives the DNS response packets, selects the DNS response from the network with higher priority as the DNS result, and sends the appropriate DNS response packet back to the PC through the PPPoE/IP translator (step (5)). The operating sequence of the proxy DNS device is thus the same as that of the proxy resolver in the user-terminal-type method. These network functions provide the PC with an environment in which nothing changes with respect to name resolution in the Internet.

The proxy DNS device caches the name resolution data requested by PCs. As a result, it can provide a DNS response immediately, without sending a new request to the DNS servers. It can also refresh this data by periodically sending requests to the DNS servers. Thus, this approach resolves the second issue of the waiting time in the user-terminal-type method.

The PPPoE/IP translator can resolve the first issue, in which the IP routing table for the PC must be configured in advance. The PPPoE/IP translator examines the IP headers of the PPPoE-encapsulated IP packets. If the destination of an IP packet is in the CDN, the translator removes the PPPoE header from the packet and sends it as an IP packet to a router in the CDN (step (6)). On the other hand, if the IP packet is not destined for the CDN and it is not a DNS query packet, the translator transmits it without removing the PPPoE header by applying the bridge transmission approach (step (7)). Thus, the PPPoE/IP translator can correctly send packets to the CDN or to the Internet through the PPP-based access network.

This sequence of operations in the DNS-based seamless access method lets a PC access the optimum server automatically, without requiring any additional functions or configuration.

5. Summary

We have proposed a new method for seamless access to multiple networks, based on DNS with a novel concept of network priority. This method allows convenient access to a CDN in an environment with simultaneous connections to the Internet and the CDN.

Akihiro Otaka
Senior Research Engineer, NTT Access Network Service Systems Laboratories.
He received the M.S. degree in physics from the University of Tokyo, Tokyo in 1991 and joined NTT's LSI Laboratories the same year. He is now working on broadband access systems and networks. He is a member of the Institute of Electronics, Information and Communication Engineers and the Japan Society of Applied Physics.

Morimichi Hirahashi
Senior Research Engineer, NTT Access Network Service Systems Laboratories.
He received the M.E. degree in civil engineering from Tohoku University, Sendai, Miyagi. After working on broadband access systems and networks for NTT Access Network Service Systems Laboratories, he moved to NTT West in 2003 .

Masahide Migita
Research Engineer, NTT Access Network Service Systems Laboratories.
He received the B.E. and M.E. degrees in civil engineering from Kyushu University, Fukuoka in 1993 and 1995, respectively. After working in optical access network planning, he moved to NTT West in 2003 and is now promoting broadband services.