Open 6to4 Relay Router Operation

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Abstract

A method called 6to4 enables separate IPv6 sites to connect to the IPv6 Internet via a 6to4 relay router without an explicit IPv6 over IPv4 tunnel setup. There are currently about ten open 6to4 relay routers worldwide but none of these had been installed in Japan. We therefore decided to evaluate 6to4 technology and set ourselves the goal of improving 6to4 operation within Japan. To accomplish this, in March 2002, we installed an open 6to4 relay router within Japan with the cooperation of the WIDE Project and started this experiment. This paper describes our experiment and reports statistical information acquired in operation as well as problems during operation.

1. Introduction

Progress is being made on introduction of IPv6 [3] into the Internet but this progress has not yet reached the end user. So in many cases, the IPv6-over-IPv4 tunneling technique [2] is used to connect end users to the IPv6 Internet. The method called 6to4 [1] is one of tunneling techniques, and it is relatively easy for end users to set up the IPv6-over-IPv4 tunnel and to connect to the IPv6 Internet by using 6to4.

To connect to the IPv6 Internet via 6to4, the user uses a 6to4 relay router for relaying communications between the IPv6 Internet and a site installed with 6to4. There are currently about ten open 6to4 relay routers worldwide [4]. However, none of these had been installed in Japan so in order to connect to the IPv6 Internet, a Japanese user had to utilize an overseas router. Particularly, even if connecting to an IPv6 server in Japan, the connection had to be routed overseas and had problems with poor performance. Therefore, we decided to evaluate 6to4 technology and set ourselves the goal of improving 6to4 operation within Japan. To accomplish this goal we installed an open 6to4 router within Japan in March 2002, with the cooperation of the WIDE Project and started this experiment.

2. 6to4 overview

2.1. 6to4 address

A 6to4 address format is shown in Fig.1. The IANA (Internet Assigned Numbers Authority) assigns a 16 bit IPv6 address prefix for utilizing 6to4, which is represent as 2002::/16. So if a user is assigned at lease one globally unique IPv4 address which is referred to in Fig.1 as V4ADDR, it is equivalent that the user is assigned a 48 bit IPv6 prefix which is represent 2002:V4ADDR::/48.

16 bit	32 bit	16 bit	64 bit
2002	V4ADDR	Subnet ID	Interface ID

Figure 1. 6to4 address format

2.2. 6to4 site

A 6to4 site is a site running IPv6 internally using 6to4 addresses. In a 6to4 site, a 6to4 router is installed at the boundary of the 6to4 site. The 6to4 router encapsulates IPv6 packet sent from the 6to4 site in IPv4, and decapsulates IPv4 packets addressed to the 6to4 site to IPv6.

When the IPv4 address 1.1.1.1 is assigned to the 6to4 router, the 6to4 site can use an IPv6 prefix 2002:0101:0101::/48. Normal IPv6 routing is performed within the 6to4 site, and by receiving a router advertisement message from the IPv6 router or 6to4 router, the IPv6 host within the 6to4 site can also configure an IPv6 address having a 6to4 format in its own interface.

2.3. Making connections with 6to4

There are two types of communication between the 6to4 site and other IPv6 networks. One is the communication between 6to4 sites, and another is the communication between 6to4 site and the IPv6 Internet.

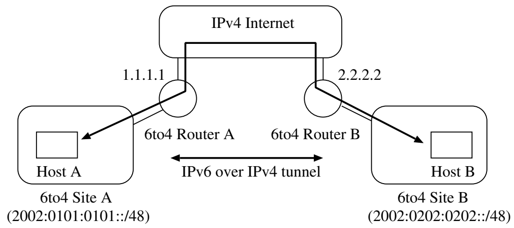

Figure 2. Communication between 6to4 sites

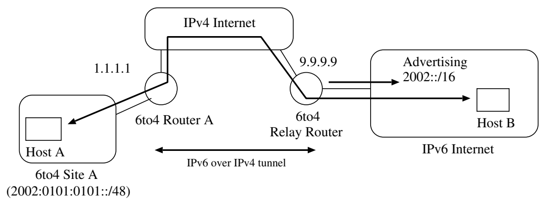

Figure 3. Communication between a 6to4 site and the IPv6 Internet

Fig.2 illustrates the communication between 6to4 sites. When host A communicates with host B, first the IPv6 packet P sent to host B arrives at the 6to4 router A. Since the destination IPv6 address of this IPv6 packet P is a 6to4 address, the 6to4 router A recognizes that this packet is addressed to a 6to4 site and that the IPv4 address for the tunnel endpoint is 2.2.2.2. The IPv6 packet P is therefore encapsulated in an IPv4 packet at the 6to4 router A and sent to the 6to4 router B. The 6to4 router B that received the packet P removes the IPv4 header from the packet P and forwards the inner IPv6 packet P to the host B.

Fig.3 illustrates the communication between a 6to4 site and the IPv6 Internet. A 6to4 relay router must be used in this communication. The 6to4 relay router is located between the IPv4 and IPv6 Internet, and relays communications between the 6to4 site and the IPv6 Internet. The 6to4 router must explicitly designate the 6to4 relay router to be used, and the IPv6 default route for the 6to4 router is pointed to the 6to4 relay router. In order to relay communication from the IPv6 Internet to 6to4 sites, the 6to4 relay router must advertise IPv6 prefix 2002::/16 to the IPv6 Internet.

Communications between host A and host B in Fig.3 are carried out as follows. The 6to4 router A that received IPv6 packet P from host A checks the destination address of packet P. In this case, the destination IPv6 address is not the 6to4 address, so the packet P is sent to the 6to4 relay router. The 6to4 relay router that received the packet P, first removes the IPv4 header from the packet P, and then sends it towards the destination host B following the IPv6 routing table that it has.

On the other hand, the IPv6 packet P' from host B to host A is transfer as follows. The destination address of packet P' is a 6to4 address, so the packet P' is forwarded to the 6to4 relay router according to the routing of the IPv6 Internet. And the 6to4 relay router is able to recognize that the packet P' is addressed to a 6to4 site, and also that the IPv4 address for the tunnel endpoint is 1.1.1.1. The packet P' is therefore encapsulated in an IPv4 packet, and forwarded to the 6to4 router A. The 6to4 router A which received the packet P', removes the IPv4 header from the packet P' and then forwards the inner IPv6 packet P' to the host A.

3. Experiment of utilizing 6to4

To make the 6to4 method more convenient to use, 6to4 relay routers must be widely dispersed over the IPv6 Internet. There were several open 6to4 relay routers overseas but none within Japan. So in order to connect to the IPv6 Internet from Japan via 6to4, an overseas open 6to4 relay router had to be used. In such cases, even if the user inside Japan communicated with an IPv6 host also in Japan, the packets had to make a trip overseas and back. This caused problems such as increasing the RTT between two hosts and lowering the throughput so that in most cases communication didn't have a good performance.

We therefore began the experiment of 6to4 using an open 6to4 relay router on March 2002. The first goal of this experiment was to improve the IPv6 communications environment by installing a 6to4 relay router and advertising 2002::/16 to ISP and academic institutions inside Japan. A second goal of this was to verify that IPv4 users could easily connect to an IPv6 network via actual 6to4 operation, and also that 6to4 could be used effectively during the transition stage from IPv4 to IPv6.

Fig.4 illustrates the network structure used in our experiment. Our relay router is connected to the IPv4 Internet at 100Mbps and to the NSPIXP-6 at 100Mbps, which is

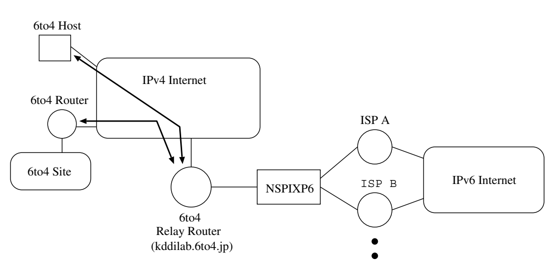

Figure 4. Experiment network structure

the IPv6-dedicated Internet exchange point operated by the WIDE project. Peering for multiple academic institutions and commercial ISP are made on NSPIXP-6 and we have advertised 2002::/16 to 18 ASs in Oct. 2002.

4. Statistical information

4.1. RTT

Fig.5 shows results when measuring the RTT between the 6to4 host which is connected to the KDDI IPv4 network and an IPv6 server which is located in the KDDI IPv6 network. RTT measurements were made using fping [5], and sending 10 consecutive ICMPv6 echo packets every 15 minutes.

On the left side of the horizontal axis in Fig.5 prior to 12:00, our relay router advertised 2002::/16 to KDDI, and then the RTT was about 5 milliseconds. Here, the RTT time increased to about 140 milliseconds as a result of temporarily stopping the 2002::/16 advertising to KDDI. On restarting the 2002::/16 advertising to KDDI prior to 12:00 as shown on the right side of the horizontal axis in Fig.5, the RTT diminished to about 5 milliseconds again. This shows that installing a 6to4 relay router inside Japan and advertising 2002::/16 succeeded in drastically improving performance of communication utilizing 6to4 inside Japan.

4.2. Traffic volume

Fig. 6 shows the traffic volume measured on the 6to4 tunnel interface of our relay router. Most traffic is to 6to4 sites, and the traffic patterns seem to resemble bursts. The average one-day traffic volume to 6to4 sites was about 60 Kbps, but the maximum traffic volume over a five-minute period was 14.5 Mbps.

Fig. 7 shows the traffic volume on September 25, 2002. From 11:30 to 14:00 on this day, the live streaming video of B'z, who are one of the most popular musician in Japan, was delivered on the Internet by IPv6 and IPv4. In Fig. 7, we

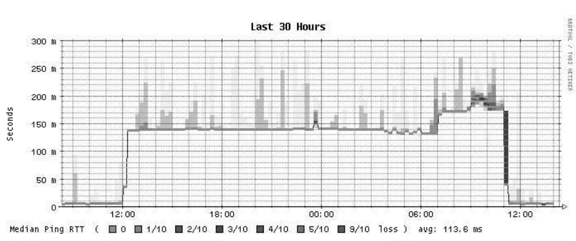

Figure 5. Change of RTT with or without advertising 2002::/16 to KDDI

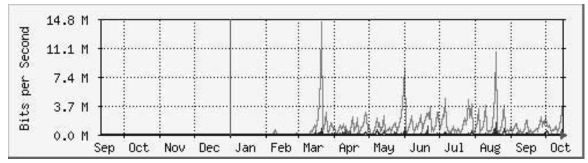

Figure 6. Traffic volume of 6to4

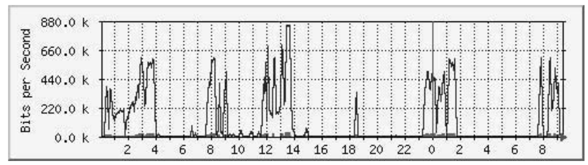

Figure 7. Traffic volume on September 25, 2002

can notice that the traffic volume during the B'z live was increased. The bandwidth of this streaming video was 50kbps, so we suppose that the maximum of about 10 Japanese users received this live at the same time by IPv6 via 6to4.

4.3. Estimating the number of users

In our experiment, there was no user registration to use our 6to4 relay router, so accurately calculating the number of users is impossible. Therefore, in order to estimate the approximate number of users, we monitered the source IPv4 addresses of the IPv4 encapsulated packets coming into our relay router and counted the number of IPv4 addresses by one day unit.

Fig. 8 shows the result. From Fig. 8, the number of IPv4 addresses seems to increase gradually and now over 150, so we may estimate that the number of 6to4 users are now about 150 per day.

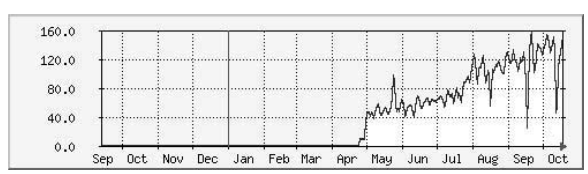

Figure 8. The number of source IPv4 addresses coming into our relay router

5. Consideration in operating and using 6to4

5.1. Applicability of 6to4 service

Here we consider some points of 6to4 service applicability as seen from the side providing connections to the IPv6 Internet via an IPv6 over IPv4 tunnel.

When using a configured tunnel, the configuration and administration load increase as the number of tunnels is larger. However, because of making it necessary to set up the explicit tunnel, it has the benefit that a user can be identified and therefore illegal access prevented. When using an automatic tunnel as the 6to4 mechanism on the other hand, there is no need to make separate tunnel settings for each user so the configuration and administration load is lighter. However, in the 6to4 mechanism it is difficult to prevent malicious users using 6to4 routers. And the other problem is that the packet paths are often asymmetric because 6to4 relay routers advertise only the IPv6 prefix 2002::/16 to prevent increasing the size of IPv6 routing table. For this reason, in the 6to4 mechanism the service provider has trouble in guaranteeing quality of communication service for users. Therefore an IPv6 connection service using 6to4 is not applicable enough to be used for example by a commercial ISP that provides service only to its own customers.

5.2. Using 6to4 in a NAT environment

Nodes in the site connected to the IPv4 Internet via a NAT (Network Address Translator) are usually assigned IPv4 private addresses, so normally these nodes cannot use 6to4. The best way to solve this problem is to implement the 6to4 method in a NAT box. But it depends on the manufacturer of your NAT box and you may not expect it. The alternative way is a little tricky one as follow; (1) generate the 6to4 address by using an IPv4 global address held by NAT; and (2) configure an address mapping for IPv4 packets that have the header whose protocol number field is 41 in NAT.

Fig. 9 illustrates the structure of a 6to4 site for a NAT environment. An IPv4 private address 192.168.1.1 is assigned to the 6to4 router but the IPv6 prefix of the 6to4 site is generated by utilizing a global address 1.1.1.1 held by NAT. And IPv4 address 1.1.1.1 and protocol number 41 is statistically mapped for the IPv4 address 192.168.1.1 so that 6to4 can be utilized in the NAT environment.

5.3. Security

Because of the nature of open relay and the use of IPv6 address embedded IPv4 address, an open 6to4 relay router is susceptible to abuse such as DoS (Denial of Service) attacks. This means the careful operation should be taken such as setting appropriate packet filter and monitoring traffic status.

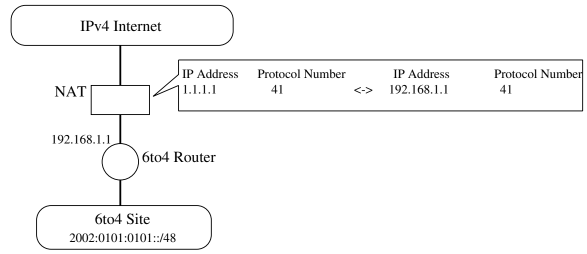

Figure 9. Structure of a 6to4 site for a NAT environment

Here we consider packet filtering in the 6to4 relay router. IPv6 packets relayed by the 6to4 relay router are; (1) packets from the IPv6 Internet that are headed for 6to4 sites; and (2) packets from 6to4 sites, headed for the IPv6 Internet.

In (1), the destination IPv6 address is a 6to4 address so any IPv6 packets should be blocked whose IPv4 address embedded in a 6to4 address is not an global unicast address. And any IPv6 packets whose source address is a 6to4 address should be also blocked, because the communication between 6to4 sites is not relayed by the 6to4 relay router.

In (2), any packets should be blocked whose inner IPv6 destination address is a 6to4 address, or inner IPv6 source address is a 6to4 address generated with embedding no global IPv4 unicast address. Also a check should preferably be made before decapsulation, as to whether the source IPv4 address matches the IPv4 address embedded in the source IPv6 address of inner IPv6 packet.

6. Conclusions

In this paper, we describe 6to4 that is one method for automatic setting of IPv6-over-IPv4 tunnels, experiments using 6to4, and usage and statistical information acquired in operation up till now. Though not having a great impact compared to IPv4, 6to4 is relatively easy to use and the number of 6to4 users is greater than was estimated. In the future, we intend to continue experiments and making further evaluations of the effect of 6to4 technology.

References

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[4] http://www.kfu.com/~nsayer/6to4/.
[5] http://www.fping.com.