A native plug & play IPv6 WLAN based on IVI

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***Abstract*—IVI is a new way for IPv4/IPv6 transition which requires IPv6 host to be configured with a specific IPv6 address, called IVI6 address, manually or dynamically. A native plug and play IPv6 WLAN subnet based on IVI, DHCP and RA is deployed in this paper. WLAN clients in the scenario can connect to a native IPv6 network automatically, means plug and play, and can also access IPv4 web sites without any trouble at the same time. It shows that IVI is a fare well method for smooth v4/v6 transition with the merits like stateless, end-to-end address transparency, multi-homing capability, good scalability and easy deployment. In this paper, the related technologies, methods and configuration parameters are described in detail and some problems of IVI deployment are discussed.**

Keywords-IVI; IPv6; native; plug and play

I. INTRODUCTION

Since IPv4 and IPv6 are different protocols with different addressing structures, a translation mechanism is necessary for communication between endpoints using different address families. There are several ways to implement the translation. One is the stateless IP/ICMP translation algorithm (SIIT) [1], which provides a mechanism for translation between IPv4 and IPv6 packet headers (including ICMP headers) without requiring any per-connection state. But, SIIT does not specify the address assignment and routing scheme [2]. For example, the SIIT uses IPv4 mapped IPv6 addresses [::FFFF:ipv4-addr/96] and IPv4 compatible IPv6 addresses [::ipv4-address/96] for the address mapping, but these addresses violate the aggregation principle of IPv6 routing [3]. The other translation mechanism is NAT-PT, which has serious technical and operational difficulties and IETF has reclassified it from proposed standard to historic status [4].

The IVI is a prefix-specific and stateless address mapping mechanism for "an IPv6 network to the IPv4 Internet" and "the IPv4 Internet to an IPv6 network" scenarios. In roman numerals, the IV stands for 4 and VI stands for 6, so IVI stands for the IPv4/IPv6 translation. In IVI, subsets of the ISP's IPv4 addresses (called IVI4) are embedded in the ISP's IPv6 addresses (called IVI6) and the hosts using these IPv6 addresses can therefore communicate with the global IPv6 Internet directly and with the global IPv4 Internet too via stateless translators. The communications can either be IPv6 initiated or IPv4 initiated. The basic mechanism of IVI is shown in Figure 1.

Figure 2 gives the address mapping mechanism of IVI, where bit 0 to bit 31 are the prefix of ISP's /32 (e.g. using document IPv6 address 2001:DB8::/32), in the CERNET implementation bit 32 to bit 39 are all one's as the identifier of the IVI addresses, bit 40 to bit 71 are embedded global IPv4 address (IVI4) presented in hexadecimal format. (e.g. 2001:DB8:ff00::/40). Note that based on the IVI mapping mechanism, an IPv4 /24 is mapped to an IPv6 /64 and an IPv4 /32 is mapped to an IPv6 /72. More detailed information of IVI can be found at [5].

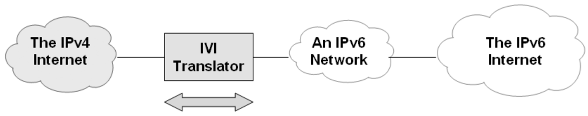

Figure 1. Basic mechanism of IVI

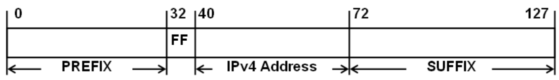

Figure 2. IVI address mapping

IVI has many merits such as:

- It supports communication between IPv4 and IPv6 hosts regardless the initiator
- It supports the end-to-end address transparency and multi-homing
- It can be implemented easily by ASIC and has good scalability
- It can be deployed incrementally and ISP's global IPv4 and IPv6 routing tables are not affected.

II. IVI DEPLOYMENT IN CERNET2

China Education and Research Network has two backbones using different address families. The CERNET is IPv4-only and CERNET2 is IPv6-only. More than 100 top campus networks connecting the two backbones at the same time currently. In order to make IPv6 clients of CERNET2, which are the respected campus networks, communicate with the IPv4 Internet, IVI translators are installed at the border of CERNET and CERNET2 as shown in Figure 3 to provide address translation. Each campus network was allocated an IVI4 and the corresponding IVI6 address blocks by CERNET2 National Center.

In Figure 3, each campus network has a /48 IPv6 subnet connecting with CERNET2. Some PCs have IVI6 address so that IPv4 hosts can access them. Some other PCs do not have IVI6 address thus can only access IPv6 Internet. Since DNS is an essential service for clients, a dual-stack IVI DNS is also installed between CERNET and CERNET2 performing name resolving. When the IVI6 host queries an AAAA record for an IPv4 only domain name, the IVI DNS will query the AAAA record first. If the AAAA record does not exist, the IVI DNS will query the A record and map it to an IVI6 address and return an AAAA record to the IVI6 host. The working flow of IVI DNS is shown in Figure 4.

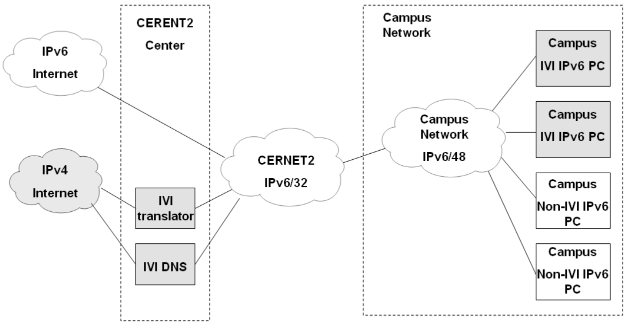

Figure 3. IVI deployment in CERNET2

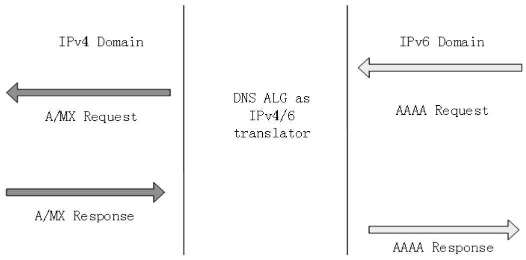

Figure 4. IVI DNS working flow

III. NATIVE PLUG&PLAY IPV6 WLAN SUBNET

To work with IVI, campus client must be configured with an IVI6 address as its identifier and makes use of this IPv6 address to communicate with other IPv4 or IPv6 hosts afterwards. The address auto-configured by RA can not be used in IVI, which requires the "autonomous address-configuration flag (A-bit)" of RA prefix to be set to zero [6] and, therefore, the client's IPv6 address to be set manually by hand or dynamically by DHCP.

Obviously, for the convenience of plug and play, stateful DHCP is a good IPv6 configuration method for IVI clients. To work with stateful DHCP, another two flags of RA, M-bit and O-bit, must be specified [7,8,9,10]. Table 1 shows the regarding operations with different combination of M-bit and O-bit when A-bit is set to zero.

Figure 5 shows a native plug and play IPv6 WLAN subnet be set up in Tsinghua University IPv6 Network (TUNET6), where 2001:da8:ff3a:c881::/64 is the IVI6 address block allocated to Tsinghua and 58.200.129.0/24 is the corresponding IVI4 address block. Default route of TUNET6 points to CERNET2. The AP works in transparent-mode and clients' default gateway is a L3 switch (Cisco 7609). DHCPv6 Server runs with ISC DHCP4.1.1-P1[11]. In this environment, clients use RA to retrieve default gateway and use DHCPv6 to retrieve DNS server address and IVI6 addresses automatically and can access IPv6 and IPv4 websites simultaneously without any trouble. Detailed configuration parameters are provided as following.

TABLE I. OPERATIONS WHEN A-BIT IS 0

M	O	Operation
1	0	the client use DHCPv6 to retrieve a managed IPv6 address and other configuration parameters from a DHCPv6 server (for example, the expire time of the managed IPv6 address)
0	1	the client use DHCPv6 to retrieve other configuration parameters (for example, DNS server address) but not the client's IP address.
1	1	the client use DHCPv6 to retrieve a managed IPv6 address and other configuration parameters (for example, DNS server address)

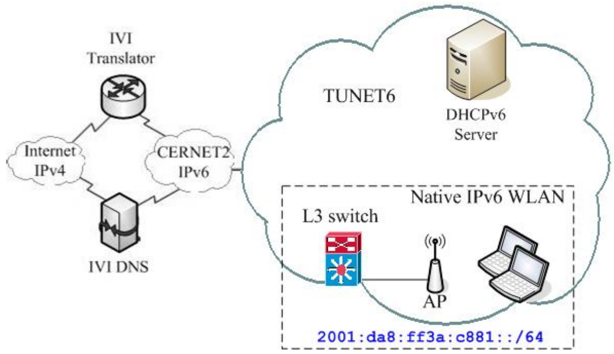

Figure 5. Native IPv6 WLAN subnet toplogy

A. L3 switch（Cisco7609, Version 12.2(33)SRE）：

```
interface Vlan30
  no ip address
  ipv6 address 2001:DA8:FF3A:C881:100::/64
  ipv6 enable
  ipv6 nd prefix default 2592000 604800 no-autoconfig
  ipv6 nd managed-config-flag
  ipv6 nd other-config-flag
  ipv6 nd ra suppress
  ipv6 dhcp relay destination 2402:F000:1:901::9:8
```

where 2001:DA8:FF3A:C881:100::, corresponds to IVI4 address 58.200.129.1, is default gateway of the native IPv6 WLAN subnet. 2402:F000:1:901::9:8 is the DHCPv6 Server address. It is noticed that "no-autoconfig", which sets A-bit to zero, as well as "ra suppress" are configured to tell clients do not auto-produce IPv6 address with RA prefix for the reason that an auto-produced IPv6 address with RA prefix cannot work with IVI translator. The other two parameters, mangaged-config-flag and other-config-flag, set M-bit and O-bit of RA prefix to 1 to make sure that clients retrieve DHCPv6 address, DNS server address and default route information without any handiwork.

B. DHCPv6 server（ISC DHCP4.1.1-P1）：

```
subnet6 2001:da8:ff3a:c881::/64 {
    range6 2001:da8:ff3a:c881:200:: 2001:da8:ff3a:c881:200::;
    range6 2001:da8:ff3a:c881:300:: 2001:da8:ff3a:c881:300::;
    ... ...
    range6 2001:da8:ff3a:c881:fe00:: 2001:da8:ff3a:c881:fe00::;
    option dhcp6.name-servers 2001:250:aaa0:100:1::2;
    option dhcp6.domain-search "v6.tsinghua.edu.cn";
  }
```

Since IVI6 address is derived from an embedded IPv4 address (called IVI4 address), IVI requires one IVI4 address corresponds to one IVI6 address and vice versa. Therefore IVI6 address space is not continues as IVI4. To ensure DHCPv6 client retrieve an eligible IVI6 address, the address range-pool of DHCPv6 server should only have IVI6 addresses. So, IVI6 addresses have to be enumerated one by one. That's the reason why the IPv6 address at the beginning is the same as the one at the end of each range6 pool as shown above. In addition, the IVI DNS server address, 2001:250:aaa0:100:1::2, is provided as an option in the configuration. This ensures that clients can get DNS server address automatically when RA prefix's O-bit is set to 1and that IPv4 websites can be resolved to IVI6 websites.

C. *Windows7 client*

If client is Windows7, nothing is needed to do to get IVI6 address, DNS server address and default gateway in the above native IPv6 environment. Figure 6 shows the IPCONFIG information of a Windows7 system. It can be seen that Windows7 client gets an IVI6 address, 2001:da8:ff3a:c881:800::, as its source address. In addition, it gets a link-local address from RA, fc80::219:7ff:feab:c600, as the default gateway. It also retrieves the DNS server address provided by DHCPv6 server.

IV. IPCONFIG IN WIN7 SYSTEM

A. *Result*

With the configuration above, client can automatically connect into such a native IPv6 environment and access IPv6 and IPv4 websites at the same time without any trouble. Figure 7 shows a PING result of a famous IPv4 website in China from IVI6 client. It can be seen that IVI DNS returns an IVI6 address of that website, 2001:da8:ff79:c200:cd00::, regarding to the A record in IPv4 DNS.

Figure 6. IVI DNS translation

V. CONCLUSION

The paper gives a brief introduction of IVI and describes the detailed information to set up a plug and play native IPv6 subnet with IVI, DHCPv6 and Router Advertisement. IVI lets clients of IPv6 and IPv4 communicate with each other and it supports many kinds of application transparently. For the merits of IVI, it provides an innovative smooth way for IPv4/IPv6 migration.

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