LANCOM™ Techpaper
IPv6 Migration

Introduction

The Internet and the networks connected with it formerly worked with IPv4 only. The new protocol IPv6 was created to address a number of issues, one of the most significant being the severe limitation on the number of IP addresses available with IPv4. This techpaper discusses the migration from IPv4 to IPv6. It should be noted, however, that there will be no hard transition from IPv4 to IPv6, but rather that both standards are to coexist for a very long time to come. The dual stack technique enables both IPv4 and IPv6 to operate on a common physical network, so that clients supporting just one of these protocols are still able to participate in communications. The dual stack offer a further advantage in that migration can be performed incrementally, so that not all services have to be switched over at once. In view of this, the aim of the migration to IPv6 is not the transition from IPv4 to IPv6, but initially the introduction of the dual stack.

Stages of migration

The initial situation in most scenarios is a straightforward IPv4 Internet access (fig. 1). A router links the IPv4-based Internet connection to the IPv4-based corporate network.

When operating the dual stack, the router connecting to the Internet receives both an IPv4 address and an IPv6 address. Both IPv4 and IPv6 are available to the internal network, and clients can choose which protocol they want to use according to their needs.

If native IPv6 Internet access is unavailable, IPv6 can still be operated over an IPv4 Internet connection by using the IPv6 tunneling technologies (fig. 3). These are explained in more detail in the LANCOM techpaper, IPv6 Tunnel Technologies. Services such as VPN, which may not, or only partially be, available due to IPv4 NAT at the provider, can be used over the IPv6 Internet connection thanks to the dual stack.

Abb.1 IPv4 Internet access

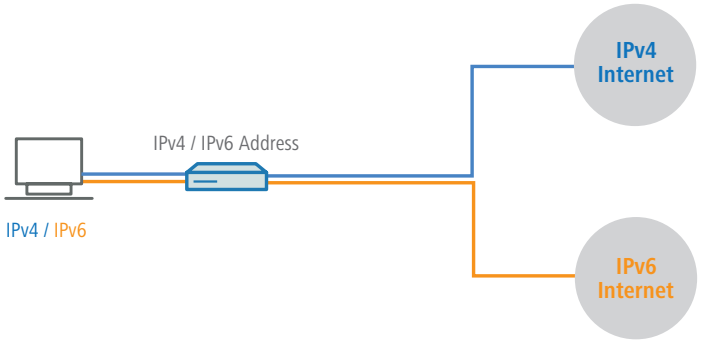

Abb.2 Dual stack Internet access

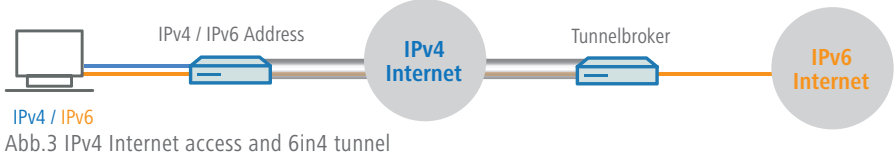

Abb.3 IPv4 Internet access and 6in4 tunnel

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New concepts

IPv6 includes a number of new concepts, the most important of which are briefly presented here.

IPv6 addresses

One new and obvious aspect of IPv6 is the content and the length of an IPv6 address. With a length of 128 bits, an IPv6 address is four times longer than an IPv4 address. It is written as a hexadecimal number and is divided into eight blocks of 16 bits each (four hexadecimal digits). A typical IPv6 address appears as follows:

2001:0db8:0000:0000:02a0:57ff:fe18:3b9e/64

For improved legibility the leading zeros can be omitted from each block, and one contiguous group of blocks that contain only zeros can be abbreviated once with :: (double colon). The simplified notation of the above IPv6 address would be:

2001:db8::2a0:57ff:fe18:3b9e/64

An IPv6 address always consists of two parts; a prefix and an interface identifier. The first part of an IPv6 address is the prefix, the length of which in bits is specified by the decimal number after the slash. In our example the prefix is:

2001:db8::/64

The last 64 bits of the IPv6 address are the interface identifier, which is generated automatically. In our example, the interface identifier is:

2a0:57ff:fe18:3b9e

Types of IPv6 addresses

With IPv6 an interface generally has multiple IPv6 addresses, another big difference to IPv4. A distinction is made between unicast and multicast addresses. The former are used for direct communication between two interfaces, while the latter are used to send information to multiple interfaces.

Link Local Unicast

This address has the prefix fe80::/10 and is not forwarded by routers. Among other things, it is used for the autoconfiguration.

Multicast

These are multicast addresses used in IPv6. All multicast addresses are in the network ff00::/8. The next 8 bits contain 4 bits for flags and 4 bits for scope.

Unique Local Unicast

The IPv6 addresses with the prefix fc00::/7 to fd00::/7 are not routed to the global IPv6 Internet and can be used in private networks.

Loopback

The loopback address in IPv6 is ::1/128.

Unspecified Address

The IPv6 address ::/128 indicates the absence of an IPv6 address.

Global Unicast

The remaining IPv6 addresses that are used on the internet. Currently addresses are being issued with the prefix 2001::/3. The prefix 2002::/16 is used by the 6to4 tunnel technology.

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Stateless address autoconfiguration

Abbreviated as SLAAC, stateless address autoconfiguration allows clients to automatically assign themselves an IPv6 address, as shown schematically in fig. 4. The client evaluates the router advertisements sent from a local router. If the router advertisements contain a prefix and the "autonomous" flag, the client automatically generates an IPv6 address consisting of the transmitted prefix and the interface identifier that the client sets for itself. Before using the address, the client conducts a duplicate-address detection to avoid an address conflict on the local link. The gateway address is the router's local link address as learned from router advertisement. This mode is recommended for small networks to keep the work required for configuration to a minimum.

Stateful address autoconfiguration

Operating a DHCPv6 server allows stateful address autoconfiguration to be used instead of stateless address autoconfiguration (fig. 5). In this case, the router advertisement contains no prefix and the flag is set to "managed". The client evaluates the router advertisement and sends a DHCP request, which is answered by the network's DHCPv6 server. The client then receives its IPv6 address and other information, such as the DNS server. However, the client continues to be informed about the gateway via the router advertisement. This method offers the advantage that clients are always assigned IPv6 addresses from a fixed range, rather than allowing them to generate random addresses themselves. This greatly reduces, and indeed fundamentally facilitates, the work required for the administration of network components. This mode is preferable for large networks as each individual interface always receives the same IPv6 address, which simplifies administration.

Abb. 4 Stateless Address Autoconfiguration

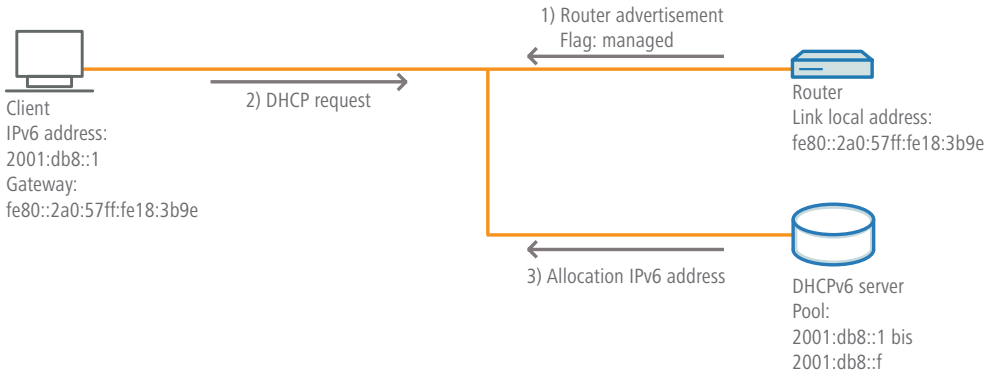

Abb. 5 Stateful Address Autoconfiguration

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ICMPv6

Another essential component of IPv6 is ICMPv6. The Internet Control Message Protocol is essential for operating IPv6 networks, whereas the use of ICMPv4 is only optional for IPv4 networks. Just like the IPv4 version, this protocol is used to exchange information and error messages. It is also used by a number of other protocols.

Neighbor Discovery Protocol

The Neighbor Discovery Protocol (NDP) is responsible for finding other components in the same network segment and for determining the IPv6 addresses corresponding to these components. This makes it important for Duplicate Address Detection, which checks whether a generated IPv6 address already exists on the network and, where required, initiates the generation of a new address. NDP also works with the information in the router advertisement, and it stores and updates information about the available routers. It additionally monitors the DNS server and the availability of other active neighbors.

DNS

Since IPv6 addresses are much longer and more complex than IPv4 addresses, DNS plays a crucial role. While the A-type resource record in the DNS resolves a name into an IPv4 address, with IPv6 it is the AAAA-type resource record that is responsible for resolving an IPv6 address.

Firewall

As NAT (Network Address Translation) is unnecessary for IPv6, the firewall takes on even greater importance than with IPv4: In theory, any global unicast address on the local network can be accessed directly from the Internet. Thus the careful configuration of the IPv6 firewall is especially important because the rules that relate to IPv4 no longer work.

Header

In comparison to IPv4 the IPv6 header has been optimized in that it has a fixed length of 40 bytes and no longer contains optional components.

Address assignment from the provider

With IPv4 Internet access the customer is assigned an IPv4 address by the provider. However, in the case of IPv6 we are dealing with an IPv6 address and a prefix, which propagates in the customer's network and is used by clients for their global unicast address.

Summary

The step-by-step and future-proof migration to the dual stack technique is easy to implement with LANCOM devices. Apart from that there is no pressing reason for hasty action because IPv4 will not disappear very quickly – the integration of IPv6 in all areas of the Internet will take a considerable time.

More information on IPv6 is available under:
www.lancom.eu/IPv6