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Praktikum RouterLab SS 2009
Work Sheet 8: Internet Protocol Version 6 (IPv6)

This work sheet introduces Internet Protocol Version 6 (IPv6). We will start by configuring a regular IPv4 between lg102-ham/muc, ham/muc-rj2, and ham/muc-rc1, complemented by an IPv6 network between ham/muc-rc1, ham/muc-rj1, and lg103-ham/muc. lg102-ham/muc will serve as IPv6 gateway to lg104-ham/muc, providing access to the IPv6 network via a tunnel established with ham/muc-rc1 over the IPv4 network. Finally, we'll set up a service on lg102-ham/muc, which will provide lg104-ham/muc with the appropriate configuration.

Note: Again, draw a topology map and fill in the IPv4-, and IPv6-addresses as you assign them to the devices, along with the used VLAN IDs. This topology map is part of the documents to be submitted(!).

Table 1: Assignment of devices to groups

Gruppe	Ham-Cloud	Muc-Cloud
Router	ham-rj1, ham-rj2, ham-rc1	muc-rj1, muc-rc1
Switches	ham-sc1, ham-sc2	muc-sc1, muc-sc2
Loadgens	loadgen102-ham, loadgen103-ham, loadgen104-ham	loadgen102-muc, loadgen103-muc loadgen104-muc
IPv4 range	10.1.0.0/16	10.2.0.0/16
IPv6 range	2001:1::/32	2001:2::/32
VLAN ID range	1XX	2XX

Question 1: (15 Points) *IPv6 Addresses*

  (a) Name at least four differences between IPv4 and IPv6 (see e.g., RFC 2460)!

  (b) Get familiar with IPv6 addresses by reading RFC 4291 or by consulting other IPv6 literature!
      Answer the following questions:

      • What are *link-local* addresses and what IP address range do they use?
      • What is the standard IPv6 loopback address?
      • Which address blocks are globally routable and currently assigned by the IANA?
      • What is the complete/long text representation of `2001:0::0:1:2`?

  (c) Log on to loadgen102-ham/muc and run ifconfig. Which *link-local* IPv6 address has been assigned to the interface `eth0`? Explain how this IP address has been derived from the MAC address. For more information read Section "Links or Nodes with IEEE 802 48-bit MACs" of RFC 4291 or look for other sources in the web.

Question 2: (25 Points) *Preparations*
In this part, we'll prepare the networks for the subsequent IPv6-over-IPv4 tunnel experiment. We'll create a set of 5 logical LANs, two of which will be running IPv4, two of which will be running IPv6, and one of which will (in the end) run both. In this setup, ham/muc-rc1 and muc-rj2 will represent the IPv4 infrastructure and a IPv6 relay run by your local ISP. lg102-ham/muc will represent your home router, connected to the ISP, while lg104-ham/muc will represent your local client. lg103-ham/muc represents an IPv6 only machine you'd like to connect to.

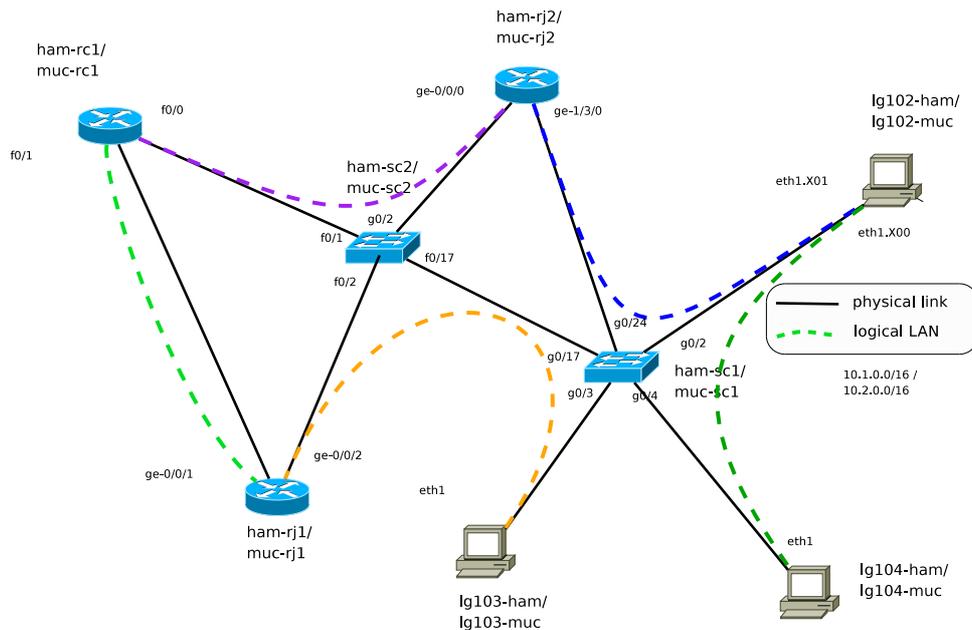 (a) Setup the (V/)LANs, as indicated in Figure 1.

Figure 1: Topology: Mapping of VLANs to physical links.

(b) Log on to loadgen102-ham/muc, and loadgen104-ham/muc and use ping6 on loadgen104-ham/muc to ping the local link address of loadgen102-ham/muc.

(c) Configure an IPv4 network between lg104-ham/muc and ham/muc-rc1. Traceroute ham/muc-rc1 from lg104-ham/muc to verify it works.
(Note: You will need to write '1' into /proc/sys/net/ipv4/ip_forward on the appropriate loadgen to enable routing on the device ; a value of 0 disables the routing)

(d) Configure an IPv6 network between ham/muc-rc1 and lg103-ham/muc. Install the ndisc6 package on loadgen103-ham/muc and use rltraceroute6 ham/muc-rc1 to verify it works. Use the following commands to configure routes: (Cisco:) ipv6 route , (Juniper:) set routing-options rib inet6.0 .

Question 3: (45 Points) *Migrating your home network to IPv6*

Now that your home network is connected to your provider's IPv4 network, you'd like to add IPv6 support and connect it to the IPv6 side of the internet. In order to allow all clients in your home network access, we'll configure your router (loadgen102-ham/muc) to provide a tunnel to an IPv6 gateway (ham/muc-rc1) offered by your service provider. We'll refer to the loadgen102-ham/muc interface connecting to ham/muc-rj2 as 'exterior' interface, and the one connecting to loadgen104-ham/muc as 'interior' interface.

(a) Search the web and briefly explain each of the following concepts in 2 or 3 sentences:
   - Tunneling IPv6 over IPv4
   - Automatic Tunneling, 6to4
   - Configured Tunneling, tunnel brokers, 6in4

(b) Generally, it is possible to manually configure static tunnels. What would be the disadvantage in common uplink scenarios, where a home router is connected via PPPoE and assigned a dynamic IP address?

(c) Explain how 6to4 IPv6 addresses are derived from IPv4 addresses (see RFC 3056 Section 2 or `http://linux.die.net/man/8/radvd`)!

(d) Which special IPv4 address prefix has been reserved for 6to4 relays?

(e) We will now start with the configuration of the *6to4 gateway*. What are appropriate 6to4 addresses for the tunnel endpoint (TUNNEL-6to4) and LAN interface (LAN-6to4) of the loadgen102-ham/muc? To find out you may write the following shell script[1], make it executable (chmod) and finally execute it, using the WAN interface's IP address as parameter:

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[1]To edit files on the WRT you can either use vi if you access the WRT via console/ssh or use the editor of the web interface (System → File Editor). In the second case, you first need to create a new file, e.g. by touch "file name" on the console.

```
WANIP=$1
echo "IPv4 address: $WANIP"
V6PREFIX=$(printf '2002:%02x%02x:%02x%02x' $(echo $WANIP | tr . ' '))
TUNNEL6to4=$V6PREFIX:0::1/16
LAN6to4=$V6PREFIX:1::1/64
echo "Tunnel6to4: $TUNNEL6to4, LAN6to4: $LAN6to4"
```

Try to understand the script from above (check manpages if necessary). Explain in a few sentences what the script does and add the calculated IPv6 addresses to your topology map. For more information we refer to RFC 3056 (Section 2) or other sources in the web.

(f) First configure rc1 as a *6to4* relay. Assign both an approriate IPv4, and IPv6 address and netmask (/32, /128) to a Loopback device, configuring a mtu setting of 1480. It must decapsulate packets received on this address, and forward them to the correct host in the IPv6 network. In the reverse direction, it must accept IPv6 packets with address 2002::/16, encapsulate them and send them to the appropriate IPv4 address.

In order to receive packets on the loopback device, it needs to be associated to an appropriate tunnel by the following commands:

```
interface Tunnel0
    no ip address
    no ip redirects
    ipv6 unnumbered Loopback <interface number>
    tunnel source Loopback <interface number>
    tunnel mode ipv6ip 6to4
    tunnel path-mtu-discovery
!
```

Finally, add an appropriate route for all IPv6to4 packets to the tunnel device. Since IPv6 routing is by default disabled on Cisco routers, you may have to enable ipv6 unicast routing.

(g) Now configure the 6to4 tunnel, IP addresses and routing on your home router loadgen102-ham/muc, i.e. the 6to4 gateway! To do this manually, you need the following commands:

```
ip tunnel add tun6to4 mode sit ttl 255 remote any local <IPv4 address of 'external' interface>
ip link set tun6to4 mtu 1280
ip link set tun6to4 up
ip addr add <TUNNEL6to4 address/netmask> dev tun6to4
ip addr add <LAN6to4 address/netmask> dev <'internal' interface>
ip -6 route add 2001::/3 via ::<IPv4 relay address> dev tun6to4
```

Explain what each *individual* command does! Check with ip -6 tunnel show and ifconfig whether the tunnel has been created and if the IPv6 addresses have been assigned!

(h) Remember that gateways must be reachable! Do whatever configuration is necessary to enable the tunnel establishment between loadgen102-ham/muc and ham/muc-rc1! (The same holds for communication endpoints! ;)) Log on to loadgen102-ham/muc and use ping6 to ping first ham/muc-rc1, then ham/muc-rj1, and lg103-ham/muc to ensure the tunnel and routing is working.

Question 4: (15 Points) *IPv6 Stateless Address Autoconfiguration*

As manual setup is tedious, we'd like to enable IPv6 autoconfiguration in your home network. In order to provide this service, a route advertisement daemon has to be installed on your home router and gateway (loadgen102-ham/muc)

(a) Have a look at RFC 2462. In particular, read Section 4 "Protocol Overview"!

(b) Configure your home router such that it automatically assigns IPv6 addresses to your client (loadgen104-ham/muc) in your home network! The goal is to advertise 6to4 prefixes (see RFC 3056, Section 2).

For this purpose you need the router advertisement daemon radvd. Install the application using either apt-get, or aptitude.

The following config (/etc/radvd.conf) tells radvd to announce a 6to4 prefix to an interface.[2]

```
interface <interface> {
    MinRtrAdvInterval 3;
```

---

[2]To check for available options look at the radvd.conf manpage

```
      MaxRtrAdvInterval 4;
      AdvLinkMTU 1280;
      AdvSendAdvert on;
      prefix 0:0:0:1::/64 {
       AdvOnLink on;
       AdvAutonomous on;
       AdvValidLifetime 300;
       AdvPreferredLifetime 120;
       Base6to4Interface <interface>;
      };
    };
```
Finally restart the daemon with

```
    /etc/init.d/radvd restart
```
.

(c) Run tcpdump on the interface of loadgen104-ham/muc. What do you see? Which packets belong to IPv6 autoconfiguration? What is the difference to IPv4 DHCP packets in terms of protocols and address assignment principle? What IPv6 address has been assigned to your client via IPv6 Stateless Autoconfiguration? (explain the individual parts of the address, i.e. where the individual values of its components are derived from) Use ip -6 route to display the routing table on loadgen104-ham/muc.

(d) Install the ndisc6 package on loadgen104-ham/muc and use rltraceroute6 to traceroute load-gen103-ham/muc.

For submission details please check the FAQ:
http://www.net.t-labs.tu-berlin.de/teaching/ss09/RL_labcourse/
Submit the following:

- Topology map

- All configuration inputs on routers, switches and laodgens (no trials, only the final ones)

- The outputs of all commands such as ping, tcpdump, etc.

- Answers to the questions

Due Date: Friday, June 26th, 2009, 08:00 am