Aalto University
School of Electrical
Engineering

Department of Communications and Networking

S-38.2131/3133 Networking Technology, Laboratory course A/B

Work Number 30: IPv6

Student Edition

Preliminary Exercises and Laboratory Assignments

Niko Suominen, 29.7.2003
Oskari Simola, 29.7.2004
Eero Solarmo, 1.8.2005
Anni Matinlauri, 3.1.2007
Erik Kosonen & Neela Shrestha, 7.8.2012 Riku-
Antti Oinonen & Laura Tilli, 5.8.2012
Jitendra Kumar Pandit & Sunny Dutta 9.6.2014
Abraham Afriyie 8.8.2017

1 Preliminary Exercises

Answer the following questions shortly but clearly. Remember to mention your sources. Make sure you understand the basics of IPv6 addressing before entering the lab. It is recommended to examine the laboratory assignment, the Logical Systems Configuration Guide and Juniper IPv6 HowTo Manual beforehand. There is only 3 hours reserved work time on your lab turn.

P.1 (3points)
It has been said that the new IPv6 protocol corrects many problems that appeared with IPv4. What are the main advantages of IPv6 protocol? If the IPv6 really is better than the IPv4, why don't we use it yet in the Internet?

P.2 (3 points)
In the IPv4 architecture there are three different kinds of addresses: unicast, multicast and broadcast ones. The IPv6 introduces a new type called anycast. What is the purpose of anycast addressing and what are the restrictions of using anycast addresses?

P.3 (4 points)
a) Explain various types of the IPv6 addressing.
b) Is it possible to build routing using only link local addresses? (Assume that at least the originating and the destination nodes have a site local or a global address configured.)

P.4 (2 points)
Explain the differences between stateless and stateful autoconfiguration?

P.5 (3 points)
The Neighbor discovery is a basic functionality all implementations of IPv6 on any platform must include. What Internet Control Message Protocol Version 6 (ICMPv6) messages are used by Neighbor discovery?

P.6 (4 points)
Explain how Neighbour Unreachability Detection works.

P.7 (3 points)
The address notations: RFC2373 (*http://www.ietf.org/rfc/rfc2373.txt*) describes the IPv6 addressing architecture. Study it and answer the following questions.

a) What is the IPv6 loopback address? (Just give the address.)
b) What address scope do the following addresses belong to?
   (i) fec2::2
   (ii) ff15:2:5:fece::
   (iii) 3ffe:1:4:3:efa::
c) Are the following address notations legal?
   (i) 1::
   (ii) fec0:0:0:4::2:4
   (iii) ff::ff:345::3
   (iv) ::
   (v) 3ffe::130.233.220.31

P.8 (3 points)

The transition mechanism known as 6to4 [RFC3056] is a form of automatic router-to-router tunneling that uses the IANA-assigned IPv6 prefix 2002::/16 to designate a site that participate in 6to4. Figure 1 represent a scenario of 6to4 tunneling. Describe by filling in the correct IP addresses at the various points marked "XXXX" how the IPv6 sites assign itself with a prefix and also the source and destination addresses of the packets (IPv4/IPv6) as host A send a packet to host B. There is no need to draw, just write your answer using the numbers.

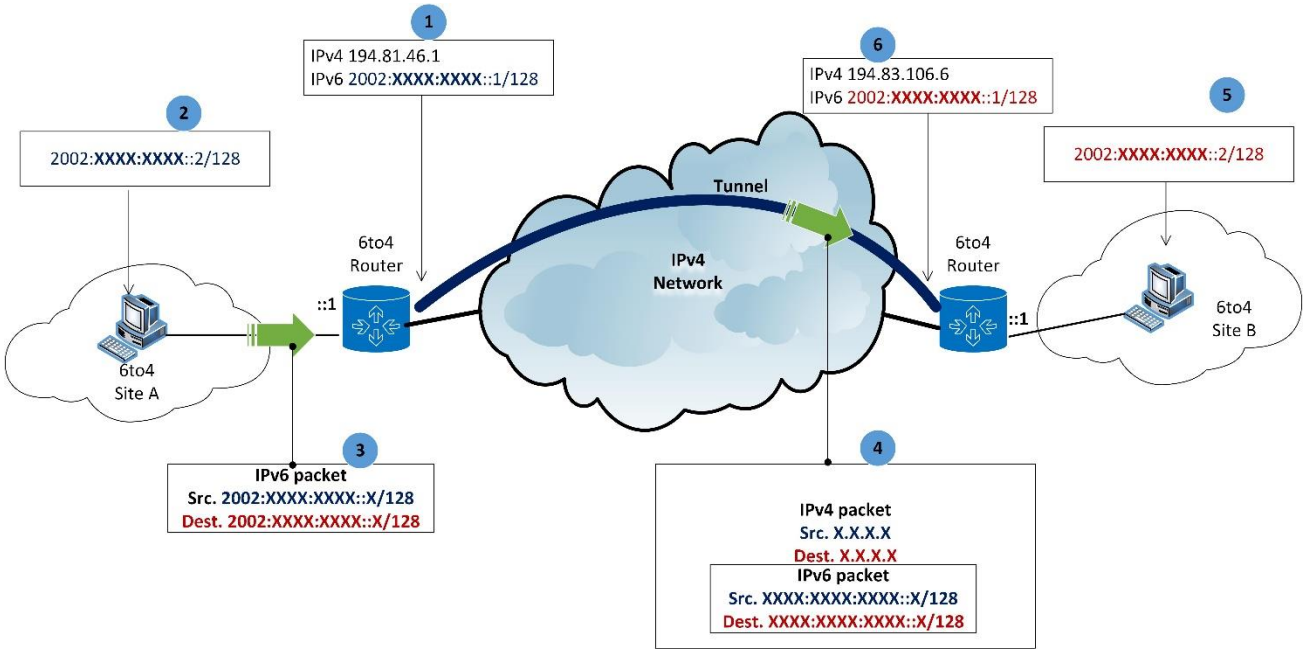

Figure 1: 6to4 Tunnel

P.9 (5 points)

Plan Ipv6 address allocation for this lab network. Check section 2.2 for detailed information and Appendix A for network topology.

Table 1: Helsinki

Interface	IPv6 address
ge-1/3/4	
lt-1/1/10.99	
lt-1/1/10.4	
lo0.40	

Table 2: Lappeenranta

Interface	IPv6 address
ge-1/1/7	
lt-1/1/10.1	
lt-1/1/10.3	
lo0.100	

Table 3: Tampere

Interface	IPv6 address
lt-1/1/10.5	
lt-1/1/10.2	
lo0.20	

Table 4: Turku

Interface	IPv6 address
lt-1/1/10.6	
lt-1/1/10.9	
lo0.30	

Table 5: Vaasa

Interface	IPv6 address
ge-1/1/10	
ge-1/2/11	

Table 6: Oulu

Interface	IPv6 address
ge-1/2/7	
ge-1/2/10	

Table 7: Rovaniemi

Interface	IPv6 address
ge-1/2/4	

Table 8: IPv6 over IPv4 Tunnel (Kallio - Mannerheim)

Interface	IPv6 address
Lappeenranta ip-1/0/10.200	
Rovaniemi ip-1/0/10.300	

Table 9: PC1 IPv6 address assignment

Interface	IPv6 address
PC1 enp0s3	

2 IPv6 Laboratory Work – Laboratory Assignment

2.1 Introduction

In this laboratory work you will familiarize yourself with Ipv6 addressing and IPv6 routing protocol OSPFv3. In addition, you will learn some ways for Ipv4-IPv6 coexistence and transition. You should be familiar with basic UNIX commands and basic IPV4 routing protocols. It is recommended that you have done the IPv4 routing assignment before you begin this work. You should also understand the basic differences between the IPv4 and IPv6 protocols as well as their addressing schemes. The preliminary exercises involves a lot of information that will help you in your laboratory work.

Another task in this lab is to configure IPv6 over IPv4 tunnel to connect two IPv6 islands (sites A and B) over IPv4 cloud. Also, you will have to configure routers in the ipv4 network to enable both Ipv6 routing in addition to existing ipv4 routing (Dual stack). After you have completed all the tasks in the laboratory you have to make a final report. You only have to answer questions, which are located in different places of this document labelled "**Q.#**". Your grade depends on the preliminary exercises, the final report and also on your laboratory work.

2.2 Work Environment

On a Juniper router (Mx80), you can build logical systems (routers) and connect them using logical tunnel (lt-x/x/x) interfaces or by making physical connections (Gigabit Ethernet). The configuration commands for configuring any feature or protocols are the same as if you configure it on a physical router. You can familiarize yourself with the syntax of the configuration commands in the "Juniper Logical Systems Feature Guide".

In order to become more familiar with logical systems, all routers are configured such that they cannot be accessed through **ssh** like in the previous labs. Only the master router has been preconfigured for management. You can **ssh** to the management interface using the IP address **10.255.4.195** and "**roo**t" as the username. **Ask assistant for password**. After that you can access all logical routers.
Please follow the lab instructions carefully and configure what you are only required to configure.

There are two Ubuntu PCs to be used to test the network. The topology of the lab network is included in appendix A. You need to configure four (4) logical routers Helsinki, Lappeenranta, Tampere and Turku with Ipv6 addresses and OSPFv3 routing to create an IPv6 network in site A. Ipv6 network in site B has already been preconfigured and you only need to add other configurations as required.
The IPv6 address range provided to you is **fdf8::/60**. Plan the IP addresses for all the interfaces including loopback interfaces and the LAN between router Helsinki and PC1.

2.3 Lab Work

As said earlier Juniper logical routers can be connected using logical tunnels as well as gigabit Ethernet interfaces. This lab work involves the configuration of both gigabit Ethernet and logical tunnel interfaces. Loopback interfaces are named lo0 with their various unites. Please ensure that the right interfaces on the various routers are configured according to the topology shown in appendix A. You will have to assign IP addresses to the logical interfaces according to the plan prepared in preliminary report.

It is possible to enable or disable each of router's interfaces by accessing switch control tool at http://switchcontrol.noc.lab/port_control.php (or use the address http://10.255.0.2/). Select or deselect the desired interfaces and click update to enable or disable the selected interfaces. You will need this feature later in the exercise. If you cannot access switch controls ask assistant for help.

For capturing packets, make sure that correct interfaces are mirrored to the capture interface to http://switchcontrol. noc.lab/port_mirroring.php and select the interfaces through which packets are to be captured. Next, login to capture server capture.noc.lab with following credentials:

Command: ssh -X capture@capture.noc.lab
Password: capture
Start wireshark and capture the traffic through interface eth1.

As you might remember from IPv4 Lab, configuration changes on routers are not applied until commit is performed. Remember to check each time the changes to configuration with the **commit check** command for errors.

2.3.1 IPv6 Address Configuration

First configure IPv6 addresses for routers Helsinki, Lappeenranta, Tampere and Turku in IPv6 site A. Assign IP addresses to the interfaces and loopback addresses. You can check the configuration of all the interfaces with the command "***show logical-systems "logical-system name" interfaces***" and remember to check reachability of interfaces by pinging. Also, statically configure IPv6 address for PC1 (Ubuntu machine) connected to Helsinki. Check the connectivity by pinging.

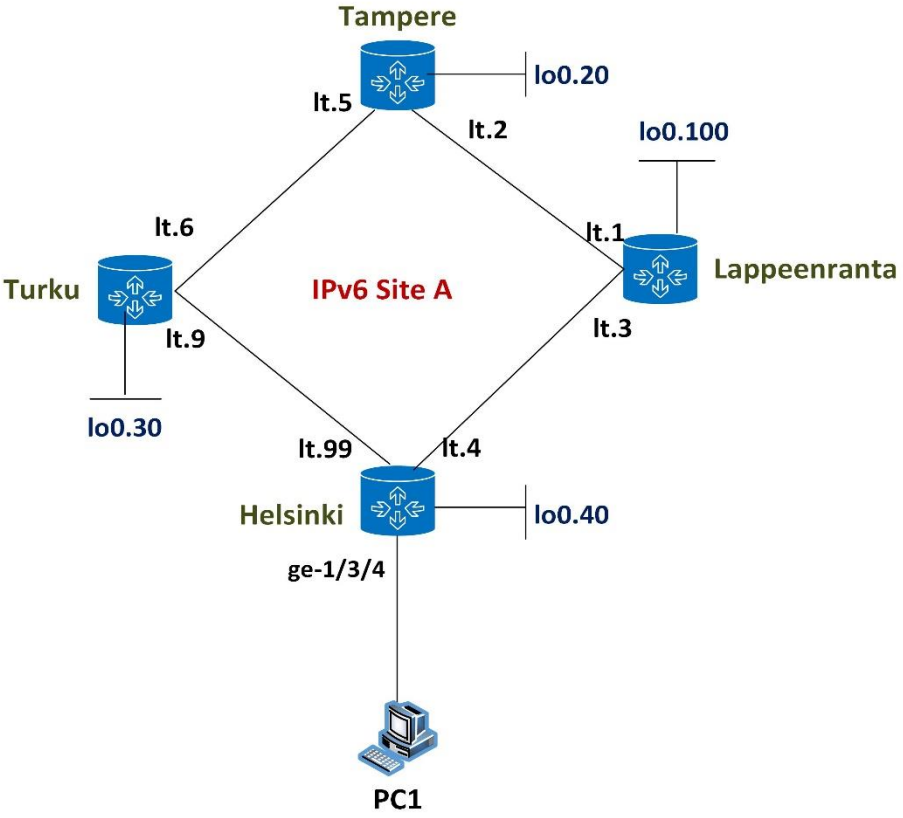

Figure 1: Site A

Q.1. (4 point)
There are two ways to configure IP address: complete manual input of an IP address and the utilization of the eui-64 functionality? Which method did you use and why?

2.3.2 Dynamic routing

IPv6 routing uses same "longest-prefix match" routing as IPv4 in CIDR notation. For IGP, IPv6 routing is supported in OSPFv3, ISIS, RIPng. In this lab, we are going to configure OSPFv3 routing. If you want to study more about the OSPFv3 protocol, it is described in RFC 2740.

Add configurations for OSPFv3 routing to the routers without IPv4 loopback addresses or router IDs. Also ensure that loopback interfaces do not run OSPF3 but advertise it. Check routing table, routes and reachability to all interfaces to determine if OSPF3 process is running. The commands are included in the manual. Now configure any IPv4 loopback addresses (eg. 10.X.X.X/32) to the routers and check routing table, routes and reachability again.

Q.2. (5 points)
Do routers have ospf3 routes in their routing table after ospf3 configuration without IPv4 loopback addresses? Why?
After the configuration of Ipv4 loopback addresses, are there routes in their routing tables? Explain how ospf3 adjacency is formed.

Q.3. (3 point)
Try pinging unicast local address of Helsinki lt-1/1/10.99 from Lappeenranta. Is it successful and why?
Now ping the link local address of the same interface from Lappeenranta. Is it successful and why?

Q.4. (2 points)
Attach the configurations done for Lappeenranta here. Just include the configurations done by you for IP addressing and dynamic routing. Tip (command: show | display set)

2.3.3 Tunnelling

Now there are two IPv6 sites, site A and site B as in the topology (Appendix A). There is IPv4 network in between them which have been preconfigured. This is similar to the real world scenario. The task is to tunnel IPv6 traffic over the IPv4 cloud to create communication between PC1 and PC2. Check that OSPFv2 is running on Lappeenrata and Rovaniemi routers. Create an IP-in-IP tunnel between the two IPv6 sites. Use the IPv4 loopback addresses configured on the routers (Lappeenranta and Rovaniemi) for the tunnel source and destination. Start packet capture for all interfaces of IPv4 network and commit the configurations.

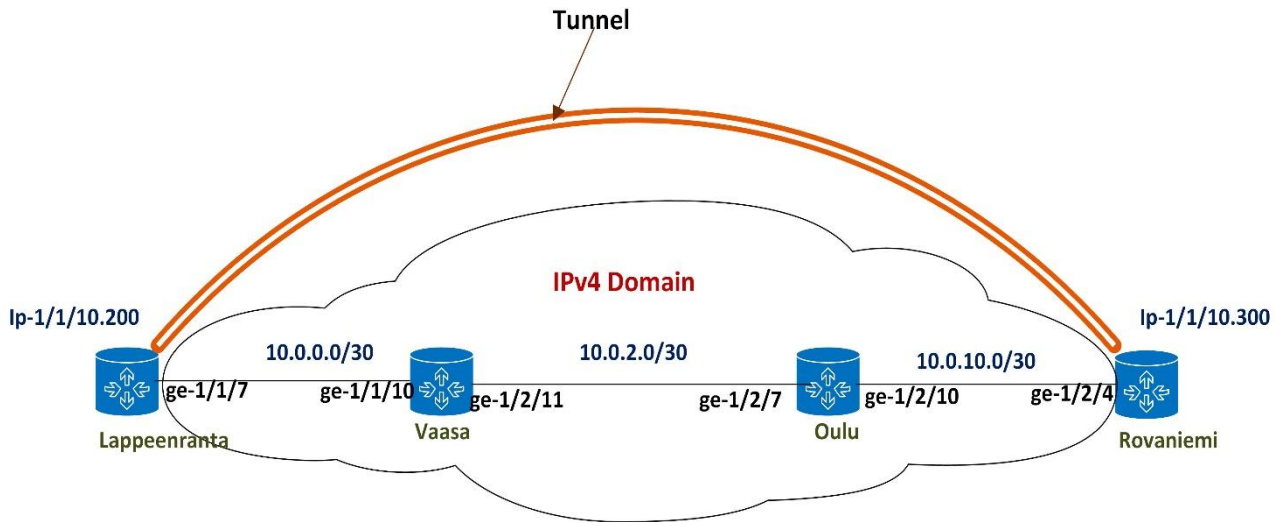

Figure 2: IPv6 over IPv4 tunnel.

Q.5. (3 points)
Generate some traffic by pinging for example. Analyze the captured packets. How is the tunnelling done? How do you notice the tunnel?

Q.6. (2 points)
Do ping and traceroute between loopback interfaces of Lappeenranta and Rovaniemi for IPv4 and IPv6. Attach the configurations added in Lappeenranta. Also attach the ping and traceroute results.

2.3.4 Static Routing

Configure routes on Lappeenranta and Rovaniemi such that PC1 on IPv6 site A can communicate with PC2 in IPv6 site B using the tunnel. Remember the IP address of PC2 can be found in the topology.

Q.7. (3 points)
Attach the configuration done for Lappeenranta router. Attach only the configuration for the IP addressing, configured static route and the dynamic routing. Tip (command: show | display set)

Q.8. (3 points)
Ping and traceroute from PC1 to PC2. Was it successful? Attach both ping and traceroute results.

Q.9. (3 points)
Disable interface ge-1/1/7 on router Lappeenranta and check connectivity between PCs. Can PC1 communicate with PC2? Give reason.

2.3.4 Dual Stack

Q.10. (4 points)
In the existing Ipv4 cloud network, you want to enable Ipv6 addressing as well. Configure the network for this. Attach the configurations added in router Lappeenranta and Vaasa.

Q.11. (3 points)
Do ping and traceroute between PC1 and PC2. What was the results? Which path is used after the Dual Stack configuration? Compare results to **Q.11**, what is the difference? Attach both ping and traceroute results.

3 Final report

In your final report answer to the questions presented during the assignment and the additional final questions below.

F.1. (3 points)
Attach your final IPv6 address plan for the topology. Briefly explain how you designed this address plan.

F.2. (2 points)
Tunnelling is a process by which information from one protocol is encapsulated inside the packet of another protocol, thus enabling the original data to be carried over the second protocol. What are the different ways tunneling can be configured?

F.3. (5 points)
Describe briefly five methods (tunneling mechanisms) for carrying IPv6 over existing IPv4 networks.

F.4. (2 points)
Complete the following table to find the equivalents of given Ipv4 functions in Ipv6.

Function	**IPv4**	**IPv6**
Address Assignment		
Address Resolution		
Router Discovery		
Name Resolution		
Multicast applications		

F.5. (3 points)
In tunnelling, you have noticed that ospfv2 was running in Lappeenranta and Rovaniemi. Will the tunnelling work if this is disabled and why?

4 Restoring the initial settings

Remember to take all the files required for the final report with you. After this you should delete all the files you have created in the client machines. Assistant will reset the **routers**.

Points and Grade

The grade should be given according to the next table:

Preliminary report: 3+3+4+2+3+4+3+3+5 = 30 pts.
Laboratory work performance: 20 pts (IP address configuration (4pts), tunnel conf. (8pts), static route (4pts) and dual stack (4pts))
Final report: 4+5+3+2+3+2+3+3+3+4+3+15 = 50 pts.
Total: 100 pts.

Grades

Points	Grade
0…45	0
46…55	1
56…65	2
66…75	3
76…85	4
86…100	5

However, the grade must be zero (0) if any of the following conditions is true:

- Less than 50% of preliminary exercises are right.
- The student has failed to pass tasks in the laboratory.

Appendix A – IPv6 Laboratory topology