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Routerlab SoSe 2018
Worksheet 1: Introduction to the RouterLab

The RouterLab is a network testbed that contains switches, routers, and load-generating VMs (loadgens/lg). In this first worksheet you will get acquainted with these devices and the RouterLab in general. The goal of this worksheet is to configure IPv6 and IPv4 addresses and static routes on routers and loadgens, and to write a report on what you did. The skills required for this worksheet will serve as a foundation for the following worksheets.

Table 1 shows the *devices* (routers, switches, and loadgens/VMs) and *address ranges* that you will use. You will find such a table on every worksheet. The routers and switches you use depend on the *cloud* you are on (`aac` for Aachen, `cgn` for Cologne, or `lev` for Leverkusen). You can only access a router or switch when it is reserved for you. Every group has its own loadgens. Your loadgens are named after your group, and are permanently reserved for you.
The IP address ranges depend on your group number. You may ONLY assign IP addresses that lie within specified range. These rules exist to ensure that no group's work interferes with the work of another group.

Table 1: Device and Address Overview

Cloud	Aachen	Köln	Leverkusen
Router	aac-rc1, aac-rj2	cgn-rc1, cgn-rj2	lev-rc1, lev-rj2
Switches	aac-sc1	cgn-sc1	lev-sc1
Loadgens		groupX-lg1,2,3,4	
IPv4 range		`10.Z.0.0/16`	
IPv6 range		`fc00:470:525b:fY00::/56`	

Note: Replace X with your group number with leading zero, e.g., $X = 03$ for group 3.
Replace Y with your group number without leading zero and use hexadecimal encoding, e.g., $Y = 3$ for group 3 and $Y = a$ for group 10.
Replace Z with your decimal group number without leading zero, e.g., $Z = 3$ for group 3.

Unless stated otherwise, you are ONLY allowed to use a device if the device is listed in an active reservation for your group in the (*labtool*) reservation system.
The tutors have already created *labtool* reservations for the time slots for each group in the labtool reservation system. If you need extra time to complete your work, it is your responsibility to reserve additional time for your assigned devices. As soon as you no longer need your devices, please end your reservation to free the devices so that others may use them.

Question 1: (5 Points) *Change your passwords*

You should have already obtained your password for the *RouterLab* giving you access to *cheetah*, *labtool*, and the RouterLab web portal.

Your first task is to change your initial password for the *RouterLab*. To change your password, follow the appropriate link located on the *Routerlab* web site [1].
`https://routerlab.inet.tu-berlin.de/trac/labtools/#UserInformation`

[1] Access to the website requires a Routerlab account and password

Question 2: (15 (5+10) Points) *RouterLab topology*

Next, we need to get an overview of the topology of the RouterLab. For this purpose, please refer to Figure 1. For general information see the *User Information* section on the RouterLab website, in particular the following sites:

- Routerlab: `https://routerlab.inet.tu-berlin.de/trac/labtools/#UserInformation`
- Labfront: `https://routerlab.inet.tu-berlin.de/labfront/viewonly/devices/list`

(a) Answer the following questions using the information you gathered via the Labfront:

1. Which types of devices exist in the RouterLab?
2. How many interfaces do your assigned routers have (see Table 1) and what are the interface names?
3. What types of links exist in the RouterLab? Can you guess what the bandwidths of the links are?

(b) In this worksheet, your goal is to configure your devices so that packets can be sent from groupX-lg1 over aac-rc1 (cgn-rc1 / lev-rc1) to aac-rj2 (cgn-rj2 / lev-rj2) and vice-versa. The rest of this worksheet will guide you through the necessary steps.

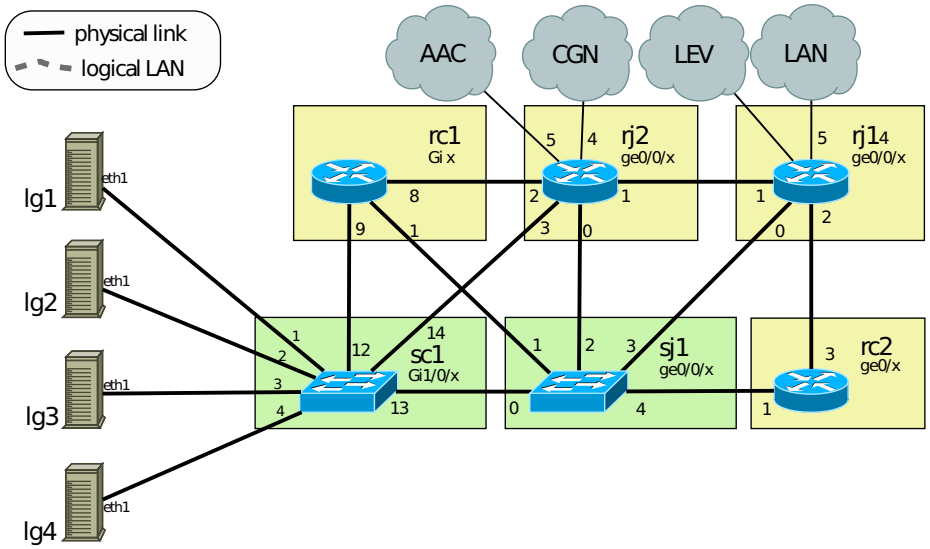

Figure 1: Link Connectivity in the RouterLab.

As dual stack IP is default for new setups, we want you to *assign both IPv6 and IPv4 addresses*. You will need to edit the topology map in Figure 1, which you find on the course website, and add with the following information:

1. Select *two* different /64 IPv6 prefixes from your group's range (see Table 1) and include them in your report. Also, pick *two* different /24 subnets from your IPv4 range and include them in your report as well.
   Remember: You are not allowed to use devices and IP ranges other than those specified in Table 1.
2. There is going to be IPv6 and IPv4 connectivity between groupX-lg1 and aac-rc1 (cgn-rc1 / lev-rc1). For this, pick addresses from *one* of your /64 IPv6 prefixes and from *one* of your /24 IPv4 subnets for the relevant network interfaces. Write the IPv4 and IPv6 addresses you pick in your topology map next to the interfaces on which you will assign them. Make sure that your address assignments are clear and unambiguous or you may lose points.
3. Next, there needs to be connectivity between aac-rc1 (cgn-rc1 / lev-rc1) and aac-rj2 (cgn-rj2 / lev-rj2). This time, pick addresses from the remaining, unused IPv6 prefix and IPv4 subnet. Assign the chosen addresses to your map as before.

Hints:

- We provide the topology map on the ISIS course website.
- We recommend to use a program such as inkscape or dia to edit the topology map.

Question 3: (25 (2+7+8+8) Points) *Connecting to the devices and Linux IP config*

Now we discuss how to connect to the devices of the RouterLab. The devices of the RouterLab are not connected directly to the public internet. Instead, the host `cheetah` serves as a stepping stone, providing access to all devices.

You can connect to `cheetah` using an SSH client from anywhere that you have Internet access via the following UNIX/Linux/Mac OS command, or using PuTTY on Windows:

```
ssh group<number>@cheetah.inet.tu-berlin.de
```

Note: Remember the leading zero in your group number.

From cheetah all devices can be accessed interactively via a serial console terminal server, while the loadgens should also be reachable with ssh, as long as their network configuration was not changed.

The RouterLab management terminal servers provide a number of serial ports that are connected to the serial ports of the loadgens, routers, and switches. You can access them from cheetah by connecting to the console server with telnet. The labtool simplifies this process by mapping the name of every device (e.g., aac-rc1) to the correct port of the console server. The following example labtool command will provide a serial console to aac-rc1 from cheetah:

```
lab -c aac-rc1
```

In order to close the connection to a certain device from a Linux shell, you may type Ctrl +] or from the windows SSH client PuTTY, type Ctrl + +. This will get you to the command mode of telnet, where you can then exit with q or quit.

(a) Your virtual loadgens groupX-lg1 ... groupX-lg4 will stay powered on during the semester. You can powercycle them (**This loses all your non-saved configuration!**) using lab -p groupX-lg1 on cheetah.

You can connect to the console using the command lab -c groupX-lg1. Note that only one person at a time can connect to the console using this command[2]. Also note that this console is the last resort to access your device if you have misconfigured the management Ethernet interface.

(b) Log on as root to groupX-lg1 using ssh. The initial password is 'routerlab'. Find out to which cloud your loadgen is connected by executing the command cloud. Read the *manpage* of ip and the subpage ip-address, describing the tool that is now used[3] on Linux to configure IP addresses and interfaces.[4] We recommend you change the password on the loadgens as well, so no other group can log in by accident.

1. How many network interfaces exist on groupX-lg1? Explain the differences between the different types of interfaces you see. (**Hint:** Don't forget interfaces that are currently down!)
2. Some interfaces have IPv6 addresses from the network `fe80::/10` configured. Find out what is special about them. Are they needed? Describe their purpose in 2-3 sentences.
3. Configure the IPv6 and IPv4 address that you assigned to groupX-lg1 in Question 2b on the appropriate interface.

(c) aac-rc1 (cgn-rc1 / lev-rc1) runs the operating system Cisco IOS. In this course, we will mainly use the command line interface to configure routers. Cisco IOS distinguishes between modes where you can only display the current configuration of the device and modes where you can actually change the configuration [5]. Acquaint yourself with the modes that exist in Cisco IOS by reading Section "Cisco IOS CLI Command Modes Overview" in the Cisco CLI basics guide linked on the ISIS course page.

Create a state diagram where nodes reflect the CISCO IOS modes and edges show the transitions from one mode into another. Consider only the following modes: *user EXEC mode*, *privileged EXEC mode*, *global configuration mode*, *interface configuration mode*.

A directed edge from mode A to mode B exists if there is a Cisco IOS command that allows you to directly switch from mode A to mode B. Label the directed edges with the required IOS commands. Label the nodes with the mode names and the characters that identify the node at the prompt. Add the diagram to your report.

Which Cisco IOS version is installed on aac-rc1 (cgn-rc1 / lev-rc1)? (**Hint:** Use "?" in *privileged EXEC mode* to find the appropriate command. You can use *TAB* key for command completion.)

[2] The commands tmux or screen can be used to address this limitation if you know what you are doing.
[3] This command replaces the deprecated utility ifconfig.
[4] Use command man ip and man ip-address.
[5] The default password is: routerlab

(d) aac-rj2 (cgn-rj2 / lev-rj2) uses JUNOS as operating system. To get accustomed with the modes on Juniper routers[6], read at least the following parts of the Juniper CLI User Guide linked on the ISIS course page: ch1 (until p7), ch2 (until p12), p14-p16, ch4 (until p40).

Draw a state diagram similar to the one for the Cisco router. Consider the following states: *UNIX shell*, *CLI operational mode*, *CLI configuration mode (top-level)*, *CLI configuration mode (interfaces)*

(**Hint:** When you first log on to a router, you will be in *CLI operational mode* or in a UNIX shell. To go to *CLI operational mode* from the shell, type cli. To go back, type exit.)

Which JUNOS version is installed on aac-rj2 (cgn-rj2 / lev-rj2)? (**Hint:** Use "?" in *CLI operational mode* to find the appropriate command)

Note: The switches in the RouterLab use Cisco IOS as operating system, too. Therefore, the general handling of switches is similar to Cisco routers.

Question 4: (15 (4+4+3+4) Points) *Reserving devices and dumping configurations*

The labtool is a program that allows users to create and manage reservations for devices. It will be useful in the future to familiarize yourself with it.

(a) Inspect the manual of the labtool by typing lab -h on *cheetah*. Find out which reservations are currently active. The device aac-rj1 (cgn-rj1 / lev-rj1) has not yet been reserved for you. Reserve this device for the remainder of your current active timeslot. Note that you do not need to actually log on to this device throughout this worksheet. Just provide us the output of the labtool commands showing that this device is reserved by you.

(b) Router and switch configurations can be saved manually. This is done by accessing the router, displaying the complete configuration of the router, marking the configuration text in your terminal window and pasting it to a plain text file. To display the configuration on Cisco use show running-config in *privileged EXEC mode*, on Juniper use show configuration on the *CLI operational mode*. Manually dump the configuration of aac-rc1 (cgn-rc1 / lev-rc1) and aac-rj2 (cgn-rj2 / lev-rj2). Check that there are no extra characters copied to the file.

(c) Change the hostname of aac-rc1 (cgn-rc1 / lev-rc1) and aac-rj2 (cgn-rj2 / lev-rj2) to a random name, e.g., your first name. On Cisco use *?* in *global configuration mode* to find the appropriate command. On Juniper use the set system host-name command in the *configuration mode*. Use write memory on Cisco and commit on Juniper routers to save your new changes.

(d) Now we will restore the configuration that we dumped in question 4b. Restore the configurations of aac-rc1 (cgn-rc1 / lev-rc1) and aac-rj2 (cgn-rj2 / lev-rj2) both.

On Junipers use the command load override terminal in *CLI configuration mode*. Afterwards paste your configuration into your terminal window and then press Ctrl + d. Don't forget to commit your changes!

On Cisco you don't need a special command. It's sufficient to just paste your configuration into the terminal window while being in *global configuration mode*.

Question 5: (20 (3+3+3+3+3+2+3) Points) *IP address configuration on routers*

We will now configure the IP addresses that you assigned in your topology map of Question 2.

(a) Find out how IP addresses are configured on Cisco routers by using "?" in the appropriate *interface configuration mode*. Assign IPv6 addresses to aac-rc1 (cgn-rc1 / lev-rc1) according to your topology map. Use the following command:

```
ipv6 address <ipv6 prefix>/<prefix length>
```

It may be neccessary to bring the device up after you configure it, as the default config disables most of them. Use the following command:

```
no shutdown
```

(b) Now configure the IPv4 addresses on aac-rc1 (cgn-rc1 / lev-rc1) in analogy to the IPv6 addresses. (The command is ip instead of ipv6 and the syntax is slightly different. If you get stuck, the "?" command in interface configuration mode should help.)

(c) Assign IPv6 addresses to aac-rj2 (cgn-rj2 / lev-rj2) according to your topology map. IPv6 addresses can be configured on Juniper routers with the following command:

```
set interfaces <if-name> unit 0 family inet6 address <ipv6 prefix>/<prefix length>
```

Don't forget to use the commit command afterwards!

[6] you may login to juniper routers with password:Routerlab (login:root)

(d) Configure the IPv4 address. The syntax is nearly identical to the one above once you have replaced the address family with "inet". How can you force the usage of IPv6 or IPv4?

(e) Find out how to delete IP addresses for Cisco and Juniper routers. Provide examples for both.

(f) Take a look at the topology Figure 1 again specifically: aac-sc1 (cgn-sc1 / lev-sc1). For this worksheet you will use this device as a plain Layer-2 switch. However it still needs to be configured. In order to to this, activate the required interfaces on aac-sc1 (cgn-sc1 / lev-sc1)[7] by entering the following from global configuration mode.

```
interface Gi1/0/<interface-number>
```

to enter the corresponding Interface Configuration Mode, followed by

```
no shutdown
```

to activate the interface.

(g) Ensure that the following pairs of devices can mutually reach each other via IPv6 and IPv4. (Meaning: each of the two pairs need to be able to initiate a ping to the other).

- groupX-lg1 and aac-rc1 (cgn-rc1 / lev-rc1)
- aac-rc1 (cgn-rc1 / lev-rc1) and aac-rj2 (cgn-rj2 / lev-rj2)

The ping command is available on Cisco and Juniper routers in *user EXEC mode / CLI configuration mode.*

1. What do you have to do to ping an IPv6 address under IOS and JUNOS?
2. How do you do this from groupX-lg1? (**Hint:** Make sure that the interfaces are up.)
3. Why does it make a difference from where to initiate the ping even when using it between two directly connected hosts? **Hint:** Execute the following command (from global configuration mode) on aac-rj2 (cgn-rj2 / lev-rj2) to make ping work from aac-rc1 (cgn-rc1 / lev-rc1) to aac-rj2 (cgn-rj2 / lev-rj2).

   ```
   set security zones security-zone anywhere host-inbound-traffic system-services
   ping
   ```

   What is the purpose of this command?

Question 6: (15 (2+2+2+3+3+3) Points) *Static routes*

Recall that the goal of this work is to send packets from groupX-lg1 to aac-rj2 (cgn-rj2 / lev-rj2) over aac-rc1 (cgn-rc1 / lev-rc1) and vice-versa.

(a) Check if aac-rj2 (cgn-rj2 / lev-rj2) can reach groupX-lg1 using ping. Why doesn't it work?

(b) Configure a static route on aac-rj2 (cgn-rj2 / lev-rj2) to groupX-lg1 via next-hop aac-rc1 (cgn-rc1 / lev-rc1).

Hint: Static routes on Juniper routers can be configured with the following command in *Configuration Mode*:

```
set routing-options rib inet6.0 static route <destination prefix>/<destination
mask> next-hop <next-hop>
```

for IPv6 or

```
set routing-options static route <destination prefix>/<destination mask> next-hop
<next-hop>
```

for IPv4.

(c) On aac-rc1 (cgn-rc1 / lev-rc1), you may have to enable routing first. Do this using

```
ipv6 unicast-routing
```

for IPv6 and

```
ip routing
```

for IPv4 in *global configuration mode.*

(d) Check if ICMP echo requests arrive at the appropriate interface of groupX-lg1. For this purpose use tcpdump on the appropriate interface of groupX-lg1. Do you see incoming packets? For more information on tcpdump we refer to the manpage.

Why doesn't ping from aac-rj2 (cgn-rj2 / lev-rj2) to groupX-lg1 work yet?

[7] password: routerlab

(e) Modify your setup such that groupX-lg1 can reach aac-rj2 (cgn-rj2 / lev-rj2) and vice-versa. (**Hint:** Check the manpage of the commands route and ip.)

To verify that everything is correctly configured, also do a *traceroute* and *traceroute6* from groupX-lg1 to aac-rj2 (cgn-rj2 / lev-rj2) and include the output in your answer.

Briefly explain how *traceroute* works.

Note: Using *traceroute* with ICMP works best in our case. Your implementation might be using another protocol by default.

(f) Ping groupX-lg1 from aac-rj2 (cgn-rj2 / lev-rj2) and vice versa. What is the round-trip time (RTT) in each case? What do you think is happening?

Question 7: (5 Points) *End your reservation*

(a) End your reservation using the labtool. What is the proper command?

Coming up next week: VLANs and 802.1Q. Finished early? Get a head start on next week's assignment by reading up on the 802.1Q protocol. Try setting some vlans on aac-sc1 (cgn-sc1 / lev-sc1) for fun.

Submission details (more in ISIS):
Please submit an archive (.tar.gz or .zip) containing a *directory*, which contains all files you want to submit. Please have *your group number* in the file name and the directory name.
A report (one single PDF file, named *worksheet(num)-group(num).pdf*) containing the following elements is mandatory:

- Your group number on the first page
- Topology map with relevant routers, switches, *loadgens*, and interfaces, IPs and subnet masks (CIDR).
- For each question, the written answers with the **relevant** portions of output from all commands such as ping, tcpdump, etc in a text format. **No** screenshots of terminal windows are accepted. For ping 3-4 lines of ping requests are usually sufficient.
- For each question all commands needed to configure the *loadgens*.
- For each question all **changed parts** in the configuration of routers and switches (differences to the default config).
- **Never** include the full verbatim switch or router configuration in the pdf report.
- For all questions, state your assumptions, say what you did, describe what you observed, explain your conclusions.

Additionally, please include your config files in the archive.
For each question, please provide the full switch and router configuration in a separate text file named after the device and question, e.g.: *q01-config-sc1.txt*. This makes it easier for us to reproduce your configuration and understand what you did.
We can only grade what we find in your submission and what we understand. Please state your assumptions and observations as clearly as possible.
Your submission to this assignment will not be graded yet. However, we will give you feedback on it and its contents will be asked in the oral exam.
Due Date: Thursday, 3. May, 23:55[8]

[8] We will not accept any solutions submitted after this deadline.