TECHNISCHE UNIVERSITÄT BERLIN

Fakultät IV – Elektrotechnik und Informatik
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Work Sheet 2: VLANs, Routing revisited

The purpose of this work sheet is twofold: First, we will learn how to configure Virtual LANs (VLANs), that allow to set up logical layer-2 networks upon a physical topology. Second, we'll configure the involved machines to a fully routed network setup.

Note: An additional link has been established between ham-sc1/muc-sc1 and ham-sc2/muc-sc2 for this worksheet.

Table 1: Assignment of devices to groups

Group	Ham-Cloud	Muc-Cloud
Router	ham-rc1, ham-rj1, ham-rj2	muc-rc1, muc-rj1, muc-rj2
Switches	ham-sc1, ham-sc2	muc-sc1, muc-sc2
Loadgens	loadgen10[2/3/4]-ham	loadgen10[2/3/4]-muc
IP range	`10.1.0.0/16`	`10.2.0.0/16`
VLAN IDs	$x00 - x99$ where x is your team number	

Question 1: (80 Points) *Virtual LANs (VLANs)*

Virtual LANs (VLANs) have the same attributes as a physical LAN, but they allow for end stations to be grouped together into logical LANs. This question motivates possible applcations of VLANs and gives an introduction into the 802.1Q standard.

(a) The first step is to enable IP connectivity between adjacent routers in a similar manner as in the previous work sheet! For this purpose, please have a look at Figure 1. It shows adjacencies between routers as thick dashed lines (every color will later on correspond to one separate virtual LAN). Your configuration must satisfy the following conditions:

- If two routers are interconnected with an arc ("logical LAN"), then the interfaces of these two routers must be able to ping each other.
- Each "arc" will be configured as a "logical LAN" later on. Therefore, assign IP addresses in a way such that there is no (!) overlap in IP address range for all pairs of "logical LANs" shown in Figure 1. The IP address ranges used for different "logical LANs" must be disjoint.
- It is possible to assign multiple IP addresses to a router interface. For now, assign two IP addresses to *ge-0/0/0* of ham-rj2/muc-rj2!

Draw a topology map that shows your IP address assignment (see Figure 1)! Configure IP addresses accordingly and check if ping works!

Note: As our switches also run Cisco IOS, the configuration of switches is similar to Cisco routers. Note that switches are shared resources. Therefore, state such as VLAN IDs is not deleted when a new reservation starts. For this purpose you may have to use the following statement in the appropriate *interface configuration mode*:

```
no switchport mode trunk
switchport trunk allowed vlan none
```

(b) Assume that ham-sc2/muc-sc2 is replaced by an Ethernet hub. Which routers would see Ethernet frames that are sent from ham-rc1/muc-rc1 to ham-rj2/muc-rj2?

Do a ping from ham-rc1/muc-rc1 to ham-rj2muc-rj2! Check with tcpdump on ham-rj1/muc-rj1 if it sees the ICMP Echo Request! Explain!

(Note: tcpdump on Juniper routers is available in the UNIX shell!)

(c) Our goal is to have a separate VLAN (802.1Q standard) for each "logical LAN" shown in Figure 1. Please have a look at the following sources! You'll find pointers to these sources on the RouterLab website.

- http://en.wikipedia.org/wiki/Virtual_LAN
- VLANCisco: p12-1 to p12-3, p12-8 to p12-9, p12-10, p12-14 to p12-18
- ... there is a lot of material in the web!

Answer the following questions:

1. What are motivations for using VLAN? Pick two reasons and explain briefly (2-4 sentences)!
2. What is the difference between *Port-based VLANs* and *VLAN Trunks*?
3. Which mechanism is used to distiniguish between Ethernet frames of different VLANs (VLAN Trunks)?
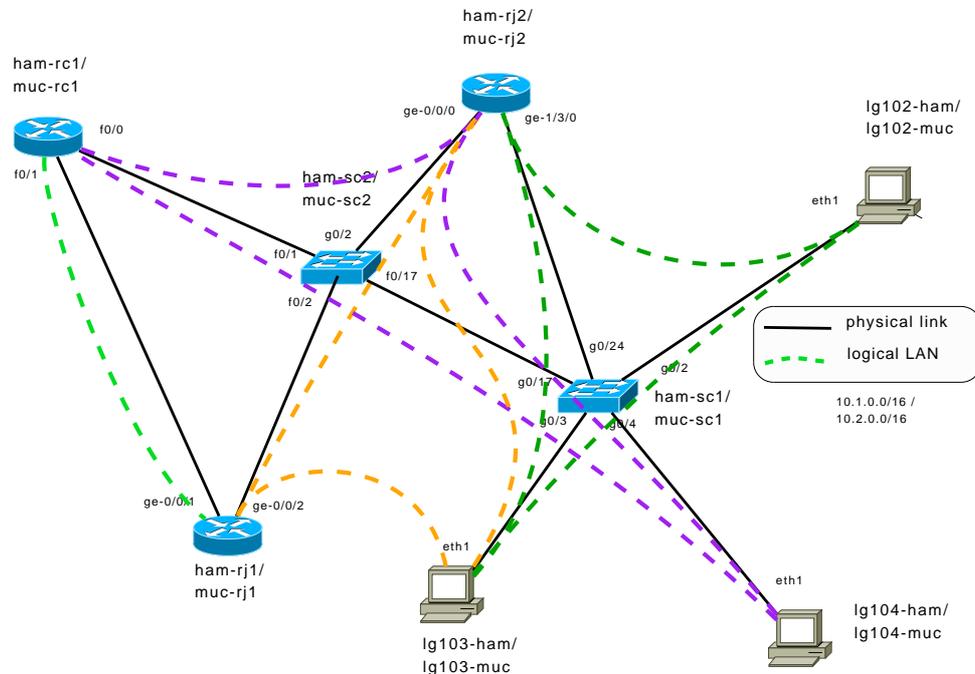

Figure 1: Topology: Mapping of VLANs to physical links.

(d) Configure a separate VLAN for each "logical LAN" in Figure 1 except for the direct link between ham-rj1/muc-rj1 and ham-rc1/muc-rc1, and add the used VLAN IDs to your topology map! Make sure that adjacent router can ping each other! Your setup must satisfy the following conditions:

- Only use VLAN IDs of in the range $x00 - x99$ where x is your team number!
- Do not use interfaces other than those specified in Figure 1. However, you are allowed to configure subinterfaces for your physical interfaces.
- Whenever possible, use access mode on the switches!
- Altogether you will need to configure three separate VLANs (please also check the colored version of this worksheet which is provided on the course website):
  - "purple" arcs: ham-rc1/muc-rc1, ham-rj2/muc-rj2 and loadgen104-ham/loadgen104-muc
  - "orange" arcs: ham-rj1/muc-rj1, ham-rj2/muc-rj2 and loadgen103-ham/loadgen103-muc
  - "darkgreen" arcs: ham-rj2/muc-rj2, loadgen103-ham/loadgen103-muc and loadgen102-ham/loadgen102-muc

(e) From all loadgens: ping the interfaces of devices in the same VLAN to verify they're interconnected. Do the same between ham-rj1/muc-rj1 and ham-rc1/muc-rc2

Some hints:

- Figure out which mode (`switchport mode <access|trunk>`) to use for the switches!
- For the routers: Figure out where you need *subinterfaces* (Ciscos) or new *units* (Juniper)! If possible, avoid configuring subinterfaces or extra units
- List of switch commands you will need:

  ```
  (config)vlan <vlan-id>
  (config-if)switchport mode <trunk|access>
  (config-if)switchport access vlan <vlan id>
  (config-if)switchport trunk allowed vlan add/remove <vlan id>
  ```

- Cisco router: Create subinterface if needed, e.g. `f0/1.<id>`!

  ```
  (config-subif)encapsulation dot1Q <vlan-id>
  ```

- Juniper router: Create a `unit` and enable `vlan-tagging` (please mind that some of the configuration items are only reachable by 'set' (as opposed to 'edit')):

  ```
  ge-x/x/x {
      vlan-tagging;
      encapsulation flexible-ethernet-services;
      unit <id> {
          vlan-id <vlan-id>;
          family inet
  ...
  ```

- The following example illustrates for loadgens how to set up a subinterface such that all outgoing Ethernet frames are tagged with a VLAN ID[1]:

  ```
  root@loadgenxxx:~# ifconfig ethX up
  root@loadgenxxx:~# vconfig add ethX <vlan-id>
  root@loadgenxxx:~# ifconfig ethX.<vlan-id> <ip-address> netmask <netmask>
  ```

For more information on how to configure VLANs on switches on routers, please check the Cisco and Juniper documentations and the FAQ!

Use ping to check if all adjacent devices of your cloud are mutually reachable!

Question 2: (20 Points) *Static Routing*

Now all components inside a logical LAN should be able to communicate with each other on layer two, while components of other VLANs are unreachable. In this part of the exercise, we'll establish connectivity across this set of networks to bind them together in one holistic network, allowing for arbitrary connection between all your assigned components. This will be done by configuring static routes between these networks.

Note: In this exercise, loadgens are not be allowed to forward packets, received from other components.

(a) On which layer are we creating the connectivity between the VLANs?

(b) Answer the following questions for every loadgen of your cloud:

1. Which network[s] does it directly participate in? (name prefix/netmask)
2. Name a next hop (IP address) for each network that needs to be routed for this loadgen. Choose a next hop providing the shortest route to the respective network.

(c) Which components (aside from the loadgens) need to be configured with additional routes in order to communicate with the loadgens of the cloud?

(d) Add the respective static routes to the loadgens and to the additional components identified in the previous question. (Always choose the shortest route)

(e) For each loadgen: traceroute every other configured interface (the ones *you* have given IP addresses) of your assigned routers and loadgens to verify that they're all reachable. Check which paths the packets are taking.

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[1]subinterfaces can be removed with vconfig rem, see man vconfig

Submission details: read the FAQ on
http://www.net.t-labs.tu-berlin.de/teaching/ss09/RL_labcourse/
Submit the following:

- Topology map (see Figure 1)

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

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

- Answers to the questions

Due Date: Friday, May 08th, 2009, 08:00 am