Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Networked Systems
ETH Zürich — seit 2015

Communication Networks

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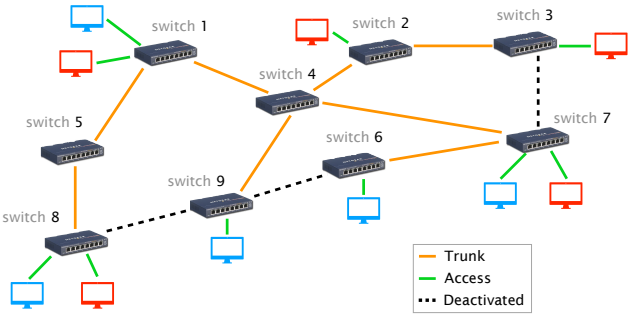
Solution: Exercises week 6 – VLAN, Internet Protocol & Forwarding

VLAN

The network below consists of 9 switches and hosts in two different VLANs (blue and red). Compute a spanning tree in the network using switch 1 as root. Indicate the type of each link (trunk, access or deactivated).

Solution:



L2-network with hosts in two different VLANs (blue and red).

a) Using the previously computed spanning tree, which path will the red host connected to switch 7 use to communicate with the red host connected to switch 1?

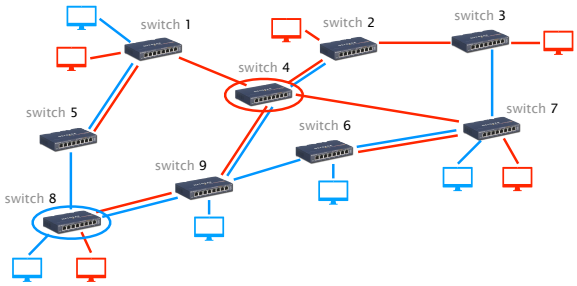
Solution: 7-4-1

b) Using the previously computed spanning tree, which path will the red host connected to switch 7 use to communicate with the blue host connected to switch 8?

Solution: Not possible. A host in the blue VLAN cannot directly communicate with a host in the red VLAN. Traffic would have to go over a layer 3 router to reach the other destination.

c) Compute now two per-VLAN spanning-trees (one for each VLAN) such that each link is active in at least one spanning-tree.

Solution: Multiple solutions are possible, for example:



IPv4 vs. IPv6

a) In the lecture you heard about IPv4 and IPv6. Why was IPv6 introduced? What is the main difference?

Solution: The main motivation for IPv6 is the IPv4 address exhaustion. Even though Network Address Translation (NAT) could temporarily solve the problem, there are no longer enough IPv4 addresses / subnets for all the devices connected to the Internet. The main difference is the higher number of bits for each IP address (128 instead of 32). Furthermore, IPv6 also handles e.g. fragmentation or header options in a different way.

b) How many IPv4 and IPv6 addresses exist? Is it possible to use all the addresses for hosts in the Internet?

Solution: IPv4: $2^{32} \approx 4.3 * 10^9$

IPv6: $2^{128} \approx 3.4 * 10^{38}$

No, it is not possible to use all the addresses. Some address spaces are reserved e.g. for private addresses. Other addresses are used to identify the network/router or as broadcast addresses.

c) Assuming there are 7.5 billion people in the world, how many IPv4/IPv6 addresses are theoretically available per person?

Solution: IPv4: $2^{32}/(7.5 * 10^9) \approx 0.57$

IPv6: $2^{128}/(7.5 * 10^9) \approx 4.5 * 10^{28}$

d) Even though IPv6 has been standardized more than 10 years ago, it still has very limited coverage. What are the reasons why the deployment of IPv6 is so slow?

Solution: Every network device, which has to interact with the network layer, needs to be able to understand the new IPv6 addresses and the corresponding header. It is therefore not possible to switch from IPv4 to IPv6 on one specific day. Upgrading the hardware is costly and especially for end-users there is no real motivation. At the moment, everything seems to work well with IPv4 addresses.

IP Calculations

Each row in the following table describes an IP network. Fill in the missing values.

Solution:

Slash–notation	Netmask–notation	First usable address	Last usable address	Broadcast address
10.0.0.0/24	10.0.0.0/255.255.255.0	10.0.0.1	10.0.0.254	10.0.0.255
126.127.128.0/17	126.127.128.0/255.255.128.0	126.127.128.1	126.127.255.254	126.127.255.255
12.34.32.0/19	12.34.32.0/255.255.224.0	12.34.32.1	12.34.63.254	12.34.63.255
222.208.0.0/12	222.208.0.0/255.240.0.0	222.208.0.1	222.223.255.254	222.223.255.255
123.45.67.224/27	123.45.67.224/255.255.255.224	123.45.67.225	123.45.67.254	123.45.67.255

IPv6 addresses have a slightly different notation. Because the addresses are 128 bit long, we switch from a decimal notation to a hexadecimal one. In general, IPv6 addresses are represented by eight colon-separated blocks of up to four hexadecimal digits each. In a block, leading zeros can be omitted. Furthermore, we can use the "::" symbol to compress one or more consecutive zero blocks. However, the "::" symbol can only be used once in a single IPv6 address. As an example, the IPv6 address: 2001:0db8:0000:0000:0000:ff00:0042:8329 can be simplified to 2001:db8::ff00:42:8329.

a) You are the operator of an enterprise network. Your ISP is giving you a /96 subnet 2001::/96. How many addresses do you have available? Is that a reasonable subnet size compared with the currently available IPv4 addresses?

Solution: You have $2^{128-96} - 1 = 4'294'967'295$ addresses available (no broadcast addresses in IPv6). This is as if you had all IPv4 addresses available exclusively for your enterprise network.

b) In your enterprise network, each host machine is identified by a unique ID starting from 1. Now that you have a lot of IPv6 addresses available, you decide to give each host a unique IP address. The host with ID 1 gets the first IPv6 address in your subnet (2001::1), the host with ID 2 the second IP address and so on. Complete the following table:

Solution:

IPv6 address	host ID
2001::5	5
2001::E	14
2001::3A5	933
2001::FFFF:FFFF	4 294 967 295
2001::3:0	196 608

Detective work

You just started your first job as a network operator of a small network. To get more familiar with the network, you look at a packet trace captured at a switch. The trace contains packets from multiple hosts and one router connected by a (layer 2) switch. The router acts as default gateway, providing access to the Internet and is assigned the first IP address in the subnet. Each row in the following table represents one packet observed at the switch.

SRC MAC Address	DST MAC Address	SRC IP Address	DST IP Address
6a:00:02:49:a1:a0	11:05:ab:59:bb:02	192.168.11.1	192.168.8.2
6a:00:02:49:a1:a0	da:15:00:00:01:11	192.168.11.1	192.168.16.1
da:15:00:00:01:11	11:05:ab:59:bb:02	129.132.103.40	192.168.8.2
11:05:ab:59:bb:02	40:34:00:7a:00:01	192.168.8.2	192.168.15.254
11:05:ab:59:bb:02	ac:00:0a:aa:10:05	192.168.8.2	192.168.9.99
ac:00:0a:aa:10:05	01:05:3c:34:00:02	192.168.9.99	192.168.13.255
6a:00:02:49:a1:a0	da:15:00:00:01:11	192.168.11.1	192.168.8.1

a) Can you identify all the hosts that are part of the local network?

Solution: The local hosts are all the sources and destinations that do not have to go through the default gateway (e.g., their MAC address is not replaced by the MAC address of the router):

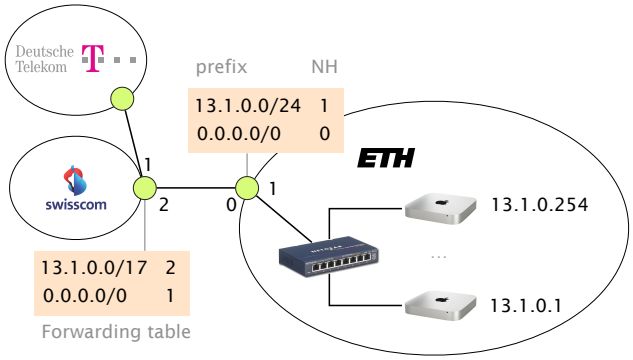
- 192.168.11.1
- 192.168.8.2
- 192.168.9.99
- 192.168.15.254
- 192.168.13.255

b) Can you reconstruct the IP subnet used to address the hosts within that local network?

Solution: First, we should note, that the router MAC address is only used for IP sources or destinations outside the local subnet (router is used as gateway) or for packets from/towards the router. With this in mind, we can identify the lowest subnet address from the packets (192.168.11.1 -> 192.168.8.1) and (192.168.11.1 -> 192.168.8.2) as 192.168.8.1. Furthermore, we can infer that 192.168.15.254 still belongs to the local subnet (192.168.8.2 -> 192.168.15.254) but 192.168.16.1 is a destination outside of the network (192.168.11.1 -> 192.168.16.1). We can therefore identify the used subnet as 192.168.8.0/21.

The Art of Defaulting Properly (Exam Style Question)

Consider this simple network configuration between ETH and Swisscom. Assume that ETH owns a large IP prefix 13.1.0.0/17, but only uses 13.1.0.0/24 to address its internal hosts. For simplicity, we assume that ETH and Swisscom operators configure their forwarding table statically and rely on the use of a default route (0.0.0.0/0).



Where are my IP packets going?

a) How many IP addressable addresses does ETH "own" in total?

Solution: $2^{(32-17)} - 2$

b) Give the first and last IP address that ETH can use for addressing a host.

Solution: 13.1.0.1 and 13.1.127.254

c) Suppose Swisscom receives a packet for 13.1.0.66 from Deutsche Telekom. What is the path taken by this IP packet?

Solution: Swisscom/1 → Swisscom/2 → ETH/0 → ETH/1

d) Suppose Swisscom receives a packet for 13.1.66.1 from Deutsche Telekom. What is the path taken by this IP packet?

Solution: Swisscom/1 → Swisscom/2 → ETH/0 → Swisscom/2 → ETH/0 → ...

e) What eventually happens to the packet for 13.1.66.1? As an attacker observing this, could you use this observation to congest the ETH-Swisscom link more easily? Explain why (or why not).

Solution: It will eventually be dropped as the TTL reaches 0. Permanent forwarding loops can be used to perform a Denial of Service (DoS) attack with few resources. Here an attacker can simply start sending fake traffic to 13.1.66.1 which will start "pilling up" on the Swisscom ↔ ETH link. The actual damages will depend on: *i)* the rate at which the attacker can send; *ii)* the TTL of the packets; as well as *iii)* the actual capacity of the link. Observe that the induced congestion negatively impact *all* traffic, including traffic destined to 13.1.0.0/24.