DT222A and DT098A
Advanced Networking Concepts
Laboratory assignment I & II

Lennart Franked*

November 11, 2025

Contents

Goals

After passing this laboratory excercise you will have shown that you

- are able to create an IPv4 addressing scheme,

- build a network from a given topology,

- and apply this addressing scheme to it.

---

*E-post: lennart.franked@miun.se.

- Given a topology and cost values, can calculate the path a package will take using Dijkstras' algorithm.

- can perform very basic router configurations.

Aims

This laboratory assignment covers the areas of IP subnetting, static routing and dynamic routing.

Reading assignment

Before starting this lab you should get aquinted with the configuration documentation for Cisco IOS [3, Initial Configuration Using the Command-Line Interface] and [4, Enabling OSPF]. You should also have attended the lectures covering the internet-layer and routing or read up to and including [1, chapter 5]

1   Introduction

This laboratory assignment is split into two parts. The first part covers IP subnetting, and in the second part, you will setup and configure a network running static- and dynamic routing.

You will work in groups of maximum four students for this assignment.

2   Assignment

This lab is divided into subsections, and each subsection contains a set of instructions followed by a set of item that must be answered. Always motivate your answers, add references when necessary and show your calculations.

2.1   Laboratory Session 1: Subnetting

During this first session you will in start by calculating your groups IP-address range. Next you will subnet this network, according to a given topology. Finally you will allocate the subnets to the different networks shown in the topology Figure 1 on page 4.

2.1.1 Create the IP-address range

The first thing needed is a IP-addressing range to use in our network. Since this assignment is done in a laboratory setting, we don't have to comply to the RFC1918[2] standards of private IP-addressing.

An IP address is written in the form shown in equation (2.1.1).

$$\underbrace{x}_{grp1} \cdot \underbrace{x}_{grp2} \cdot \underbrace{x}_{grp3} \cdot \underbrace{x}_{grp4} \text{ where } \{x \in \mathbb{Z} \mid 0 \leq x \leq 255\} \tag{2.1.1}$$

We need however to take into consideration that the address range of 224.0.0.0/3 have been reserved, for amongst other thing multicast, and localhost. Because of this, we will need to use another modulus-value on the first octet when we are generating a usable ip-address range.

Start by creating your groups unique IP-address range using equation (2.1.2)

$$\underbrace{x}_{grp1} \cdot \underbrace{y}_{grp2} \cdot \underbrace{y}_{grp3} \cdot \underbrace{y}_{grp4} \text{ where } \{x, y \in \mathbb{Z} \mid 0 \leq x \leq 223, 0 \leq y \leq 255\} \tag{2.1.2}$$

Where each octet will be based on each group members birthday. Value X is calculated according to equation (2.1.3), and value Y is calculated according to equation (2.1.4).

$$YY * MM + DD \mod 223 \tag{2.1.3}$$

$$YY * MM + DD \mod 255 \tag{2.1.4}$$

.

The fourth group in the IP-address should be set to 0. Finally we will start with a subnet mask of /20, and you will end up with an address range that looks like equation (2.1.5)

$$\underbrace{x}_{grp1} \cdot \underbrace{y}_{grp2} \cdot \underbrace{y}_{grp3} \cdot \underbrace{0}_{grp4}/20 \tag{2.1.5}$$

Before continue to the next part, answer the following item:

- What is the network-ID of your groups subnet?

- What is the broadcast address of your groups subnet?

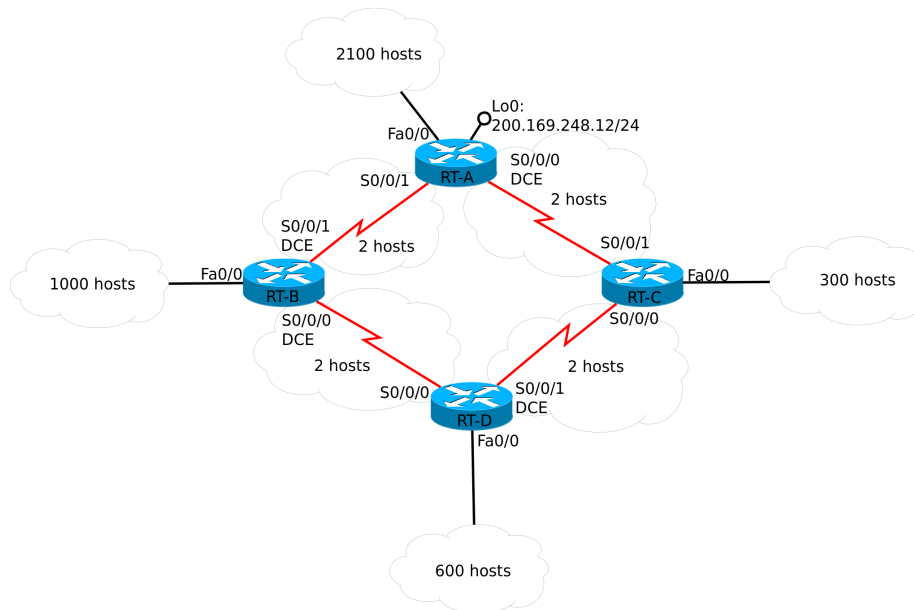- How many hosts in total can this subnet hold?

Figure 1: Lab topology

2.1.2 Planning your network

With the help of Table 1 on the next page, Table 2 on the next page, Table 3 on the next page, Table 4 on the next page and Figure 1 create suitable subnets from the subnet that was given to you in 2.1.

NOTE: It is possible to allocate more than one subnet per interface.

Questions regarding subsection: 2.1.2

- Create a table for each of the eight networks that contains the network-ID and subnet mask for the subnet/subnets in that network.

- Fill the 'IP-address' and 'Subnet mask' in the interface tables and give each interface an IP-address based upon your addressing scheme. In the case you might need several subnets, give the corresponding interface an IP-address from both subnets.

Table 1: Interface table for RT-A

RT-A Interface	IP-Address	Subnet mask	DCE/DTE	Bandwidth	# Hosts	Description
Serial 0/0/0			DCE	256 kbit/s	2	Link to RT-C interface S0/0/1
Serial 0/0/1			DTE	128 kbit/s	2	Link to RT-B interface S0/0/1
FastEthernet 0/0				100 Mbit/s	2100	Link to RT-A Ethernet network
Loopback 0				100 Mbit/s		WAN-connection using address 200.169.248.12/24

Table 2: Interface table for RT-B

RT-B Interface	IP-Address	Subnet mask	DCE/DTE	Bandwidth	# Hosts	Description
Serial 0/0/0			DCE	64 kbit/s	2	Link to RT-D interface S0/0/0
Serial 0/0/1			DCE	128 kbit/s	2	Link to RT-A interface S0/0/1
FastEthernet 0/0				100 Mbit/s	1000	Link to RT-B Ethernet network

Table 3: Interface table for RT-C

RT-C Interface	IP-Address	Subnet mask	DCE/DTE	Bandwidth	# Hosts	Description
Serial 0/0/0			DTE	128 kbit/s	2	Link to RT-D interface S0/0/1
Serial 0/0/1			DTE	256 kbit/s	2	Link to RT-A interface S0/0/0
FastEthernet 0/0				100 Mbit/s	300	Link to RT-C Ethernet network

Table 4: Interface table for RT-D

RT-D Interface	IP-Address	Subnet mask	DCE/DTE	Bandwidth	# Hosts	Description
Serial 0/0/0			DTE	64 kbit/s	2	Link to RT-B interface S0/0/0
Serial 0/0/1			DCE	128 kbit/s	2	Link to RT-C interface S0/0/0
FastEthernet 0/0				100 Mbit/s	600	Link to RT-D Ethernet network

2.2 Laboratory Session 2: Building the network

In this session we will now create the network shown in Figure 1 on page 4.

The teacher will give you an introduction to the network lab in the beginning of the session, and assign each group with the necessary equipment.

Once you have been assigned the equipment, start by connecting the routers according to the topology. *Make sure that you are connecting the correct interfaces togheter.* Otherwise you will encounter alot of problems further down the road.

For each router make sure that you have configured the following:

- Hostname

- Run the following commands in the Router Configuration Mode:

    - `Router(config)# line console 0`
    - `Router(config-line)# logging synchronous` % prevents log messages to interrupt the command line input.
    - `Router(config-line)# exit`
    - `Router(config)# no ip domain-lookup` % Prevents DNS-lookups that will lock the console for a short time.

- Interfaces

    - Set the IP address according to the ip-address plan you made in the previous laboratory session.
    - For the DCE serial interfaces, set the clock rate to reflect the speed of the serial link between the routers.
    - When you create a sub-interface you need to enable the "host interface", and for each sub-interface you must change so that the router will use IEEE 802.1Q standard for VLAN-tagging. See Table 3 on page 11

Once you have configured the interfaces, issue a `ping` between neighbouring routers to ensure connectivity.

Save the running configuration to a file named `L3_basic_conf.txt` on your computer, using the instructions given in 3.

2.2.1 Setting up static routing

You now have a base network set-up, however you should only be able to ping between neighbouring routers. In order for the routers to be able to reach beyond their neighbors, we will configure a couple of static routes, see Table 3 on page 12.

- Router A

  - Create static routes so that Router A can reach all the subnets on routers B - D, including the links between Router D — C and Router D — B.
  - Configure a default route out towards Loopback0.

- Router B and C

  - Create static routes so that Router B and C can reach all subnets on Router D.
  - Set a default route towards Router A.

- Router D

  - Set a default route towards router A through both Routers B and C.

Once you have configured static routes, check that everything works by issuing `pings` to all the router interfaces.

Save your running config to a file named `L3_static_routing.txt`, see 3.

Questions regarding subsection: Setting up static routing

- In your report, list all the static routes you configured along with a short explanation.

- Issue multiple `pings` from RT-D to the loopback on RT-A, which path will the ICMP-packet take and why?

- With the help of modifying the cost of the static routers, force the ping packets to always travel through router C when trying to reach loopback on RT-A from RT-D. How did you achieve this?

2.2.2 Setting up dynamic routing

Restart the routers so that they are empty from configurations, and load your base config according to the instructions given in 3

Static routing works fine in small networks like this, however networks are seldom small and it can quickly become very cumbersome to maintain static routes over larger network. Therefore you will now configure OSPF in this network.

Before you start configuring OSPF though, you must calculate the cost of each of the links. The bandwidth of the links can be found in Figure 1 on page 4 and in each routers interface table. cOSPF (which is Cisco's implementation of OSPF) use the following formula for calculating the cost of a link:

$$\text{cost} = 100\,000\,000/\text{bandwidth (bps)} \tag{2.2.1}$$

Questions regarding subsection: Setting up dynamic routing part 1.

- Draw up the topology and write the cost on each link according equation (2.2.1).

- Each group member will now select one of the four routers, and from this router calculate the shortest path to all the sub-networks using Dijkstra's algorithm. What are the costs to reach the different networks?

Next step is now to configure OSPF routing in the topology, see Table 3 on page 12 for how to make the configurations.

For each router, make sure that the following configuration guidelines are followed.

- Use OSPF area 0 for all the networks.

- Use the `bandwidth` command on all the interfaces to ensure that OSPF are using the correct bandwidth in its calculations.

Finally, save your configuration as `L3_ospf_conf.txt`

Questions regarding subsection: Setting up dynamic routing part 2.

- Issue the command `show ip route` and look at the metric OPSF use for all the networks in the routing table. Are the metrics the same as the metrics you calculated in item 2.2.2?

- Issue the `ping` command from RT-D to the loopback on RT-A. Which path does the ICMP-packet take to reach RT-A loopback?

- Modify the OSPF-metric so that it prefers to send packages though RT-B instead of RT-C when sending packages from RT-D to RT-A. Show how you achieved this.

- Which group member was doing the configuration for this part?

3 Examination

Hand in your laboratory report in PDF-format, together with all the configuration files in the submission box for 'laboratory assignment 1 & 2'. *Remember to add the names of all the group members in the report.*

References

[1]   James F. Kurose and Keith W. Ross. *Computer networking : a top-down approach.* 7th ed. Boston: Pearson/Addison Wesley, 2017. ISBN: 9781292153599.

[2] Robert Moskowitz et al. *Address Allocation for Private Internets*. RFC 1918. Feb. 1996. DOI: 10.17487/RFC1918. URL: https://www.rfc-editor.org/info/rfc1918.

[3] Cisco Systems. *Cisco 2800 Series Software Configuration Documentation*. Accessed 2018-11-15. 2004. URL: http://www.cisco.com/c/en/us/td/docs/routers/access/1800/1841/software/configuration/guide/sw/b_cli.pdf.

[4] Cisco Systems. *IP Routing: OSPF Configuration Guide, Cisco IOS Release 12.4T*. Accessed 2018-11-15. 2018. URL: https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_ospf/configuration/xe-16/iro-xe-16-book/iro-cfg.html.

Router Configuration Cheat Sheet

Basic IOS

Command	Description
`Router> enable` `Router#`	Enables privileged commands
`Router# configure terminal` `Router(config)#`	Enters configuration mode
`Router(config)# exit`	Leaves current mode (configuration, priviliged, interface...)
`Router(config)# ?`	Shows available commands with description Can be used on partially entered commands as well
`Router# ena<tab>` `Router# enable`	Tab completion, by pressing tab on a started command, if the command exist, it will auto-complete.

`Router(config)# no <command> e.g`
`Router(config-if)# ip address 129.0.0.1`
`255.255.255.0`
`Router(config-if)# no ip address`
`129.0.0.1 255.255.255.0`
`Router(config-if)# ip address 192.0.0.1`
`255.255.255.0`
	Removes the command <command> written in the same place as the original command.

`Router(config)# hostname MyRouter` `MyRouter(config)#`	Changes the hostname to 'MyRouter' (MyRouter is of course just a placeholder for whatever name you want to give your router)

Backing up Router Configurations

1. In teraterm go to `file -> log`
2. Select where you want the configuration to be save.
3. In the routers privileged mode run `show running-config`
4. Press `space` until you get the prompt again.
5. Close the log in teraterm.

Configuring Interfaces

Command	Description
`Router(config)#interface <interface>` `Router(config-if)#`	Enters a specific interface for configuration <interface>: Name of the interface, eg serial 0/0/0, fastethernet 0/0, loopback0...
`Router(config-if)# ip address 10.9.0.7 255.255.255.0`	Sets the IP address on the selected interface to 10.9.0.7/24
`Router(config-if)# no shutdown`	Enables the interface (interfaces are by default turned off)
`Router(config)# interface serial 0/0/0` `Router(config-if)# clock rate 64000`	Sets the clock rate on a serial interface to 64000 bps
`Router(config-if)# bandwidth 64`	Sets the bandwidth value (the value that routing protocols use for metric calculation) to 64 000 bps

`Router(config)# interface fastethernet 0/0`
`Router(config-if)# no shutdown`
`Router(config-if)# exit`
`Router(config)# interface fastethernet 0/0.1`
`Router(config-subif)#`
	Creates a logical subinterface, used when multiple subnets needs to be given on same physical interface.

`Router(config-subif)# encapsulation dot1q 1`	Sets the VLAN-id of the subinterface to 1 (VLAN-ID Must be unique for each subinterface) *If subinterfaces are used, the IP address for each subinterface is added here.*

Restoring a Router from a Backup

1. In the router go to the global configuration mode `Router(config)#`

2. In Teraterm, go to `File` -> `Send`

3. Select your `L3_basic_conf.txt`

4. Your router have now been reconfigured with your basic configuration.

Configuring Routing

Command	Description
`Router(config)#`ip route \<network-id\> \<mask\> \<next-hop\> \<cost\>	Configures a static route \<network-id\>: The Destination network to reach \<mask\>: The subnet mask to use for the static route \<net-hop\>: The ip-address to the next hop router \<cost\>: (Optional) Change the cost for this route
`Router(config)# router ospf <process id>` `Router(config-router)#`	Enables OSPF Routing \<process id\>: Sets the process id of the OSPF process. Allows multiple OSPF instances to be run. Common usage is area ID.
`Router(config-router)#`network \<network-id\> \<wildcard\> area \<area-id\>	In OSPF configuration mode. Sets what interface(s) that should be enabled for OSPF. \<network-id\>: The network-id of the subnet that the interface(s) belongs to. \<wildcard\>: Inverted subnet mask eg. $255.255.255.0 \rightarrow 0.0.0.255$ \<area-id\>: Which OSPF area that the interface should belong to (use area 0)

Tools for troubleshooting

Command	Description
`Router# ping <dest. ip>`	Ping

`Router# ping`
`Protocol [ip]:`
`Target IP address: <dest. ip>`
`...`
`Extended commands [n]: yes`
`Source address or interface: <source`
`address or interface>`
`...`
	Extended Ping
	Allows to choose which interface
	to be used as the source interface
	when performing a ping operation.

`Router# traceroute <destination ip>`	Performs a traceroute
`Router# show running-config`	Shows the full configuration of the router.
`Router# show ip interface brief`	Lists all the interfaces and their status (up/down, address etc.)
`Router# show ip route`	Displays the current routing table.
`Router# show ip ospf <process-id>`	Shows the OSPF settings
`Router# show ip ospf interface`	Shows OSPF-related interface configurations.
`Router# show ip ospf neighbor`	Shows OSPF neighbor information (used to verify that two router have established a OSPF-adjecency.)
`Router# show ip ospf <process-id>` `database`	Displays the OSPF database