Data Networks WS 18/19
INTERNET ARCHITECTURE:

Assignment 6

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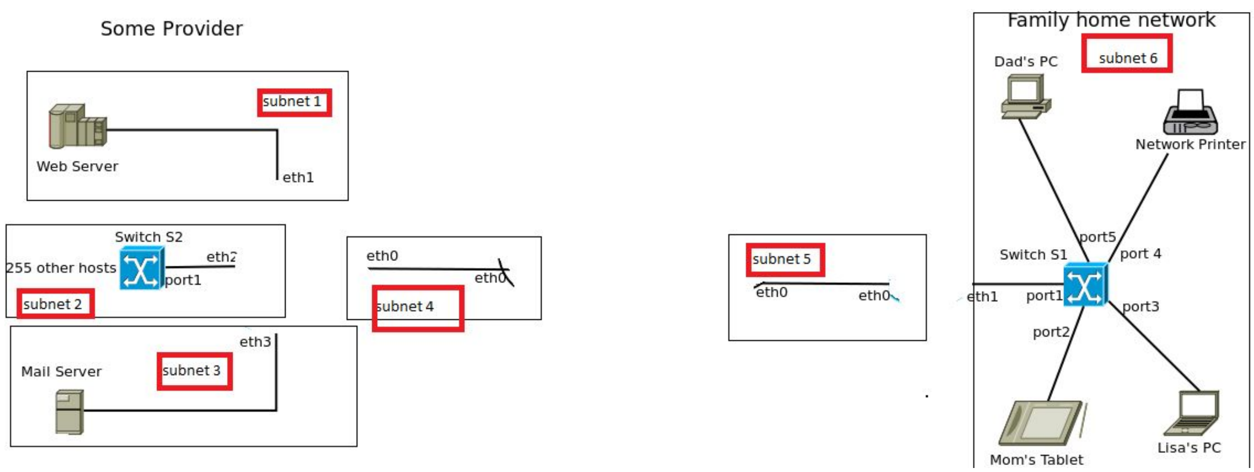
NOTE: WE HAVE ASSUMED THAT X.X.X.0 AND X.X.X.1 CAN ALSO BE USED FOR HOST ADDRESSES TO MAKE IP ASSIGNMENT SIMPLER. IN GENERAL, THESE ADDRESSES ARE RESERVED AND CANNOT BE USED FOR HOSTS.

Question 1: (1 + 1 + 0.5 + 1 + 0.5 + 0.5 + 1 + 0.5 = 6 points) IP Address

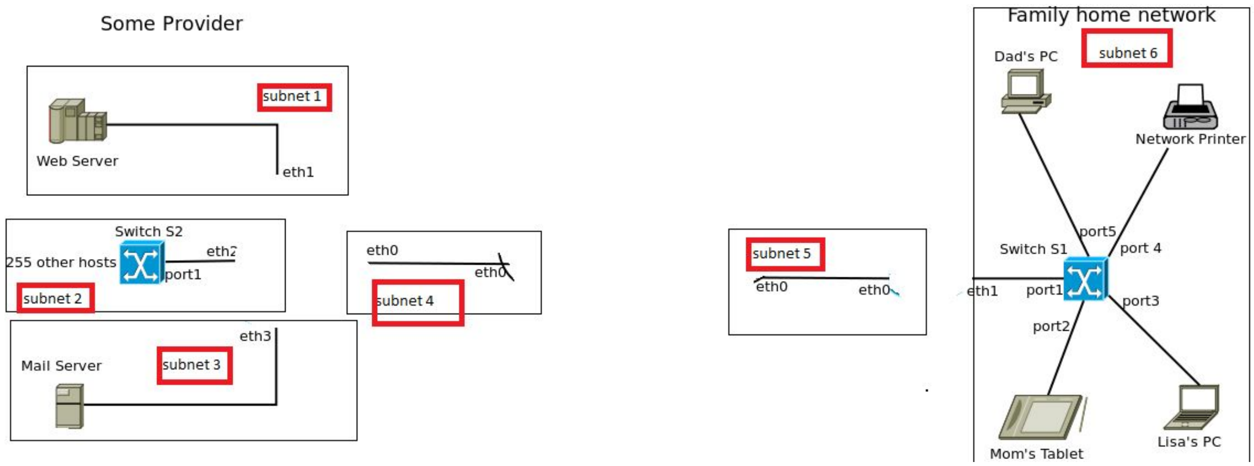
(a) In the topology, draw a circle around each sub-network (subnet), i.e., mark which devices, interfaces, and links belong to the same subnet. Assume that the switches are Layer-2, so they do not speak IP and they do not have IP addresses.

Hint: Remember that the boundary of the subnet is at the router, as routers connect different subnets with each other.



(b) Within each subnet, how many interfaces are there? How many IP addresses are needed for each subnet, if each interface only gets one IP address?

Hint: The number of interfaces and the number of IP addresses needed are NOT equal.



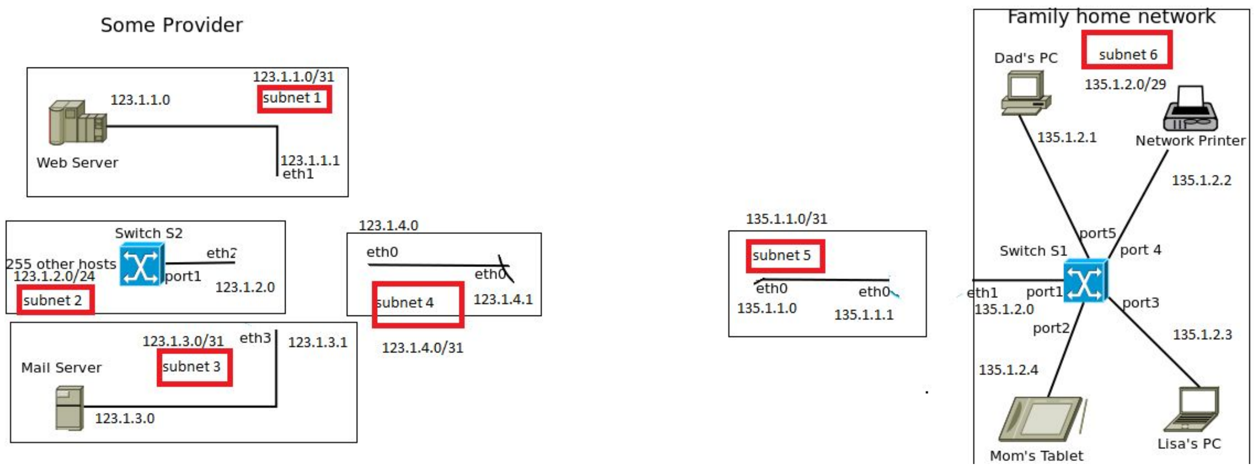
Subnet	No. of Interfaces	No. of IP addresses required
1	2	2
2	256	256
3	2	2
4	2	2
5	2	2
6	5	8

(c) Based on your answer to the previous question, what are the smallest possible IPv4 subnet sizes for each subnet? Briefly explain how you get these numbers.

Subnet	Subnet Mask Size	Subnet size i.e number of interfaces in subnet

1	32-1 = 31	2^1 = 2 *2 interfaces need 2 IPs and in IPV4 2 IPs can be assigned 2 addresses with a Subnet Mask of 31 to represent the network part of the address and 1 bit is used for the host part.*
2	32-8 = 24	2^8 = 256 *Need 256 interfaces. With a subnet mask of 24, exactly 256 addresses can be assigned.*
3	32-1 = 31	2^1 = 2 *Same explanation as Subnet 1.*
4	32-1 = 31	2^1 = 2 *Same explanation as Subnet 1.*
5	32-1 = 31	2^1 = 2 *Same explanation as Subnet 1.*
6	32-3 = 29	2^3 = 8 *Need 5 interfaces. With a subnet mask of 29, 8 addresses can be assigned. Even though only 5 interfaces are present, in IPV4 it is only possible to assign 8 addresses as it is the nearest.*

(d) Assign IPv4 addresses to all interfaces in the above topology, using the smallest possible
subnets. Annotate the topology figure: For each subnet, provide the address of the entire
subnet in CIDR notation, and then also the IP address for each interface.
Hint: You do not have to assign individual IP addresses for the “255 other hosts” in the network of “Some provider”, but consider this number in your choice of subnet size



Subnet	CIDR notation
1	123.1.1.0/31
2	123.1.2.0/24
3	123.1.3.0/31
4	123.1.4.0 /31
5	135.1.1.0 /31
6	135.1.2.0/29

With 254 addresses remaining after the assignment of subnet 1, the 254 addresses could still be assigned as we use CIDR notation. This can be extended to remaining addresses from subnet 3,4,5.

(e) If we were traveling back to the past, where only classful addressing was available: How would your previous IPv4 address assignment change? How many unused IP addresses would there be in each subnet? Why is classful addressing (nearly, hopefully) not used anymore?

Assuming class B address for **some provider network** connected to R3. The address range is : 128.0.0.0 to 191.255.0.0

Assuming class C address for **family home network** connected to R1. The address range is : 192.0.1.1 to 223.255.254.254

Subnet	Classful Subnets in CIDR notation	No. of Unused IP addresses Inside the subnet
1	128.0.0.0/24	256-2 = 254
2	128.0.1.0/24	0
3	128.0.2.0/24	254
4	128.0.3.0/24	254
5	192.0.2.0 /24	254
6	192.0.3.0/24	250

For some provider network:

In each Class B block the available addresses are 2^16. The number of addresses needed are 262(2+256+2+2 for subnet1, subnet2, subnet3, subnet 4). Therefore, the number of addresses wasted = (2^16) - 262=250

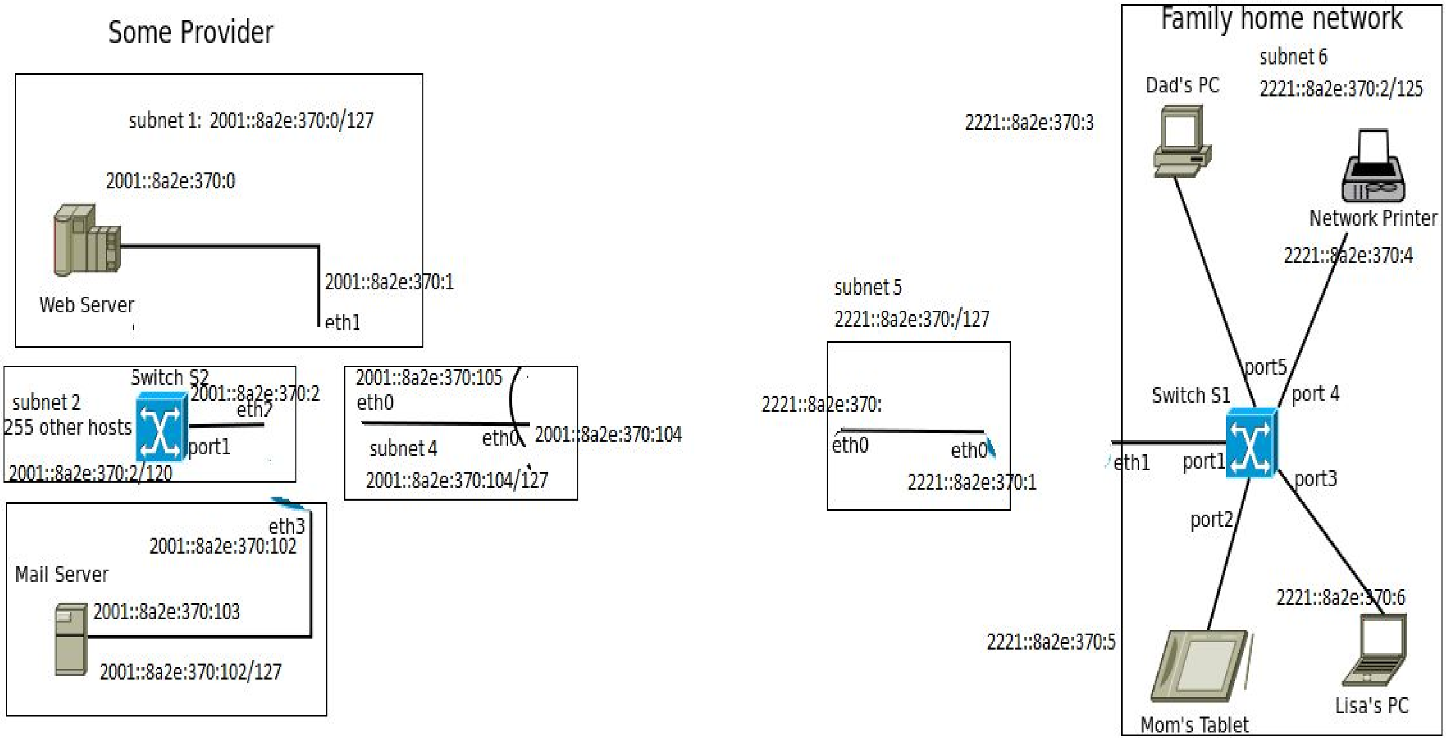
For Family home network:
In each class C Block the available addresses are 2^8. The number of addresses needed are 7 (2+5 for subnet5 and subnet 6). Therefore, the number of addresses wasted = (2^8) - 7 = 249

Classful addressing is not used as too many addresses are wasted as seen above. And also because there was too much of a demand for Class B addresses as the number of addresses (2^16) in this block was what most organizations required. Class A blocks were too big and Class C blocks were too small. Due to such demand and wastage of addresses, classful addressing is nearly, hopefully not used anymore.

(f) What is the recommended prefix length for IPv6?
How many IPv6 addresses are in one subnet of this size?

Recommended Prefix length = 64
IPv6 addresses= 2^64

(g) Now assign IPv6 global unicast addresses to all interfaces in the above topology, one address per interface. Annotate the topology figure: For each subnet, provide the address of the entire subnet in CIDR notation, and the IP address for each interface.
Hint: You can shorten the addresses by leaving out leading empty zeros and by (once) substituting all-zero hextets by a double-colon.



Subnet	IPv6 subnet addresses in CIDR notation
1	2001::8a2e:370:0/127
2	2001::8a2e:370:2/120
3	2001::8a2e:370:102/127
4	2001::8a2e:370:104/127
5	2221::8a2e:370:/127
6	2221::8a2e:370:2/125

(h) What other kind of IPv6 addresses, starting with fe80::, do all of the interfaces in the above topology have, in addition to a global unicast address? What can this kind of IPv6 address be used for?

IPv6 address starting with fe80:: is a link local unicast address which can be configured on any interface using the local link prefix fe80::/10 .

Yes, all of the interfaces in the above topology there is link-local address in addition with global unicast address. All IPv6 enabled interfaces have a link-local unicast address.

This kind of IPv6 address, that is link-local address is used only within a network for local signaling, that is it used to signal the neighbouring nodes.

Question 2: (0.5 + 0.5 = 1 points) Special-Purpose Address Space

(a) Why do we need private address space (10/8, 172.16/12, 192.168/16, FC00::/7), which is not routed in the Internet? In what type of networks is this address space typically used?

Private address space can be used within a private network such as in a campus or company and are private to it.

Private address space is needed when one wants to keep the connection private and not directly expose the device connections to the Internet.

Both IPv4 and IPv6 specifications define private address ranges.

Typically in residential IPv4 networks private address space are used.

In addition, such private addresses can be reused inside multiple networks.

(b) What is the most commonly used local loopback address in IPv4, and what is the loopback address in IPv6? Why do we need local loopback addresses?

IPv4 loopback: 127.0.0.0/8

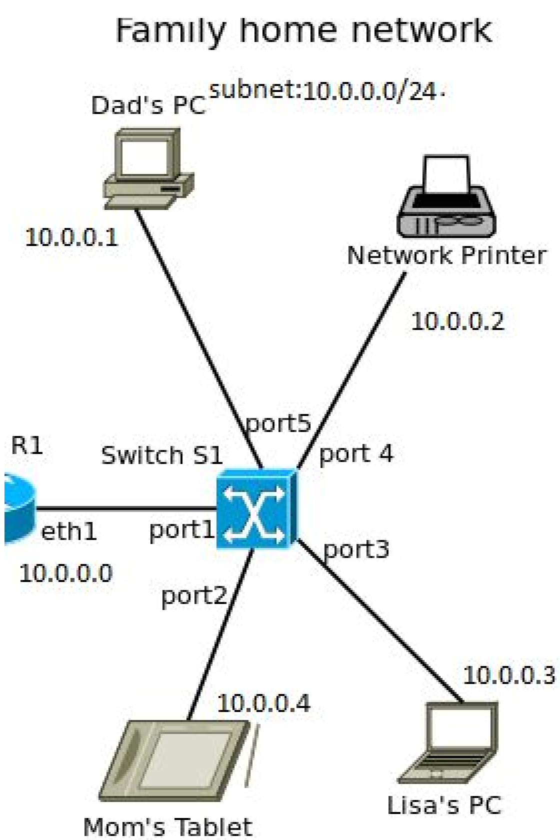
IPv6 loopback: ::1/128

It is primarily a means of testing the transmission or transportation infrastructure on a local network. Data packets sent on a loopback address are rerouted to the originating node without having made any changes to the data part.

Question 3: (0.5 + 0.5 + 0.5 + 0.5 = 2 points) Network Address Translation

Given that there are not enough global IPv4 addresses, the Internet Service Provider of the “Family home network” does not provide global IPv4 addresses for this network, but uses Network Address Translation (NAT). For this question, assume that the NAT gateway is running on router R1. The “Family home network” is now called a Local Area Network (LAN), and the rest of the topology is a Wide Area Network (WAN).

(a) Change the IPv4 address assignment of the interfaces within the “Family home network” by using private addresses. In your solution, provide the topology figure with both the subnet address for the entire LAN and the private IPv4 addresses of all interfaces on the “Family home network”.



Entire LAN = 10.0.0.0/24
Devices = 10.0.0.1;10.0.02;10.0.0.3;10.0.0.4
Interface eth1 = 10.0.0.0

(b) With NAT, all hosts on the LAN are “behind” a single global IPv4 address. When the NAT gateway receives a packet to this global IPv4 address, how does it determine to which host on the LAN the packet goes? Explain briefly.

NAT implements the REPLACE method,that is; Replacing the NAT IP address & new port number in the destination fields of every incoming datagram with the corresponding source IP address and port number stores in the NAT table.

Replace (NAT IP address, new port number) in destination fields of every incoming datagram with corresponding (source IP address, port number) stored in the NAT Table.

When it comes to new connections trying to contact a device behind a NAT for the first time, port forwarding is used. This is configured by the network administrator by setting aside one port number on the gateway for the exclusive use of communicating with a service in the private network, which is located on a specific host.

The external hosts must be aware of this port number and the address of the gateway to communicate with the internal/private network. Often these port numbers of Internet services such as port number for web services- HTTP -80 are used in port forwarding, this way enabling the common Internet services to be implemented on hosts within the private network.

(c) Lisa's computer wants to load a web page from the web server, for which it has to establish a TCP connection. It uses 49170 as its source port and 443 as destination port.
Show the NAT table of R1 after forwarding the TCP SYN packet of that connection. For this purpose, use the following table template:
LAN IP LAN port WAN IP WAN port

123.1.1.0 is the IP address we assigned to the web server.

LAN IP	LAN port	WAN IP	WAN port
10.0.0.3	49170	123.1.1.0	443

(d) Now Lisa's ex-boyfriend Tom wants to load the same web page using Dad's PC. The PC establishes a TCP connection to the webserver in parallel.

Similar to Lisa's computer, it uses 49170 as source port and 443 as destination port. Show the NAT table of R1 after forwarding the TCP SYN packet of that connection. Again use a table similar like Table 1.
123.1.1.0 is the IP address we assigned to the web server.
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LAN IP	LAN port	WAN IP	WAN port
10.0.0.1	49170	123.1.1.0	443

Question 4: (0.5 + 0.5 = 1 points) Forwarding Tables
(a) Briefly explain the difference between routing and forwarding.

Routing	Forwarding
Determines routes taken by packets from source to destination. Involves routing algorithm to find the path	Moving packets from router's input to appropriate router output.

(b) Provide the IPv4 forwarding table of router R2, using the following table template:

prefix/mask	next hop IP address	interface
123.1.1.0/31	123.1.1.1	eth1
123.1.2.0/24	123.1.2.0	eth2
123.1.3.0/31	123.1.3.1	eth3
123.1.40./31	123.1.4.0	eth0