CS335a - Assignment 4

Fall 2025

Network Layer

Deadline: 15/12 at 10:59 (before the class begins)

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For any questions, send an email to the mailing list: **hy335a-list@csd.uoc.gr**

If your question might reveal part of your answer, send it directly to the TAs mailing list: **hy335a@csd.uoc.gr**

Exercise 1 - Short Answers

a. What is the function of DHCP?

Answer: The main function of DHCP is to dynamically assign IP addresses.

b. In DHCP when a host sends a DHCP request why is the source IP 0.0.0.0 and not the IP the DHCP server offered?

Answer: Because the IP does not actually belong to the host yet. It needs to receive the final ACK from the server.

c. Explain what a router will do if it attempts to forward a packet whose source address is a private IP address toward the Internet. What mechanism is required to allow this packet to be routed?

Answer: The router will drop the packet since a private address is not routable to the rest of the Internet. NAT can be used to map private IPs to a public one so that packets originating from a private network can be routed towards the rest of the Internet.

d. What is the broadcast address of a network?

Answer: The last IP of the network (all host bits are 1). When a packet is sent to the broadcast address it is sent(broadcasted) to **all** network interfaces.

e. Which animated character's name can be used to remember the names of the DHCP messages?

Answer: DORA (**D**iscover - **O**ffer - **R**equest - **A**ttack)

Exercise 2 - Subnetting

You are given the network **10.10.8.0/24**.

a. The network must be split into **three subnets**:
- **Subnet 1** must support **up to 90 hosts**
- **Subnet 2** must support **up to 50 hosts**
- **Subnet 3** must support **up to 50 hosts**

Find a prefix for each subnet that satisfies the required number of hosts.
The host part must be the smallest possible to still satisfy the above (i.e., each subnet uses the minimum number of addresses)

Besides the prefix for each subnet, list the following:

- the maximum number of available hosts
- the network address
- the broadcast address

Show your calculations and your train of thought for the above.

b. Now, a new **Subnet 4** is needed, and it must support **up to 10 hosts**. Note that there is *no remaining free address space* outside **10.10.8.0/24**. Note as well, that Subnet 1 does not need all its addresses to support 100 hosts.

i. Find a prefix for Subnet 4 such that:

- Subnet 1, 2 and 3 **remain unchanged** (keep their original prefixes).
- Subnet 4 is created **inside** Subnet 1, so that Subnet 1 still supports 100 hosts and Subnet 4 supports 10 hosts.

ii. If there is a packet with destination IP one that belongs to Subnet 4, is there any chance that a router will forward it to Subnet 1 instead, since it technically includes Subnet 4? If not, what is the algorithm/rule that prevents that?

Solution

a. Subnet 1

Prefix	10.10.8.0/25
Max Hosts	126
Network Address	10.10.8.0
Broadcast Address	10.10.8.127

Subnet 2

Prefix	10.10.8.128/26
Max Hosts	62
Network Address	10.10.8.128
Broadcast Address	10.10.8.191

Subnet 3

Prefix	10.10.8.192/26
Max Hosts	62
Network Address	10.10.8.192
Broadcast Address	10.10.8.255

b. i)

Subnet 4

Prefix	10.10.8.96/28
Max Hosts	14
Network Address	10.10.8.96
Broadcast Address	10.10.8.111

b.ii) No, there is not. Routers use Longest Prefix Match.

Exercise 3 - Longest Prefix Match

A router has the following forwarding table. From which interface will each of the incoming packets with the displayed destination IP address be forwarded to? Do a detailed analysis on which interface will be chosen and for what reason (convert the IP addresses to binary notation in order to give specific reason for your answers).

Incoming Packets

- **a.** 147.52.171.92
- **b.** 147.52.167.151
- **c.** 147.52.163.151
- **d.** 147.52.170.192
- **e.** 147.52.165.121

Forwarding Table

Network Address	Network Mask	Interface
147.52.170.0	255.255.254.0	eth0
147.52.168.0	255.255.254.0	eth1
147.52.170.0	255.255.255.0	eth5
147.52.166.0	255.255.254.0	eth2
147.52.164.0	255.255.252.0	eth3
0.0.0.0	0.0.0.0	eth4

Solution

Convert the network masks to decimal notation and network addresses to binary notation:

Network Address	Network Mask	Interface
10010011.00110100.10101010.00000000	/23	eth0
10010011.00110100.10101000.00000000	/23	eth1
10010011.00110100.10101010.00000000	/24	eth5
10010011.00110100.10100110.00000000	/23	eth2
10010011.00110100.10100100.00000000	/22	eth3
00000000.00000000.00000000.00000000	/0	eth4

Convert the incoming IPs to binary:

a) **147.52.171.92** → 10010011.00110100.10101011.01011100 → **eth0**
b) **147.52.167.151** → 10010011.00110100.10100111.10010111 → **eth2, eth3 (lpm: eth2)**
c) **147.52.163.151** → 10010011.00110100.10100011.10010111 → **eth4**
d) **147.52.170.192** → 10010011.00110100.10101010.11000000 → **eth0, eth5 (lpm: eth5)**
e) **147.52.165.121** → 10010011.00110100.10100101.01111001 → **eth3**

Exercise 4 - NAT

We have an app running on a server with IP 83.212.102.141 and port 16335. This app returns the IP and port of the packets it receives. Open Wireshark and start capturing. While it is active, send an HTTP request from your home network (it is important that you use a home network and not be connected to the university network as it does not run NAT). For this you can either use the curl command (curl http://83.212.102.141:16335/) or just paste this: http://83.212.102.141:16335/ in your browser's search bar.

a. What is your IP based on what the server sees? Is that a public or private IP? Explain. Include a screenshot of the server's response.

b. Find the HTTP request packet on Wireshark. What is your actual IP? Is that a public or private IP? Explain. Include a screenshot of the HTTP request.

c. Let's analyze the results:

i. Do you see any differences on src IP and src port numbers between the request received at the server and the Wireshark packet capture? Why does that change occur?

ii. Do the dst IP and dst port number change, if not why?

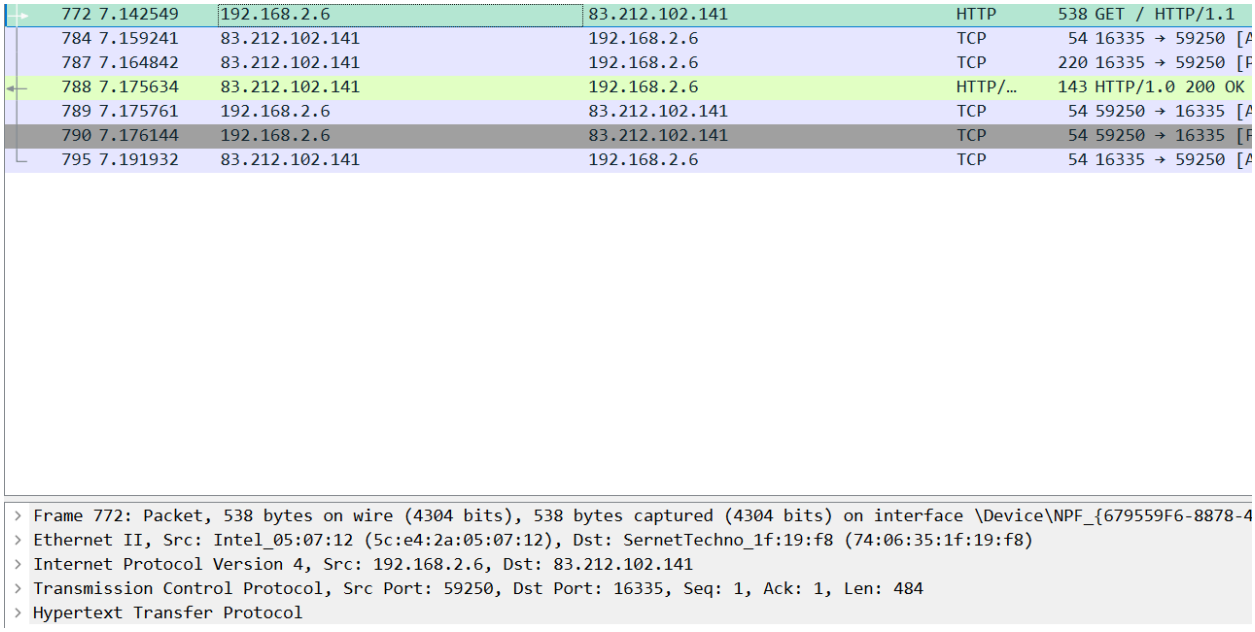
iii. If the src port remains the same, why could that be?

d. If we have NAT with port-address translation, what is the max number of simultaneous connections we could have? Explain.

Solution

a. {"dst_ip":"83.212.102.141","dst_port":"16335","src_ip":"a.b.c.d","src_port":59250}

Based on the server's response my IP is a.b.c.d which will be an IP in the public range of IPs



b. In Wireshark we see that my IP here is the private one I have inside my home network (192.168.2.6)

c. Here

- **i.** We see changes in the src IP, server saw my public IP a.b.c.d while Wireshark my private one 192.168.2.6. There were no changes in src ports (59250 in both cases). This change happens because of NAT that translates my private IP address to the router's public one in order to leave the home network and be routable in the Internet.
- **ii.** The dstIP and dst port do not change, because if they did the packets would not reach the desirable server.
- **iii.** In this case the port remains the same because there is a small number of devices in the home network so NAT does not have to translate the port number if there is no conflict.

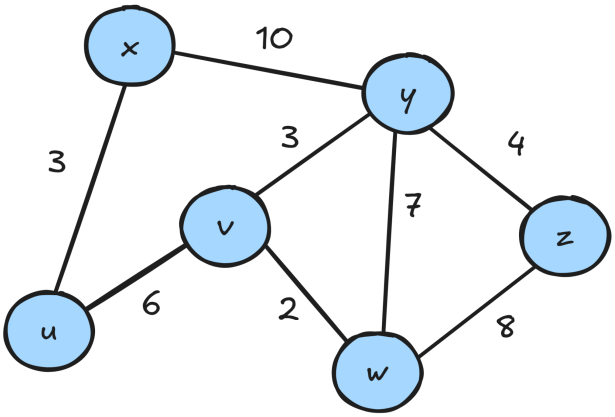
d. The maximum number of ports, since port number length is 16 bits, would be 2^16=65,536

Exercise 5 - Dijkstra

Using Dijkstra's algorithm, compute the shortest path from node **u** to all the other nodes of the network.

a. Show your reasoning with a table similar to the one in the corresponding tutorial.

b. Draw the shortest path graph.



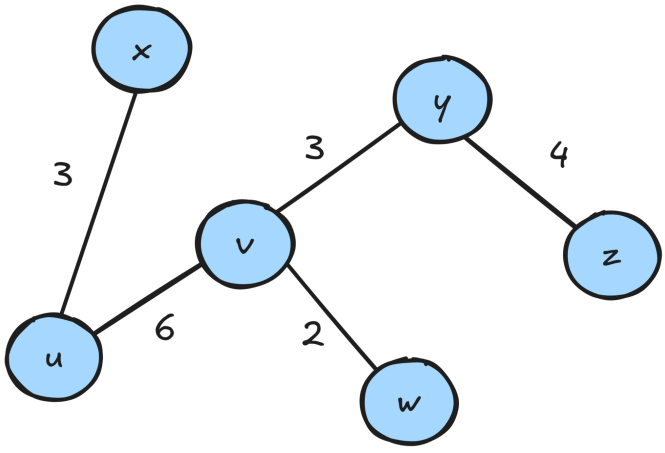
Solution

a)

Nodes	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
u	6, u	∞, -	3, u	∞, -	∞, -
ux	6, u	∞, -	-	13, x	∞, -
uxv	-	8, v	-	9, v	∞, -
uxvw	-	-	-	9, v	16, w
uxvwy	-	-	-	-	13, y
uxvwyz	-	-	-	-	-

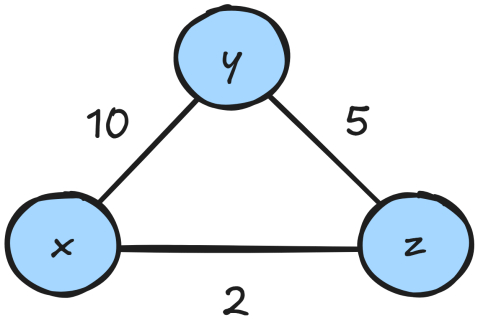
b)

- v: (6,u) ⇒ v → u
- w: (8,v) ⇒ w → v
- x: (3,u) ⇒ x → u
- y: (9,v) ⇒ y → v
- z: (13,y) ⇒ z → y



Exercise 6 - Distance Vector

Compute the routing tables for nodes x, y, and z during the Distance Vector algorithm. Show the tables at each step until the algorithm converges.



Solution

Initialization Stage

Table of node x			
	x	**y**	**z**
x	0	10	2
y	∞	∞	∞
z	∞	∞	∞

Table of node y			
	x	**y**	**z**
x	∞	∞	∞
y	10	0	5
z	∞	∞	∞

Table of node z			
	x	**y**	**z**
x	∞	∞	∞
y	∞	∞	∞
z	2	5	0

Table of node x			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

Table of node y			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

Table of node z			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

Table of node x			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

Table of node y			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

Table of node z			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

y: $D_x(y) = c(x,y)+D_y(y) = 10+0 = 10$
$D_x(z) = c(x,y)+D_y(z) = 10+5 = 15$

z: $D_x(y) = c(x,z)+D_z(y) = 2+5 = \mathbf{7}$
$D_x(z) = c(x,z)+D_z(z) = 2+0 = 2$

x: $D_y(x) = c(y,x)+D_x(x) = 10+0 = 10$
$D_y(z) = c(y,x)+D_x(z) = 10+2 = 12$

z: $D_y(x) = c(y,z)+D_z(x) = 5+2 = \mathbf{7}$
$D_y(z) = c(y,z)+D_z(z) = 5+0 = 5$

x: $D_z(x) = c(z,x)+D_x(x) = 2+0 = 2$
$D_z(y) = c(z,x)+D_x(y) = 2+10 = 12$

y: $D_z(x) = c(z,y)+D_y(x) = 5+10 = 15$
$D_z(y) = c(z,y)+D_y(y) = 5+0 = 5$

Table of node x			
	x	**y**	**z**
x	0	**7**	2
y	10	0	5
z	2	5	0

Table of node y			
	x	**y**	**z**
x	0	10	2
y	**7**	0	5
z	2	5	0

Table of node z			
	x	**y**	**z**
x	0	10	2
y	10	0	5
z	2	5	0

After that the nodes x and y advertise their tables since they had updates (**z**'s vector did not change so it does not advertise).

Table of node x			
	x	**y**	**z**
x	0	7	2
y	7	0	5
z	2	5	0

Table of node y			
	x	**y**	**z**
x	0	7	2
y	7	0	5
z	2	5	0

Table of node z			
	x	**y**	**z**
x	0	7	2
y	7	0	5
z	2	5	0

All the nodes recalculate because of the advertisements. They find no new changes and that means the algorithm has converged.

Exercise 7 - Interdomain routing

Interdomain routing allows Autonomous Systems (ASes) to exchange reachability information. Since this mechanism is vital for the sustainability of the internet, various tools have been implemented that allow us to retrieve information about the internet ecosystem. One such example is Hurricane Electric (https://bgp.he.net/) that can also provide a visual representation of the graph of the internet. For this assignment you are free to use HE or any other tool that you feel comfortable in order to investigate and answer the following questions.

a. Does the University of Crete own an Autonomous System (AS)? If yes, what is the Autonomous System Number (ASN)?

b. Which prefixes (blocks of IPs) does UoC own and which is its Regional Internet Registry (RIR)?

c. Who is the upstream provider (The autonomous system that forwards the traffic from UoC to the internet)? (Hint: use the Graph v4 tab). Click on the ASN of the upstream provider and go to the AS info tab to find its name.

Solution

a. AS6867
b. 147.52.0.0/16, 192.103.20.0/24, 2001:648:2c00::/48 ripencc
c. AS5408 → GRNET - National Infrastructures for Research and Technology S.A.

Exercise 8 - Routing Protocols (BGP vs. OSPF) [15 pts]

Explain the key differences between the **Border Gateway Protocol (BGP)** and the **Open Shortest Path First (OSPF)** routing protocol. In your answer, address the following points:

1. **Type of routing problem each protocol solves**
    - What kind of networks does each protocol operate in? Is it intra or inter-AS routing? **(OSPF: intra-AS (routing inside an AS) - BGP: inter-AS (routing between ASes))**
2. **Routing algorithms**
    - What algorithm does each protocol use to choose routes? **(OSPF: dijkstra - BGP: path vector)**
    - What type of information does each protocol share with other routers? **(OSPF: link-advertisements - BGP: prefixes)**
    - How quickly does each protocol converge after changes (slow, fast), and why? **(OSPF: fast, k runs for k nodes - BGP: convergence is variable, depends on updates etc.)**

3. **Route selection**

   - In the default case, which is the path selected for each protocol? **(OSPF: least-cost path, BGP: shortest AS path)**
   - Which value(s) can we manipulate to change the path selection for each protocol? **(OSPF: weight/cost, BGP: local-pref)**