Grading Guidelines:

A right answer will get full credit when:

1. It is right (worth 25%)
2. It is right **AND** neatly presented making it easy and pleasant to read. (worth an **extra** 15%)
3. There is an **obvious and clear link** between 1) the information provided in the exercise and in class and 2) the final answer. A clear link is built by properly writing, justifying, and documenting an answer (worth an **extra** 60%).
4. Calculation mistakes will be minimally penalized (2 to 5% of full credit) while errors on units will be more heavily penalized.

Late Submission : as specified in the syllabus. Days counting starts one minute after the deadline.
Check Your Submission: after submitting, download your submission to check whether it is the right version and it is complete.

You are welcome/encouraged to discuss exercises with other students or the instructor. But, ultimately, **personal** writing is expected.

- USE THIS FILE AS THE STARTING DOCUMENT YOU WILL TURN IN. **KEEP IN THE QUESTIONS** AND INSERT YOUR ANSWERS.
- IF USING HAND WRITING (STRONGLY DISCOURAGED), REWRITE THE QUESTIONS.
- FAILING TO FOLLOW TURN IN DIRECTIONS /GUIDELINES WILL COST A 30% PENALTY.

Objectives of this assignment:

- to learn independently about an important topic
- to answer questions about the independently studied topic
- to empower you: you can learn any networking topic on your own
- to learn independently new concepts

What you need to do:

Answer the questions and/or solve the exercises described below.

Objective: The objective of this assignment is to learn independently about *Network Address Translation (NAT)*. You must research and read about NAT, and then answer the questions.

Resources:

1. **Textbook:** Tanenbaum, Andrew S. and David J. Wetherall. *Computer Networks*.
2. Module 5
3. Your instructor (Through Piazza)
4. RFC 3022
5. Wikipedia (complete, but may be confusing)
6. Internet

Note that the textbook, Module 2 material, and your instructor are sufficient to answer all questions in this homework as well as the related self-study questions.

Questions: (**hint**: read first all questions before answering. This will avoid you repeating or overlapping answers).

Generalities

1) **(5 points)** Which problem does NAT address or solve?

The Network Address Translation (NAT) helps in establishing a link that allows the communication from a private network to the Internet by providing a group of public IP addresses that will connect to other routers. The translation of one (or multiple) local IP addresses into one or more Global IP addresses and vice versa is able to provide Internet access to the local host. It helps in translating port numbers (i.e., masking the port number of the hose with a different port number), in the packet that will be routed to the destination.

2) **(15 points)** Explain briefly what NAT is (about 5 to 10 lines). Feel free to refer to **Figure 5-55** below to help your explanations.

IP Network Address Translation (NAT) is designed for IP address conservation and was originally developed to solve the problem of a limited number of Internet IPv4 addresses. The need for NAT arises when multiple devices need to access the Internet but only one IPv4 Internet address is assigned by the Internet Service Provider (ISP).

NAT is used to connect to the internet using an allocation table that re-routes traffic to the internet. Each customer network is assigned a single IP address for internet traffic. Inside the customer network, each computer gets a unique IP address used for routing internal traffic. Within the customer network, every has a unique address listed in point A. Before a packet leaves the customer premises, it passes through the NAT box that converts the internal IP source address to the customer's true shared public IP address. The NAT box device often contains a firewall that provides security by controlling what goes into the customer network and what comes out of it.

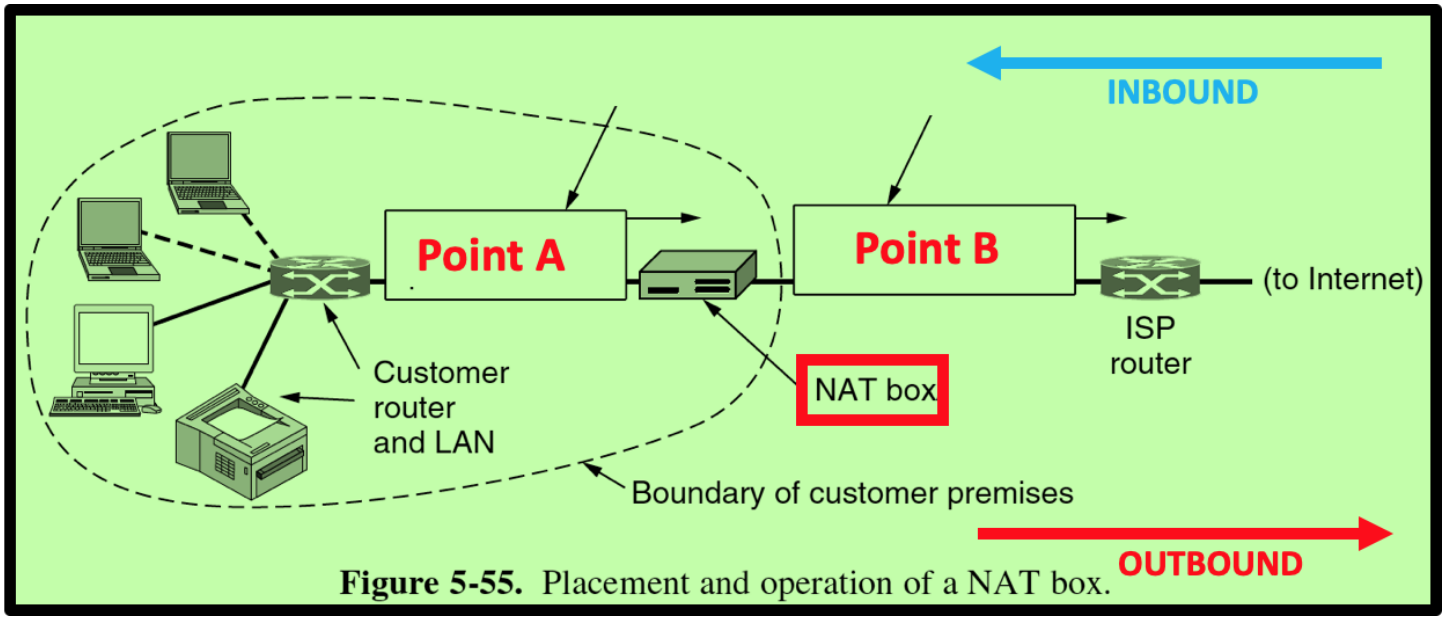

Figure 5-55. Placement and operation of a NAT box.

3) **(5 points)** Suppose you want to deploy NAT at your home. Do you need to contact some Internet organization/authority or your Internet provider to get assigned some range of IP addresses to use on your **internal** network?

Authorisation is required from the Internet Service Provider due to the ISP having a predetermined set of public IP addresses that are connected to their routers.

4) **(5 points)** What is (are) the range(s) of IP addresses you could use on your internal network?

- CLASS A (0.X.X.X – 127.X.X.X)
- CLASS B (128.X.X – 191.X.X.X)
- CLASS C (192.X.X.X – 223.X.X.X)

5) **(5 points)** Does your wireless network at home use NAT? What is the IP address of your desktop, laptop, or any device you use to access Internet from home?

Yes! My apartment complex does use NAT to connect our routers to the Internet. My IP address is 192.168.1.93.

6) **(5 points)** Suppose that you want to use NAT on your network at home. What is the smallest number of external (Internet) IP addresses you would need to acquire from your Internet provider?

A NAT address is the smallest number of external IP addresses needed from your ISP.

NAT Operations

First let us define a **flow**: *two packets belong to the same TCP (or UDP) **flow** if both packets carry a TCP segment (or a UDP datagram) that have the **same** source IP address, destination IP address, source port number, and destination port number.*

For all the following questions, we assume that the NAT box has the following available ports for translation for TCP and UDP. When the NAT box needs to translate a packet for a **new** flow, it will pick the next available port number from the table below. We assume that the next available port number for TCP (resp., UDP) is at Index 1. If the port number at Index 1 is already used, the next available will be the one at Index 2 and so on. **We assume that the NAT was just turned on**. Therefore, the next available port # for translation of a TCP (resp. UDP) flow is 2500 (resp. 8060).

Index	TCP	UDP
1	2500	8060
2	6020	2600
3	1463	1070
4	1078	2553

As seen on Figure 5-55, a customer sets up a network with multiple machines. However, the Internet provider assigned only one IP address to the customer: this IP address is 131.204.14.150.

Consider a machine M on the customer's network "behind" a NAT box, i.e. on the premises of the customer (see Figure 5-55 above). The IP address of Machine M is 192.168.64.14. A TCP client socket is established at Port # 10100 to send an http query **Q** to the server at IP address 64.233.110.188.

1) **(10 points)** Consider Packet P_1 carrying the http request **Q.** P_1 **leaves** Machine M and reaches Point A (see Figure 5-55). Fill in the array below with the source IP address, destination IP address, source port number, destination port number of Packet P_1 when it is at Point A. Tell whether this packet P_1 carries a TCP segment or a UDP datagram.

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
TCP	**192.168.2.67**	**64.233.110.188**	**10100**	**80**

2) **(10 points)** When the NAT box receives Packet P_1, it translates it and outputs on Point B (see Figure 5-55) a translated packet. Fill in the array below with the source IP address, destination IP address, source port number, destination port number of the **translated** Packet P_1. Highlight the information that will change (by the translation) and explain why.

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
TCP	128.194.20.56	64.233.110.188	2500	80

Translating Packet P1 changes the source IP address as well as the source port number. The NAT box translates the packet to give it the same IP address as other Packets that go through the NAT box. The NAT box also gives a unique port so all the computers on the network have the same IP.

3) **(10 points)** When Packet P_1 reaches the server, the server will respond with a packet **P_2**. Fill in the array below with the source IP address, destination IP address, source port number, destination port number of the Packet **P_2**.

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
TCP	64.233.110.188	128.194.20.56	80	2500

4) **(10 points)** When the inbound packet P_2 reaches the NAT box, it will be translated. Fill in the array below with the source IP address, destination IP address, source port number, destination port number of the **translated** Packet P_2 (Point A).

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
TCP	64.233.110.188	192.168.2.67	80	10100

5) **(10 points)** Suppose now that the same machine M (IP address :192.168.64.14) makes a DNS request to the server at IP address 128.194.34.204. The DNS client is bound to Port # 10020. The DNS request will be carried by Packet P_3. Fill in the array below with the source IP address, destination IP address, source port number, destination port number of Packet P_3 (Point A).

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
UDP	192.168.2.67	128.194.54.252	10200	53

6) **(10 points)** When the NAT box receives Packet P_3, it translates it and outputs on Point B (see Figure 5-55) a translated packet. Fill in the array below with the source IP address, destination IP address, source port number, destination port number of the **translated** Packet P_3. Highlight the information that will change (by the translation) and explain why.

TCP or UDP?	IP Source	IP Destination	Source Port #	Dest. Port #
UDP	**128.194.20.56**	**128.194.54.252**	**8060**	**53**

Translating Packet P3 changes the source IP address as well as the source port number. The NAT box translates the packet to give it the same IP address as other Packets that go through the NAT box. The NAT box also gives a unique port so all the computers on the network have the same IP.

What you need to turn in:

- Electronic copy of this file (including your answers) (standalone). Submit the file as a Microsoft Word or PDF file.

- Recall that answers must be well written, documented, justified, and presented to get full credit.

- How this assignment will be graded:
- A right answer will get full credit when:
- It is right (worth 25%)
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