Eidgenössische Technische Hochschule Zürich
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Communication Networks

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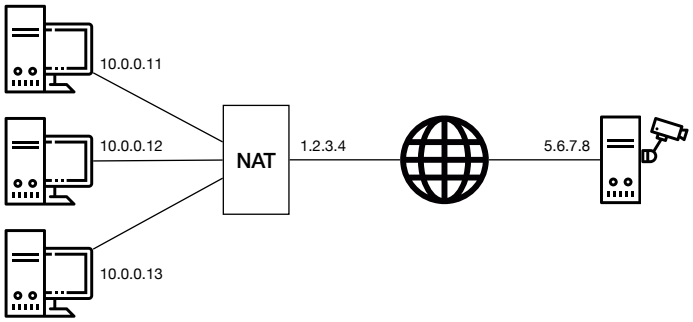
Solution: Exercise 12 – NAT & IPv6

12.1 NAT (Exam Question 2018)

Consider the network topology below. Alice has multiple PCs at home (10.0.0.11–13) which share a single public IP address (1.2.3.4) via a NAT device. Further, she operates a surveillance camera server which is directly connected to the Internet with a public IP address (5.6.7.8). The camera transmits the live video signal as a stream of UDP packets with source port 1000 to a configurable destination IP address and port.



Alice operates three PCs and one camera server

a) Alice wants to receive the live video stream on one of her PCs and thus configures the camera to send the video signal to IP 10.0.0.11 and port 1234. However, she does not receive it on her PC. Why? Where is this traffic sent to?

Solution: All IP addresses in the 10.0.0.0/8 prefix are private and not routed in the Internet. As 10.0.0.11 is one of these internal IPs, the camera has no route to this address. Consequently, that traffic is dropped.

b) Now Alice configures the camera to send the video signal to IP 1.2.3.4 and port 1234. But she still does not receive it on any of her PCs. Why? Where is this traffic sent to?

Solution: The IP address 1.2.3.4 is a globally routed address and therefore, the traffic arrives at the NAT box. However, as there is no corresponding address translation rule in the NAT for that specific destination port, the NAT does not know how to rewrite the packet and where to forward the traffic to. The traffic is dropped at the NAT box.

c) What can Alice do such that she receives the video signal at her PC with IP address 10.0.0.11 and at port 1234 assuming that she *cannot* modify the configuration of the NAT? Describe step-by-step what she can do if she has the following possibilities:

- send one single UDP packet with arbitrary source and destination addresses and ports from each of her PCs;
- observe the received packets at each of her PCs and the camera server;
- specify the destination IP address and port for the video signal.

Solution: First, you want to "open a hole" in the NAT box for the video stream to enter your network. To do this, you send a packet from an internal host, for example 10.0.0.11:1234, to the camera 5.6.7.8:1000. This leads the NAT box to install an address translation rule.

Now, you have to configure the camera with the correct destination IP address and port. The destination IP address is clear: it is the one of the NAT box (1.2.3.4). The port, however, you do not know yet.

Therefore, you start observing the packets arriving at the camera while sending packets from the interal host to the camera, from 10.0.0.11:1234 to 5.6.7.8:1000. At the camera, you will see to what port the NAT changed the source port of the packet.

Finally, configure the camera to send the video stream to the IP address of the NAT box and set the destination port to the port observed previously.

12.2 IPv6 Computations

Answer the following questions to IPv6.

a) Currently, all global unicast IPv6 addresses are inside 2000::/3. Assume that every network in the Internet gets an entire /64 prefix. How many different /64 prefixes can you distribute? How many hosts can be inside one of these /64 prefixes? Compare these numbers with the total amount of IPv4 addresses.

Solution: If every network gets a /64 prefix within 2000::/3. Then, there are $64 - 3 = 61$ bits to use. This allows for $2^{61} = 2.30 * 10^{18}$ /64 prefixes. In each prefix, you can allocate a total of $2^{64} = 1.84 * 10^{19}$ hosts. There are only $2^{32} = 4.29 * 10^{9}$ IPv4 addresses.

b) Simplify the notation of the following IPv6 addresses:

Solution:

Full IPv6 address	**Simplified IPv6 address**
000a:1234:abda:0000:0000:0140:0000:0001	a:1234:abda::140:0:1
0000:0000:0000:0000:0000:0003:0000:0010	::3:0:10
000a:0031:003f:0000:0000:0000:0000:0000	a:31:3f::
0000:0000:0000:0000:0000:0000:0000:000b	::b

c) For the following pairs of IPv6 addresses, find the longest prefix that contains both addresses.

Solution:

Address 1	**Address 2**	**Prefix**
2000::a35a	2000::ac3f	2000::a000/116
2005::2e90:12fa:1	2005::2eb0:0:1	2005:2e80:0:0/90
200a::789:3	200a:5c::	200a::/25

12.3 Putting Everything Together (v6)

Your laptop with the MAC address c0:6e:98:00:c2:43 just rebooted and has no IPv6 address at all. One of its interfaces is connected to a network with the IPv6 prefix 2000:0:0:36::/64 and one router with the address 2000:0:0:36::10. Describe all the steps that your laptop performs to autoconfigure a link-local and a global unicast IPv6 address for this interface. You can use M64(c0:6e:98:00:c2:43) to indicate the 64-bit representation of your MAC address. For each packet that your laptop sends or receives, describe the used source and destination IPv6 address.

Solution: First step, your laptop builds a temporary link-local address based on its MAC address: fe80::M64(c0:6e:98:00:c2:43).

To confirm uniqueness in the local network, it sends a neighbor solicitation message for fe80::M64(c0:6e:98:00:c2:43). As destination, the multicast address ff02::1 (all end-systems) is used. As source address, normally the unspecified IPv6 address :: (all zeros) is used.

Should another host in the network already have this link-local address, it will reply sending the answer (neighbor advertisement) to ff02::1.

Assuming the laptop has now a unique link-local address, it either already got one of the periodically sent router advertisements (source: 2000:0:0:36::10 and destination: ff02::1). If that is not the case, the laptop can actively request the prefix by sending a message to all the routers in the network (address ff02::2) with its link-local address as source.

From the received prefix, the laptop will now build a global unicast address 2000:0:0:36:M64(c0:6e:98:00:c2:43). Once again, it will confirm the uniqueness of the constructed unicast address. This time, the neighbor solicitation message has the link-local address as source (destination: ff02::1).