HW5: IP Addresses, Prefixes, and Routes

COM-208: Computer Networks

Before we start

A few basic rules:

- An IP prefix A/M is the range of IP addresses whose M most significant bits are the same as M's L most significant addresses. E.g., 10.0.0.16 belongs to IP prefix 10.0.0.0/24, because the 24 most significant bits of 10.0.0.16 are the same as the 24 most significant bits of 10.0.0.0.
- This implies that a /M IP prefix contains 2^{32-M} IP addresses. E.g., a /24 IP prefix contains $2^{32-24} = 256$ IP addresses. In other words, we don't have the freedom to create an IP prefixes that contains an arbitrary number of IP addresses, it must always contain a number that is a power of 2.
- Each IP subnet must have its own IP prefix. Hence, IP prefixes allocated to different IP subnets must not overlap.

When assigning IP addresses to network interfaces in an IP subnet, assume that the following IP addresses cannot be assigned to any network interface:

- The first IP address in the subnet's IP prefix (called "network address"). E.g., the first IP address in 10.0.0.0/24 is 10.0.0.0. This address is sometimes reserved for special uses, e.g., a discovery service provided by the subnet.
- The last IP address in the subnet's prefix (called "broadcast address"). E.g., the last IP address in 10.0.0.0/24 is 10.0.0.255. This address is sometimes reserved to be used as the subnet's broadcast address, i.e., as the destination IP address for packets that should be received by all end-systems in a subnet.

Getting familiar with forwarding tables

Basic

For the sake of this exercise only, imagine a world where IP addresses are 8 (not 32) bits long. Suppose a router uses longest-prefix matching and has the following forwarding table:

Dst IP prefix	Output link
00**	0
01**	1
100*	2
otherwise	3

For each of the 4 rows of this forwarding table, identify the range of IP addresses that would match the row. How many IP addresses does each row match?

IP prefix allocation

Basic

IP subnets A, B and C contain 10, 5, and 3 network interfaces, respectively. Allocate an IP prefix to each subnet, and assign an IP address to each network interface, from IP prefix 1.2.3.0/27.

Consider three cases (a, b, and c) for allocating prefixes to subnets. In each case, follow the given order:

(a) A, B, C (i.e., largest to smallest)

(b) C, B, A (i.e., smallest to largest)

(c) B, A, C

In the context of this exercise, when we say that allocation "follows a given order," we mean that, if Subnet X comes before Subnet Y in that order, the IP addresses for Subnet X should be arithmetically smaller than the IP addresses for Subnet Y (in the sense that IP address 1.2.3.4 is arithmetically smaller than IP address 1.2.3.5).

Note: Allocating addresses might be infeasible in some cases.

Network configuration

Consider the topology shown in Figure 1. There are three IP subnets (A, B and C) that contain some end-systems, and two IP subnets (D and E) that contain no end-systems. The green boxes (a, b, c, ...g) denote network interfaces for routers R1, R2 and R3.

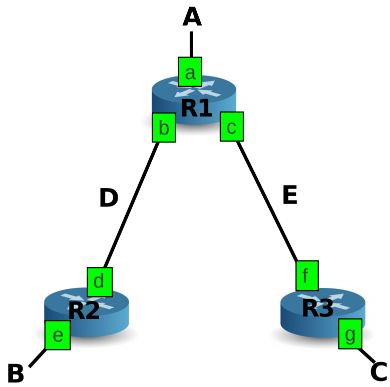

Figure 1: Problem topology.

- (*Basic*) Allocate an IP prefix to each subnets. Your allocation must respect the following constraints:
  - All prefixes must be allocated from 214.97.254/23.
  - Subnet A should have enough addresses to support 250 interfaces.
  - Subnet B should have enough addresses to support 120 interfaces.
  - Subnet C should have enough addresses to support 60 interfaces.
  - Each of subnets D and E should have enough addresses to support 2 interfaces.
- (*Basic*) Using your previous answer, provide the forwarding tables for each of the three routers (R1, R2, R3). Each table should contain two columns which show (i) the destination IP prefix, and (ii) the corresponding output link.
- (*Advanced*) Can you reduce the number of entries of each forwarding table, i.e., for each table create an equivalent one, which has the same outcome but consists of fewer entries?

Network Address Translation

Intermediate

Figure 2 illustrates how Network Address Translation (NAT) works. Consider a similar topology, but suppose that the NAT gateway has external IP address 24.34.112.235, while the private IP address space is 192.168.1.0/24.

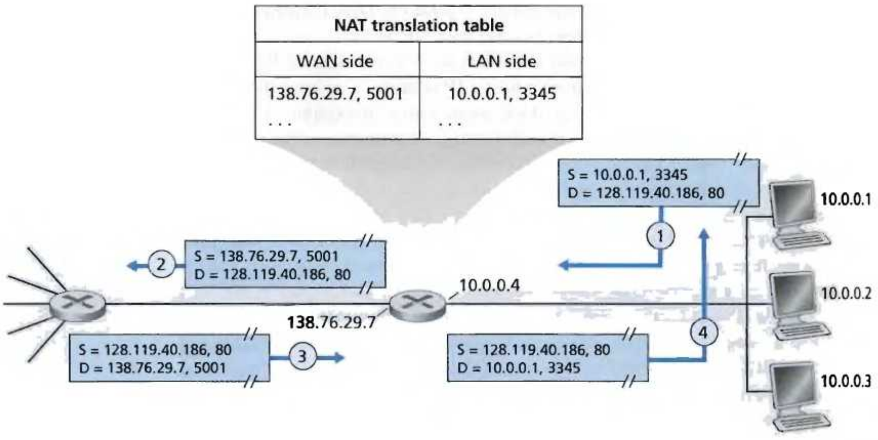

Figure 2: Network Address Translation (NAT) Process

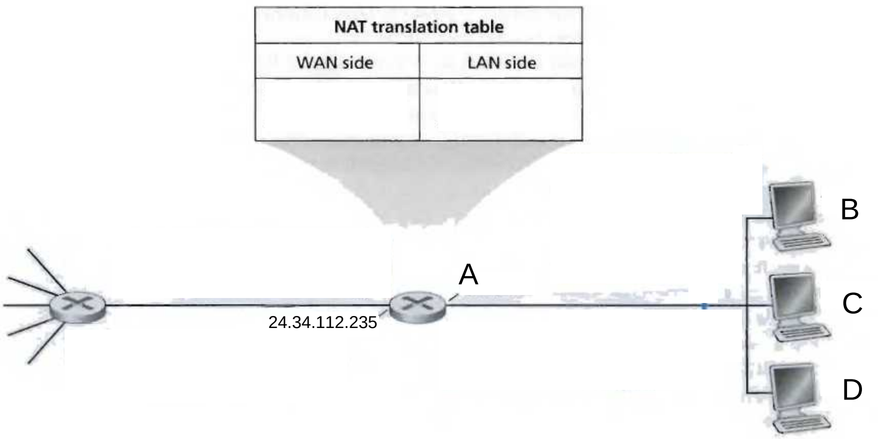

Figure 3: Problem topology.

- Complete Figure 3 by assigning IP addresses to all interfaces (labels A, B, C, and D) in the internal (private) network.
- Suppose that each end-system has two ongoing TCP connections, all to IP address 128.119.40.86, port 80. Provide the six corresponding entries in the NAT

translation table.