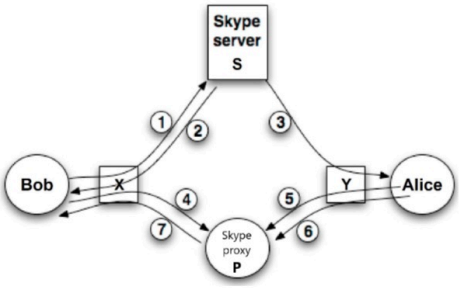
Course: Communication Networks

Date: 11/15

Topics Covered: HW #5

- MATTHEW KRUEGER -

1. Bob wants to Skype with Alice. As both Bob and Alice are at home behind their NAT routers, X and Y, a proxy (P) must be used to establish and complete the call between the two peers.



Refer to the figure above. Both Bob and Alice maintain "keep alive" connections with a Skype server, S. When Bob makes the call, the following simplified steps occur: (1) Bob sends S a message requesting a call to Alice; (2) S sends P's IP address and a port number to Bob; (3) S sends P's IP address and the same port number to Alice; (4) Bob sends a call setup message to P; (5) Alice accepts the call and sends a call setup message to P, completing the call set up; (6) Alice says "Hello" and the corresponding voice frame is sent to P; (7) P forwards the voice frame to Bob. All communication uses UDP.

- Bob's IP address is 172.16.0.2 and X's IP address is 129.10.8.8.
- Alice's IP address is 10.0.0.8 and Y's IP address is 88.76.54.32.
- P's IP address is 73.15.20.6. P sends and receives all messages on port 5401.
- S's IP address is 52.113.194.22. S sends and receives all messages on port 3600.
- Bob's next unused local port number prior to step 4 is 7201. Alice's next unused local port number prior to step 5 is 6301.
- X's next unused port number in its NAT table prior to step 4 is 4501. Y's next unused port number in its NAT table prior to step 5 is 3600.

Given all of the above, please answer the following:

(a) In step 1, what are the source and destination IP addresses in the: (i) packet from Bob to X, (ii) packet from X to S?

(b) In step 4, what is the 4-tuple (<source IP address, dest IP address, source port #, dest port#>) in the: (i) packet from Bob to X, (ii) packet from X to P?

(c) Just after step 4, what is the NAT table entry created at X? Assume the NAT table has two columns: each is a 2-tuple of the format <IP address, port number>.

(d) In step 7, what is the 4-tuple in the packet (i) from P to X, and (ii) from X to Bob?

a)

(i) Packet from Bob to X:

Source IP: 172.16.0.2

Destination IP: 52.113.194.22

(ii) Packet from X to S:

Source IP: 129.10.8.8

Destination IP: 52.113.194.22

b)

(i) Packet from Bob to X

Source IP: 172.16.0.2

Destination IP: 73.15.20.6

Source Port #: 7201

Destination Port #: 5401

(ii) Packet from X to P

Source IP: 129.10.8.8

Destination IP: 73.15.20.6

Source Port #: 4501

Destination Port #: 5401

c) NAT table entry at X after step 4

Internal (local) <addr, Port>: <172.16.0.2, 7201>

External (Global) <addr, Port>: <129.10.8.8, 4501>

d)

(i) Packet from P to X

Source IP: 73.15.20.6

Destination IP: 129.10.8.8

Source Port #: 5401

Destination Port #: 4501

(ii) Packet from X to Bob

Source IP: 73.15.20.6

Destination IP: 172.16.0.2

Source Port #: 5401

Destination Port #: 7201

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2. Fig. 4.30 depicts an OpenFlow network. Note that the numbers in this figure simply label the interfaces (i.e., they are NOT costs). For this problem let's assume the desired forwarding behaviors for datagrams arriving at **switch s3** in this network are as follows:

   (a) datagrams originating from and destined to hosts strictly outside of 10.3.*.* should be forwarded via the shortest path to their destinations (hint: you may need two table entries, one for each of s3's neighbors).

   (b) datagrams destined to a host in 10.3.*.* should be shortest-path forwarded.

   (c) host h6 datagrams destined to non-10.3.*.* hosts (i.e., 10.1.*.* and 10.2.*.*) should be forwarded in a counter clockwise direction.

   (d) host h5 datagrams destined to non-10.3.*.* hosts should be forwarded in a clockwise direction.

   In one table, specify the s3 flow table entries that implement these forwarding behaviors in a form similar to that used in the examples in the text.

Q	Port	Dest	Behavior
a	3	10.2.*.*	forward to 4
	4	10.1.*.*	forward to 3
b	all	10.3.0.5	forward to 2
		10.3.0.6	forward to 1
c	2	10.1.*.*	forward to 3
	2	10.2.*.*	forward to 3
d	1	10.1.*.*	forward to 4
	1	10.2.*.*	forward to 4

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3. Please see the AS network in the text Fig. 5.12. Suppose that the prefix 169.55.23.0/24 is reachable from host 1a in AS1 via the route [AS3 AS5 AS7] and host 1b in AS1 via route [AS2 AS9 AS13] (recall nodes in AS1 will not know this unless AS3 and AS2's gateway nodes 3a and 2a advertise this). Also note that AS5, AS7, AS9, and AS13 in the above routes are other AS's that are not explicitly shown in the figure but are known based on the advertised path. Briefly answer, with justification, the following:

   (a) What is the **AS level route** selected by router 1c to reach prefix 169.55.23.0/24 assuming that AS1 uses OSPF with all link costs set to 1 for intra-AS routing, BGP for inter-AS routing, and AS1 is a customer of both AS2 and AS3?

   (b) What AS level route is selected by 1a if AS1 is a customer of AS2 but not AS3?

   (c) Is AS prefix 169.55.23.0/24 multi-homed? Why or why not?

a) AS level route via AS7: AS3, AS5, AS7 Because using OSPF with equal link costs, intra-AS cost from 1c to AS3 gateway is lower than to the AS2 gateway. BGP prefers routes with the lowest intra-domain cost to the next hop.

b) Router 1a selects AS level route via AS2: AS2, AS9, AS13. Since AS1 is a customer of AS2 but not AS3, BGP policies give higher preference to routes received from providers where AS1 is customer.

c) Yes, the prefix is 169.55.23.0/24 is multi-homed because it is reachable through multiple AS paths terminating at different AS AS7, AS13; therefore multi-homed.