ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Networked Systems
ETH Zürich — seit 2015

Communication Networks

Prof. Laurent Vanbever

Solution: Exercise 3 – Transport Concepts and Ethernet/Switching

Reliable Transport Concepts (Part 2)

3.1 Negative Acknowledgments

In the lecture, we have mainly looked at transport protocols using (positive) Acknowledgments (ACKs). However, we could also use so called Negative Acknowledgments (NAKs or NACKs). In this case, the receiver is sending a NAK for every packet that it *did not* receive. To detect lost packets, the receiver looks at the sequence numbers of all the received packets and sends NAKs for every missing sequence number. After receiving a NAK, the sender will retransmit the corresponding packet.

a) Assuming a network with nearly no packet loss, what could be the main advantage of using NAKs?

Solution: The number of NAKs will be much smaller than the number of ACKs in a normal case. Fewer packets in the network could have a positive influence on the delay, bandwidth, ...

b) Assume now that the receiver will immediately send a NAK as soon as it detects a gap in the received packet numbers. E.g. for the following packet number sequence [4, 5, 7] the receiver would immediately send a NAK for packet 6. Can you see a problem with this implementation? How could you (partially) mitigate the problem?

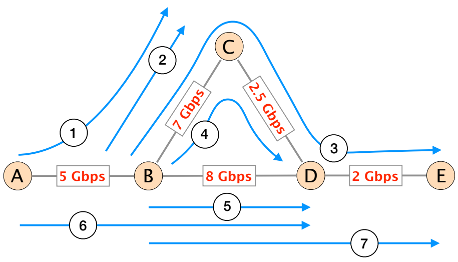
Solution: Reordered packets will immediately trigger a NAK. The receiver could e.g. wait for a certain amount of time before sending the NAK.

c) So far, NAKs look like a good alternative to (positive) ACKs. Nonetheless, TCP – the currently most-widely used transport protocol – is *not* using NAKs. There has to be a problem. Assume that the sender is transmitting 5 packets (with sequence number 1 to 5). Find at least two sequences of packet or NAK losses such that the **sender** wrongly assumes that the 5 packets were correctly received.

Solution:

- [1, 2, 3] correctly received. Packet 4 and 5 were lost.
- [1, 2, 3, 5] correctly received. The NAK for packet 4 was lost.

3.2 Fairness



A network with shared links and 7 flows.

Consider the network on the left consisting of 5 nodes (A to E). Each link has a maximal bandwidth indicated in red. 7 flows (1 to 7) are using the network at the same time. You can assume that they have to send a lot of traffic and will use whatever bandwidth they will get. Apply the max-min fair allocation algorithm discussed in the lecture to find a fair bandwidth allocation for each flow. You can use the table below. In the top row, indicate which link is the current bottleneck. The other rows contain the corresponding bandwidth distribution for each flow.

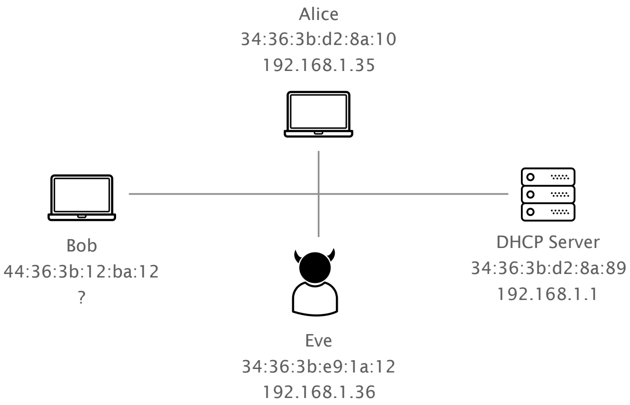
Solution:

Bottleneck link	D-E	C-D	B-C	A-B	B-D	
Flow 1 A - B - C	1	1.5	**2.25**			
Flow 2 B - C	1	1.5	**2.25**			
Flow 3 B - C - D - E	**1**					
Flow 4 B - C - D	1	**1.5**				
Flow 5 B - D	1	1.5	2.25	2.75	**4.25**	
Flow 6 A - B - D	1	1.5	2.25	**2.75**		
Flow 7 B - D - E	**1**					

Ethernet & Switching

3.3 Impostor

The three hosts Bob, Alice and Eve are all connected to the same network, which has a DHCP server.



Bob just connected to the network and wants to send important IP packets to Alice. Bob only knows the IP address of Alice (`192.168.1.35`) and his laptop is not yet configured with an IP address.

a) Explain all the steps that are necessary such that Bob's computer can finally send packets to Alice.

Solution: Please note that the lecture slides introduced a simplified version of the DHCP protocol.

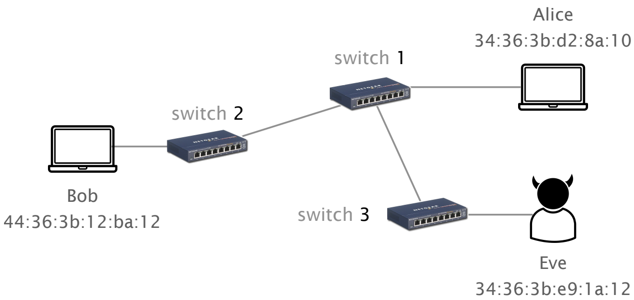
SRC MAC address	DST MAC address	Message type	Message content
44:36:3b:12:ba:12	ff:ff:ff:ff:ff:ff	DHCP discovery	I need an IP address
34:36:3b:d2:8a:89	44:36:3b:12:ba:12	DHCP offer	use 192.168.1.37
44:36:3b:12:ba:12	ff:ff:ff:ff:ff:ff	DHCP request	I want the offered IP
34:36:3b:d2:8a:89	44:36:3b:12:ba:12	DHCP ack	Lease duration & configuration
44:36:3b:12:ba:12	ff:ff:ff:ff:ff:ff	ARP request	Who has 192.168.1.35 Tell 192.168.1.37
34:36:3b:d2:8a:10	44:36:3b:12:ba:12	ARP reply	192.168.1.35 is at 34:36:3b:d2:8a:10

b) Eve is very interested to find out what Bob is sending to Alice. What could she do to intercept Bob's packets?

Solution: When Bob sends the ARP request to learn the MAC address of Alice, Eve also receives it as it is destined to the MAC broadcast address (`ff:ff:ff:ff:ff:ff`). If Eve can send a fake reply to Bob before Alice does so, she can make Bob believe that her MAC address is the one of Alice. This is called ARP spoofing.

3.4 Duplicate MAC Address

Consider three hosts Alice, Bob, and Eve connected through the network below composed of 3 Layer 2 (Ethernet) switches.



In the beginning the tables of the learning switches are still empty. Bob starts sending Ethernet frames to Alice. Eve is curious and wants to know what Bob is sending to Alice. Assume that Bob and Alice know the MAC address of each other.

a) What is the source and destination address in the Ethernet header for frames sent from Bob to Alice?

Solution: Source address: 44:36:3b:12:ba:12
Destination address: 34:36:3b:d2:8a:10

b) What do the switches do when they receive the frames?

Solution: Each switch adds a new entry to its table with the source MAC address and the incoming port. As the address of Alice is not yet in any of the switch tables, each switch floods the frame on all ports, but the port the packet came in on. This means the frame is sent to both Alice and Eve.

c) Due to the flooding, the frames are sent to both Alice and Eve. Does Eve actually receive the frames? (*hint:* promiscuous mode).

Solution: As long as Eve's Ethernet adapter is not set to promiscuous mode, the frame is not decapsulated and Eve will not receive it.

Alice starts acknowledging the received frames by sending frames to Bob.

d) Is Eve able to eavesdrop either on the frames being sent from Alice to Bob or on new frames sent from Bob to Alice? Explain.

Solution: No. The frames from Alice to Bob will not be flooded as the switches already know the path. After the first frame from Alice reaches Bob, the switches have also learned over which ports Alice can be reached. Frames from Bob to Alice are therefore no longer flooded.

e) Can you think of a way for Eve to redirect the frames destined to Alice again to herself?

Solution: Eve can send an Ethernet frame destined to Bob with the source address set to the MAC address of Alice. The switches will update their tables and Eve will receive the frames for Alice as long as Alice does not send a packet.