ETH zürich

Networked Systems
ETH Zürich — seit 2015

Communication Networks

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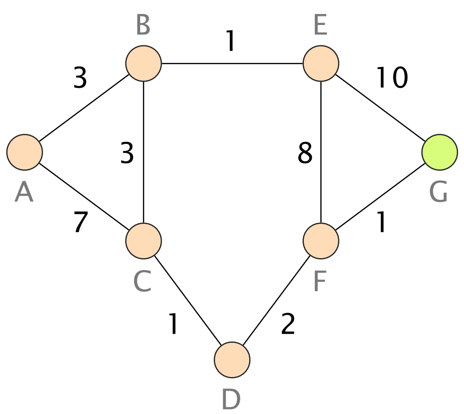
Exercise 3 – Routing Concepts, Ethernet & Switching

Routing Concepts

3.1 Distance Vector



Weighted graph representing a network topology.

The figure on the left shows a weighted graph representing a network topology with 7 nodes. The nodes in the network use a distance vector algorithm to compute the shortest-paths in a distributed way. It takes one time step for a distance vector message to be sent from one node to another on a link. A node can send the distance vector message on multiple links at the same time.

In case paths have the same weight, the node picks the path traversing the smaller number of links. In case there is still a tie, the node picks the path of the neighbor with the lower identifier (alphabetical order).

a) Compute the paths from any node in the network to G. Use the provided table to fill in the state of each node at every time step. Stop when a stable state is reached. The first time step is provided as an example.

#	A	B	C	D	E	F	G
0	∅	∅	∅	∅	∅	∅	0
1	∅	∅	∅	∅	10	1	0
2							
3							
4							
5							
6							

b) Highlight the actual paths taken in the graph.

c) The network operator realizes that there is a potential bottleneck as all traffic is crossing the following links: *C*-*D*, *D*-*F*, and *F*-*G*. She prefers to balance the traffic across the available links in the network. Therefore, she would like to have all traffic from the nodes *A*, *B*, *E* to go across the link *E*-*G* and the traffic of the remaining nodes to go across *F*-*G*.

(i) If she can only change the weight of the link *E*-*G*, what should she change it to?

(ii) If she cannot change the weight of the link *E*-*G*, what should she change instead? Propose a change that requires to change the weights of as few links as possible.

3.2 Reverse Dijkstra (Exam Question 2020)

The network engineer at your company just retired and you have to take over. Unfortunately, it is unclear how the current network looks like. All you know is that it consists of 10 nodes (see below). In addition, you know that there is at most one link between two nodes and that each link has a non-negative weight. However, you neither know which links exist nor the weights configured on these links.

a) To figure out the links and the corresponding weights, you look at an output of Dijkstra's algorithm performed from node **U**. The table below shows the entire output of the algorithm. For each iteration, the table indicates the shortest path found so far towards each other node (starting from node **U**). The algorithm follows the one discussed in the lecture. If after one iteration there are multiple nodes with an equally-shortest path, the algorithm continues with the node which comes first in the alphabet.

Add all the links with their corresponding weight that you can identify based on the output from Dijkstra's algorithm.

A network consisting of 10 nodes with unknown links and link weights.

#	U	A	B	C	D	E	F	G	H	I
1	0	2	3	1	-	-	-	10	-	11
2	0	2	2	1	8	-	-	10	-	11
3	0	2	2	1	8	-	-	10	-	11
4	0	2	2	1	8	100	-	10	-	11
5	0	2	2	1	8	9	15	10	-	11
6	0	2	2	1	8	9	15	10	-	11
7	0	2	2	1	8	9	13	10	14	11
8	0	2	2	1	8	9	12	10	14	11
9	0	2	2	1	8	9	12	10	13	11
10	0	2	2	1	8	9	12	10	13	11

For each iteration (1 to 10) the table shows the shortest path found by Dijkstra's algorithm performed on node **U** towards all other nodes.

b) After analyzing the output from Dijkstra's algorithm, you are unsure if you really found all links in the network.

Could there be an additional link starting from node **U** which you could not identify based on the output from Dijkstra? If you think that is possible, give an example (link between node **U** and node ...) and indicate in which range the weight of this link could be. Otherwise, explain why this is not possible.

c) Could there be an additional link starting from node C which you could not identify based on the output from Dijkstra? If you think that is possible, give an example (link between node C and node ...) and indicate in which range the weight of this link could be. Otherwise, explain why this is not possible.

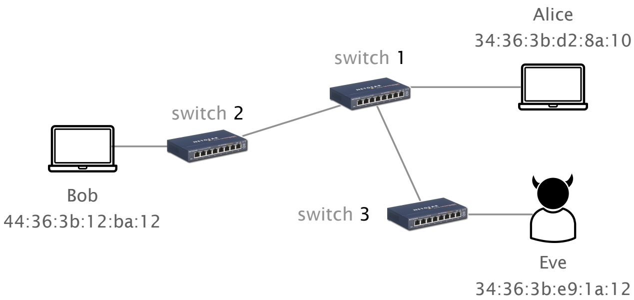
Ethernet & Switching

3.3 Duplicate MAC Address

Switches are plug-and-play devices as they build their forwarding tables on their own: When a frame arrives at a switch, the switch inspects the source MAC address of the frame. If this address is not in the forwarding table, the switch learns to forward frames to this address through the port where the frame arrived, by storing this mapping in the forwarding table. The switch also launches a timer to eventually forget the mapping.

In case a frame with an unknown (i.e., not in the forwarding table) destination MAC address arrives at a switch, the switch forwards the frame on all ports, except for the port where the frame arrived.

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?

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

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

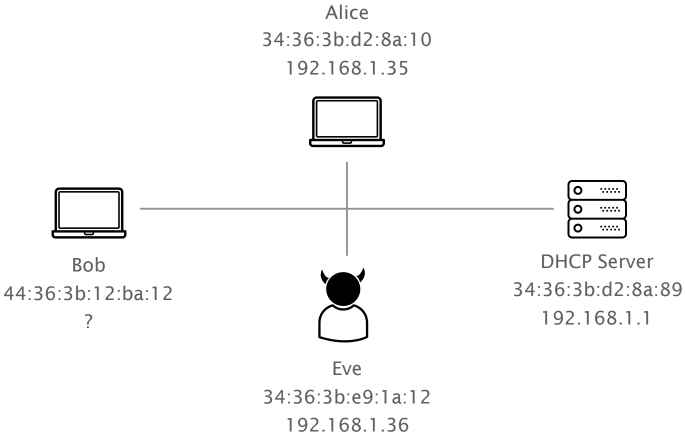
Alice starts acknowledging the received frames by sending frames to Bob.

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.

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

3.4 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.

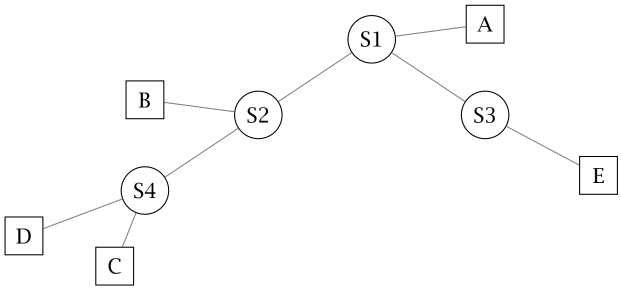
a) Explain all the steps that are necessary such that Bob's computer can finally send packets to Alice.

SRC MAC address	DST MAC address	Message type	Message content

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

3.5 MAC-Learning (Exam question from 2021)

Consider the Local Area Network (LAN) made up of 4 Ethernet switches in the figure below. Several hosts (A, B, C, D, E) are connected to the switches. The MAC tables of all switches are still empty.



a) Host A sends a packet to host B. List below all the hosts that will receive the packet. In addition, fill in the MAC tables of all switches with the learned information.

Hosts receiving the packet:

S1 MAC-Table	
dst	next hop

S2 MAC-Table	
dst	next hop

S3 MAC-Table	
dst	next hop

S4 MAC-Table	
dst	next hop

b) Host C sends a packet to host A. Again, list all the hosts that receive the packet and update the MAC tables with the learned information. The entries from task a) are still available.

Hosts receiving the packet:

S1 MAC-Table	
dst	next hop

S2 MAC-Table	
dst	next hop

S3 MAC-Table	
dst	next hop

S4 MAC-Table	
dst	next hop

c) After some time, the switches have full MAC-tables (i.e., they have an entry for each host in the network). Host B wants to hijack all the packets destined to host A. By only sending packets, how can host B manipulate the switches in the network to receive all that traffic? How many "manipulation" packets are minimally necessary and to which addresses does host B have to send them? Explain your approach, state the required number of manipulated packets, and list the source and destination addresses of all manipulated packets.

Note: The hosts are not aware of the other hosts and do not know the network's topology.