ETH zürich

Networked Systems
ETH Zürich — seit 2015

Communication Networks

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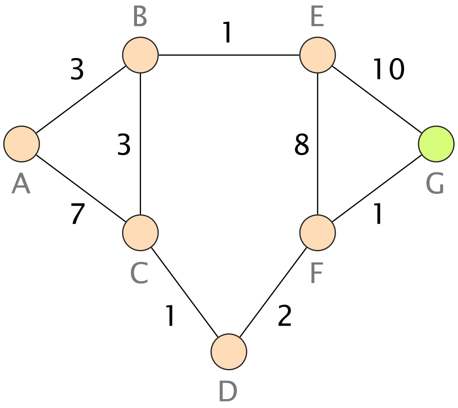
Exercise 3 – Routing Concepts, Ethernet & Switching

Routing Concepts

3.1 Distance Vector

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).



Weighted graph representing a network topology.

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							

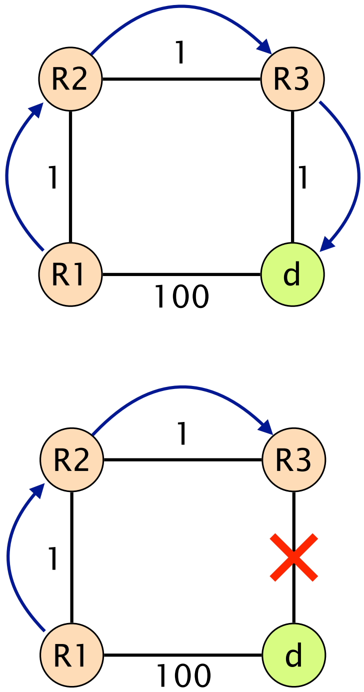
b) Highlight the actual paths taken in the graph.

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 Dijkstra's Algorithm with Link Failure



Dijkstra's algorithm with a link failure

The routers in the network on the top left use Dijkstra's Algorithm to find the shortest path towards destination d. You can assume that every router knows the entire network graph. In case of a failure, the routers directly affected by it inform the other routers by flooding this information in the network.

The blue arrows indicate how the routers forward the traffic: $R2$, for example, sends packets for destination d to router $R3$.

Now the link between router $R3$ and d fails (network at the bottom left) and $R3$ can no longer send packets towards destination d. As $R3$ is directly connected to the failed link, it detects the failure immediately. It starts to flood this information, such that all the routers can update their network view and recompute Dijkstra's algorithm.

a) What is the new shortest-path from $R3$ towards destination d?

b) Assume now that the computation of the new shortest-path is *very* fast and finishes before $R3$ starts the flooding of the messages announcing the link failure. $R3$ sends a packet towards d using the new shortest-path. Will the packet reach its destination? Which path will it take?

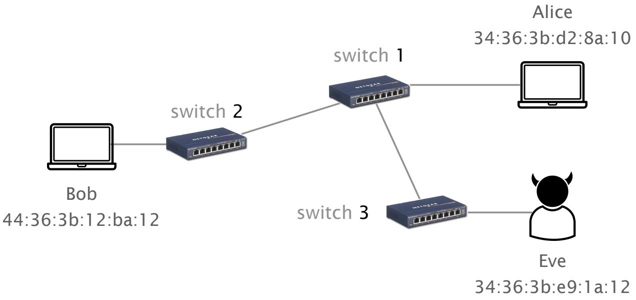
c) Can you find a sequence of link failure messages and shortest-path computations such that the problem discovered in the previous task is observed between $R1$ and $R2$? The *only* link failure is still between router $R3$ and d.

d) As we have discovered, the order in which the link failure messages are processed and the new shortest-paths are computed is crucial for a correct forwarding behavior in the network. In which order should the router update their forwarding tables, such that the previously observed problems will not occur? Can you find a more general "rule" for a safe ordering of forwarding rule updates?

Ethernet & Switching

3.3 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?

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).

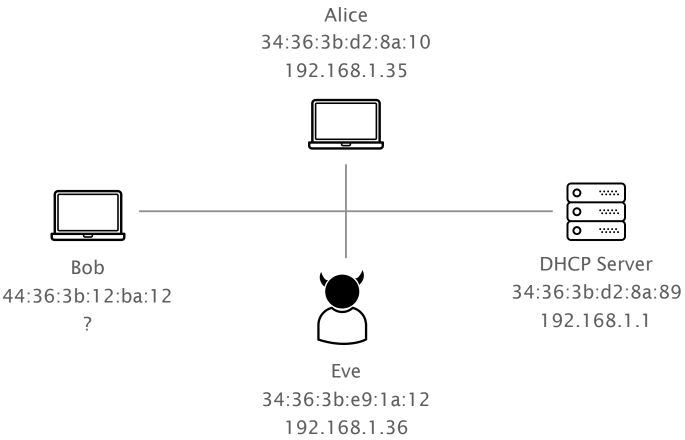
Alice starts acknowledging the received frames by sending frames to Bob.

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.

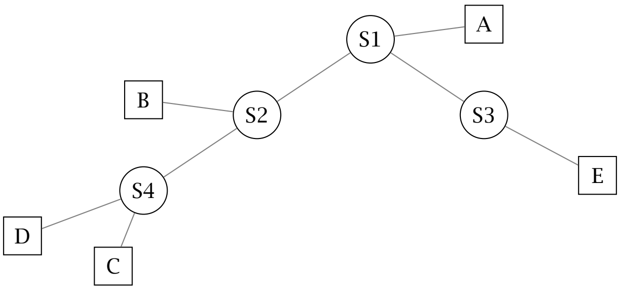
a) Explain all the steps that are necessary such that Bob's computer can finally send packets to Alice.

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.