PADERBORN UNIVERSITY

# Advanced Networked Systems SS24

## Exercise 1: Networking Fundamentals

## 1 Basic Concepts

**Question 1:** Explain how DNS exploits replication for the root name servers.

**Question 2:** Explain how TCP achieves reliability.

**Question 3:** Given an IPv4 address `192.168.1.20/20` for a host, what is the maximum number of other hosts that can exist in the same network?

**Question 4:** Briefly explain the concepts of network control and data planes.

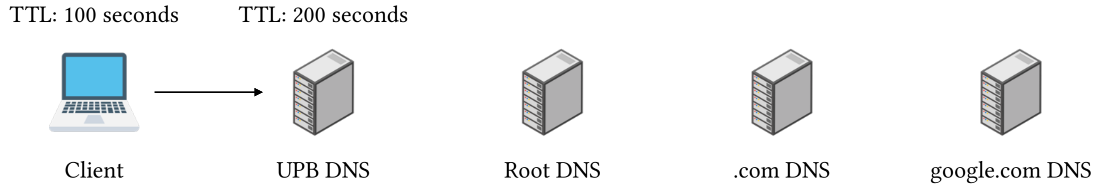
**Question 5:** Describe what is network address translation (NAT) and explain the benefits it provides.

**Question 6:** How does an Ethernet switch handle ARP requests and responses?

**Question 7:** Explain why we cannot build the Internet purely based on switched networks.

## 2 DNS Resolution

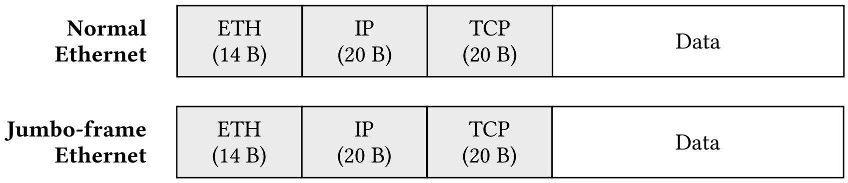
In the lecture we discussed how DNS queries are resolved by the recursive local DNS server and we also know that caching is typically applied at different layers to improve efficiency. Assume we are given the DNS setup at UPB as shown in the figure below. The client can cache DNS responses with a time-to-live (TTL) of 100 seconds, while the local UPB DNS server caches DNS responses with a TTL of 200 seconds. We also assume in the next 10 minutes, the client will make a Google search every 40 seconds.




**Question 1:** How many DNS queries will be generated on the network in total for the next 10 minutes?

## 3 TCP/IP Stack

In the TCP/IP stack, an Ethernet frame encapsulates an IP packet, which encapsulates a TCP segment together with the application data. IEEE 802.3 specifies that a normal Ethernet can carry up to 1500 B as its payload. For Ethernet with Jumbo frames enabled, this number becomes as large as 9000 B. The protocol encapsulation is illustrated in the following figure. Suppose we want to send 100 KB of data over such Ethernet networks with a TCP connection and the TCP sender initialized its sequence number with 13579.



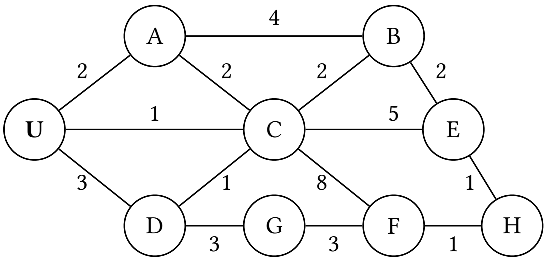

**Question 1:** What are the sequence numbers in the first five TCP segments with normal Ethernet and jumbo-frame Ethernet, respectively?

**Question 2:** What are the total numbers of bytes sent out by the sender onto the network with normal and jumbo-frame Ethernet, respectively?

**Question 3:** What are the frame efficiencies of normal and jumbo-frame Ethernet networks?

## 4 Shortest-Path Routing

The figure below shows a weighted graph representing a network topology with nine nodes.



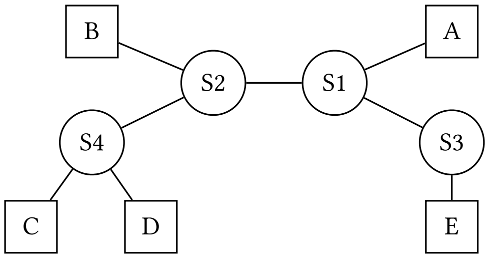

**Question 1:** Manually execute Dijkstra's algorithm and then list the obtained shortest paths from node U to each of the other nodes. For executing the Dijkstra's algorithm, you can use the table below. If multiple nodes appear to be candidates for extraction, select the node that comes first in the alphabet.

| | | Distance from U | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Iteration** | **Set of extracted nodes** | **U** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| 1 | U | 0 | 2 | ∞ | 1 | 3 | ∞ | ∞ | ∞ | ∞ |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |

**Question 2:** Based on the shortest paths from the previous task, derive the forwarding table (containing entries of destination to next-hop mapping) of node U.

## 5 Ethernet Switching

Consider the local area network (LAN) made up of four Ethernet switches in the figure below. Several hosts (A, B, C, D, and E) are connected to the switches. The MAC tables of all switches are initially empty. Assume host A sends a packet to host B and then host C sends a packet to host A.




**Question 1:** Explain how the packets are forwarded on the network and fill in the forwarding tables of all switches with the learned information.

| **S1 Table** | | **S2 Table** | | **S3 Table** | | **S4 Table** | |
|---|---|---|---|---|---|---|---|
| destination | next hop | destination | next hop | destination | next hop | destination | next hop |
| | | | | | | | |
| | | | | | | | |

**Question 2:** After some time, the switches have full forwarding tables (i.e., they have an entry for each host in the network). Host B wants to hijack all the packets destined for 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 address does host B have to send them? Explain your approach in detail. (Here we assume the hosts are not aware of the other hosts and do not know the network topology.)