Homework 1 Solutions

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Q1: Imagine that you have trained your St. Bernard, Bernie, to carry a box of three 8-mm tapes instead of a flask of brandy. (When your disk fills up, you consider that an emergency.) These tapes each contain 7 gigabytes. The dog can travel to your side, wherever you may be, at 18 km/hour. For what range of distances does Bernie have a higher data rate than a transmission line whose data rate (excluding overhead) is 150 Mbps? How does your answer change if
a. Bernie's speed is doubled;
b. each tape capacity is doubled;
c. the data rate of the transmission line is doubled.

Given:

- Bernie carries 3 tapes, each with 7 GB capacity.
- Bernie's speed: 18 km/h.
- Transmission line data rate: 150 Mbps (excluding overhead).

Solution:

First, calculate Bernie's effective data rate.

Total data carried by Bernie:

$$3 \times 7\,\text{GB} = 21\,\text{GB} = 21 \times 8 \times 10^9\,\text{bits} = 168 \times 10^9\,\text{bits}.$$

Time to travel distance d (km):

$$\text{Time (seconds)} = \frac{d\,\text{km}}{18\,\text{km/h}} \times 3600\,\text{s/h} = 200d\,\text{seconds}.$$

Bernie's data rate:

$$\text{Data rate} = \frac{168 \times 10^9\,\text{bits}}{200d\,\text{s}} = \frac{840 \times 10^6}{d}\,\text{bps}.$$

Set Bernie's data rate higher than the transmission line (150 Mbps):

$$\frac{840 \times 10^6}{d} > 150 \times 10^6 \implies d < 5.6\,\text{km}.$$

Part (a): Bernie's speed doubles to 36 km/h

$$\text{New time} = \frac{d}{36} \times 3600 = 100d\,\text{seconds}.$$

$$\text{New data rate} = \frac{168 \times 10^9}{100d} = \frac{1.68 \times 10^9}{d}\,\text{bps}.$$

$$\frac{1.68 \times 10^9}{d} > 150 \times 10^6 \implies d < 11.2\,\text{km}.$$

Part (b): Each tape capacity doubles to 14 GB

$$\text{New total data} = 3 \times 14\,\text{GB} = 42\,\text{GB} = 336 \times 10^9\,\text{bits}.$$

$$\text{New data rate} = \frac{336 \times 10^9}{200d} = \frac{1.68 \times 10^9}{d}\,\text{bps}.$$

$$\frac{1.68 \times 10^9}{d} > 150 \times 10^6 \implies d < 11.2\,\text{km}.$$

Part (c): Transmission line data rate doubles to 300 Mbps

$$\frac{840 \times 10^6}{d} > 300 \times 10^6 \implies d < 2.8\,\text{km}.$$

Final Answer:

- Original scenario: Bernie outperforms the line for $d < 5.6\,\text{km}$.
- (a) Speed doubled: $d < 11.2\,\text{km}$.
- (b) Tape capacity doubled: $d < 11.2\,\text{km}$.
- (c) Line rate doubled: $d < 2.8\,\text{km}$.

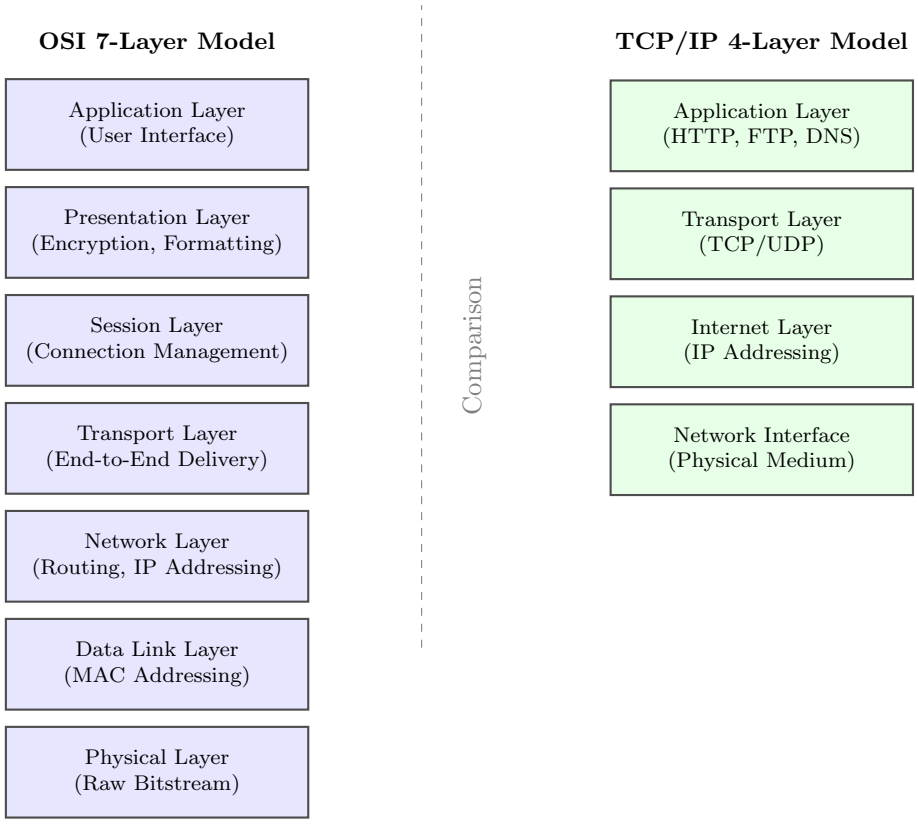
Q2: Difference Between TCP and UDP

Main Difference:

- **TCP (Transmission Control Protocol)**:
  - Connection-oriented (requires handshake).
  - Reliable: Guarantees delivery via acknowledgments and retransmissions.
  - Ordered: Data arrives in the sequence it was sent.
  - Flow and congestion control.
  - Example use: Web browsing, email.
- **UDP (User Datagram Protocol)**:
  - Connectionless (no setup).
  - Unreliable: No delivery guarantees or retransmissions.
  - No ordering: Packets may arrive out of sequence.
  - Lower latency and overhead.
  - Example use: Video streaming, online gaming.

Summary: TCP prioritizes reliability and accuracy, while UDP prioritizes speed and efficiency.

Q3: OSI vs TCP/IP Architecture



Layer Functions Summary

- **OSI Model:**
  - Physical: Transmits raw bitstream over physical medium
  - Data Link: Handles MAC addressing and error detection
  - Network: Manages IP routing and logical addressing
  - Transport: Ensures end-to-end delivery (TCP/UDP)
  - Session: Manages connections between applications
  - Presentation: Handles data formatting/encryption
  - Application: User-facing network applications
- **TCP/IP Model:**
  - Link: Combines physical and data link layers
  - Internet: Equivalent to OSI Network layer (IP)
  - Transport: Same as OSI Transport layer
  - Application: Combines OSI Application, Presentation, and Session layers