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Assignment 1 Chapter 1

R1. What is the difference between a host and an end system? List several different types of end systems. Is a Web server an end system?
A host and an end system are essentially the same thing in computer networking; both refer to devices at the edge of the network that run user applications and originate or terminate traffic. Examples of end systems include desktops, laptops, smartphones, tablets, game consoles, IoT devices (like smart thermostats), and servers. Yes, a web server is considered an end system because it runs application-layer protocols (like HTTP) and serves as an endpoint for communication.

R4. List four access technologies. Classify each one as home access, enterprise access, or wide-area wireless access.

- DSL (Digital Subscriber Line) — home access.
- HFC/Cable (Hybrid Fiber-Coax) — home access.
- FTTH (Fiber to the Home) — home access.
- Cellular (4G LTE, 5G) — wide-area wireless access.

(Additional example: Ethernet — enterprise access.)

R10. Describe the most popular wireless Internet access technologies today. Compare and contrast them.
Popular wireless technologies include:

- Wi-Fi (802.11): short-range, high throughput, used in homes and offices, unlicensed spectrum.
- Cellular (4G LTE and 5G): wide-area, supports mobility, licensed spectrum, 5G offers higher rates and lower latency than 4G.
- Fixed wireless broadband (including mmWave and fixed 5G): provides high-speed access in areas without wired infrastructure.
- Satellite (LEO constellations like Starlink): offers global coverage, higher latency than terrestrial but improving with LEO satellites.

Comparison: Wi-Fi has the highest speeds over short distances, cellular covers wide areas with mobility, satellite covers remote areas but has higher latency, and fixed wireless fills gaps where wired service isn't available.

R11. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are R1 and R2, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.)
With store-and-forward, the switch must receive the entire packet before forwarding. The total delay is:

LR1+LR2\frac{L}{R_1} + \frac{L}{R_2}R1L+R2L

where LLL is packet length, R1R_1R1 is the transmission rate from sender to switch, and R2R_2R2 is the rate from switch to receiver.

R18. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 × 10^8 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d,

propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

- Packet length = **1,000 bytes = 8,000 bits**

- Transmission rate R=2×106R = 2 \times 10^6R=2×106 bps

- Distance d=2,500 km=2.5×106 md = 2,500\ \text{km} = 2.5 \times 10^6\ \text{m}d=2,500 km=2.5×106 m

- Propagation speed s=2.5×108 m/ss = 2.5 \times 10^8\ \text{m/s}s=2.5×108 m/s

Transmission delay = L/R=8000/2,000,000=0.004L / R = 8000 / 2,000,000 = 0.004L/R=8000/2,000,000=0.004 s = **4 ms**
Propagation delay = d/s=2.5×106/2.5×108=0.01d / s = 2.5\times10^6 / 2.5\times10^8 = 0.01d/s=2.5×106/2.5×108=0.01 s = **10 ms**

Total = 14 ms.

General formula:

- Propagation delay: d/sd/sd/s.

- Transmission delay: L/RL/RL/R.

Propagation delay does not depend on packet length or transmission rate. Transmission delay does depend on packet length and rate.

Does this delay depend on packet length?
Yes, the **transmission delay** term LR\frac{L}{R}RL depends on LLL.
Does this delay depend on transmission rate?
Yes, transmission delay depends on RRR.

Does propagation delay depend on packet length or transmission rate?

No, it only depends on distance ddd and propagation speed sss.

R19. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1 = 500 kbps, R2 = 2 Mbps, and R3 = 1 Mbps.

a. Throughput is determined by the bottleneck link.

min(500 kbps,2 Mbps,1 Mbps)=500

b. File size = 4 million bytes = 32 million bits. Time = 32,000,000/500,000 = 64

c. If R2 = 100 kbps, then throughput = 100 kbps.

Transfer time = 32,000,000/100,000 = 320 seconds (5 min 20 s).

R23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

1. Application layer: Provides network services to applications (HTTP, SMTP, DNS).
2. Transport layer: End-to-end delivery between processes; reliability, flow/congestion control (TCP, UDP).
3. Network layer: Logical addressing and routing (IP).
4. Link layer: Node-to-node delivery, error detection, medium access (Ethernet, Wi-Fi).
5. Physical layer: Transmission of raw bits over the medium (electrical/optical/radio signals).

R25. Which layers in the Internet protocol stack does a router process? Which layers does a link-layer switch process? Which layers does a host process?

- Router: processes up to the network layer (IP), plus link and physical for interfaces.
- Link-layer switch: processes only link and physical layers (MAC addresses).
- Host: processes all five layers (application down to physical).

R26. What is self-replicating malware?
Self-replicating malware is malicious software that can copy itself and spread without user action. Examples include:

- Viruses: attach to files/programs and spread when those are executed.
- Worms: spread independently over networks by exploiting vulnerabilities.

These programs can quickly propagate, consuming bandwidth and system resources, and often install further payloads like ransomware or backdoors.

R28. Suppose Alice and Bob are sending packets to each other over a computer network. Suppose Trudy positions herself in the network so that she can capture all the packets sent by Alice and send whatever she wants to Bob; she can also capture all the packets sent by Bob and send whatever she wants to Alice. List some of the malicious things Trudy can do from this position.
Trudy can:

- Eavesdrop on communications to steal sensitive data.
- Modify packets in transit (alter messages, change files).
- Replay old packets.

- Drop packets to disrupt communication.
- Impersonate either Alice or Bob (session hijacking).
- Insert malicious content such as malware.
- Downgrade security protocols to weaker encryption.
- Perform traffic analysis to learn communication patterns.

P10. Consider a packet of length L that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let di, si, and Ri denote the length, propagation speed, and the transmission rate of link i, for i = 1, 2, 3. The packet switch delays each packet by dproc. Assuming no queuing delays, in terms of di, si, Ri (i = 1, 2, 3), and L, what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5 × 10^8 m/s, the transmission rates of all three links are 2.5 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

Delay: $\sum_{i=1}^{3} \left(\frac{L}{R_i} + \frac{d_i}{s_i}\right) + 2 \cdot d_{proc}$

$L = 1{,}500 \times 8 = 12{,}000$ bits

$R = 2.5 \times 10^6$ bps $\rightarrow$ transmission $= 12{,}000 / 2.5 \times 10^6 = 0.0048$ s $= 4.8$ ms/p/link

- Distances: $d_1 = 5{,}000$ km $= 20$ms ; $d_2 = 4000$ km $= 16$ms; $d_3 = 1000$ km $= 4$ms
- Processing $= 2 \cdot 3$ms $= 6$ms

  Total $= 3(4.8) + 20 + 16 + 4 + 6 = 60.4$ ms