Computer Networks (Fall 2025)

Assignment # 1 **Due on: 19th Sep, 2025 (11:59 pm)**

Instructions:

A maximum of 20% marks will be allowed after the due date.
Only handwritten submission on computer pages (without lines) will be accepted.
Answers written hastily will not be graded.
All types of plagiarism by all involved shall be punished by imposing a plenty of 20 weightage.

Thoroughly read the textbook contents related to review questions: R1 - R4, R7, R8, R10 - R 16, R18 - R10, R20, R22 - 25, R28. Now attempt the following questions. Write a textbook page and paragraph number in each part of your answer.

Q1. A packet of length L is sent over a path consisting of two links connected by a single router. The transmission rates of the first and second links are R1 and R2, respectively, and the propagation delays are d1 and d2. The router has a negligible processing delay.

a. Write the equation of the total end-to-end delay. Explain the contribution of each term.
b. What happens to the delay of part a above if R2 << R1.

Q2. A residential neighborhood is being served by two ISPs: one offering internet via HFC and the other via DSL. Both advertise a "maximum downstream rate" of 100 Mbps.

a. Explain the fundamental technical difference in how these two technologies provide this rate to a customer.
b. At 8:00 PM, when many residents are streaming video, a customer on the HFC network experiences significant slowdowns, while a customer on the DSL network does not. Explain why this happens, linking your explanation to your answer in part (a).

Q3. Consider a host requesting a webpage from a server.

a. As the HTTP request message travels from the host to the server, at which layers (Application, Transport, Network, Link) is a header added? For each header, state one key piece of information it contains and the role of that information.
b. A router on the path between the host and the server receives the packet containing the HTTP request. Which of the headers from part (a) does this router examine? Which does it ignore? Explain why.
c. The server sends back a large image file. This data is segmented into multiple packets by the Transport layer. Describe one major advantage and one major disadvantage of this segmentation process for the network as a whole.

Q4. Suppose N users share a 1 Gbps link. Each user alternates between periods of activity and inactivity. When active, a user transmits data at a constant rate of 100 Mbps.

a. How many users can be supported simultaneously under circuit switching?
b. For packet switching, why is it possible to have more than this number of users without guaranteed failure?

Q5. The "asking directions" analogy is used to describe packet switching.

a. Explain this analogy, mapping the car, the driver, the intersections, and the final destination to components in the Internet protocol stack.
b. Now, imagine a malicious entity (Trudy) sets up a fake detour sign at one of the intersections. Map this action to a specific layer in the Internet protocol stack and describe the corresponding network-level attack.
c. Which security principle (Confidentiality, Integrity, or Authentication) does this attack primarily violate?

Q6. Attempt following end-of-the-chapter problem of chapter # 1: P5, P6, P18, P24, P31,

BONUS QUESTION (rewarded in Quiz # 1)

Scenario: The Software Developer in Karachi

Ayesha, a software developer in Karachi, Pakistan (KHI), needs to download a critical 10 GB Linux distribution ISO file from a software repository server located in London, UK (LHR). The file is transferred over the modern internet using the TCP protocol. Her computer in Karachi and the server in London are connected through a path consisting of 8 hops. Each hop represents a router that forwards the packet to the next link on the path to London. The path between Ayesha's computer (KHI) and the server (LHR) is as follows:

Hop #	From Node	To Node	Link Type	Distance (approx)	Propagation Speed (in medium)	Transmission Rate (Bandwidth)	Typical Queueing Delay (per hop)
0	Ayesha's PC	Home Router	Ethernet Copper Cable	10 m	2.0 x 10^8 m/s	1 Gbps	0.1 ms
1	Home Router	Local ISP (KHI)	Fiber Optic (Metro)	5 km	2.0 x 10^8 m/s	1 Gbps	0.5 ms
2	Local ISP (KHI)	National ISP (KHI)	Fiber Optic (Terrestrial)	800 km	2.0 x 10^8 m/s	100 Gbps	0.2 ms
3	National ISP (KHI)	Landing Station	Fiber Optic (Terrestrial)	200 km	2.0 x 10^8 m/s	100 Gbps	0.2 ms
4	Karachi Landing	Submarine Cable (EMERGENT)	Fiber Optic (Submarine)	6,500 km	2.0 x 10^8 m/s	50 Tbps (per fiber pair)	2 ms (congested)
5	UK Landing	National ISP (LHR)	Fiber Optic (Terrestrial)	150 km	2.0 x 10^8 m/s	100 Gbps	0.3 ms
6	National ISP (LHR)	London Data Center	Fiber Optic (Metro)	20 km	2.0 x 10^8 m/s	100 Gbps	0.1 ms
7	London DC Router	Server (LHR)	Ethernet Copper Cable	50 m	2.0 x 10^8 m/s	10 Gbps	0.05 ms

a. Calculate the End-to-End Delay for a Single Packet
b. Calculate the Total Delay for the 10 GB File

Assumptions:

- Packet Size: The maximum segment size (MSS) for the TCP packet is 1500 bytes (a common standard, including headers).
- Queueing Delays: These are realistic averages for modern, well-provisioned internet links. The submarine cable hop has a slightly higher queueing delay due to being a shared international bottleneck.
- Processing Delay: Is negligible at each router (microseconds) and can be considered 0 ms for this calculation.
- The 10 GB File: Size = 10 Gigabytes = 10 * 10^9 bytes = 80 * 10^9 bits.

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