Homework 1: Network Delay and Performance Analysis

CSE 4/589 - Modern Networking Concepts
Instructor: Yaxiong Xie

NOTES:

- **Academic integrity**: Print the following statement at the very beginning of your homework file: "*I have read and understood the course academic integrity policy in the syllabus of the class. I confirm that the work presented in this report is my own. Where information has been derived from other sources, I confirm that this has been indicated in the report.*" Your homework will NOT be graded if you didn't print the sentence.
- For the calculation, you need to write down how the results are derived and your final answer also should be correct to obtain the credits for that question. Please state any assumptions you are making while answering a question.
- Submit the homework through UBLearns as PDF files.

Instructions

- Answer all questions using **Mbit** for data size and **Mbit/s** for transmission rates.
- Show all necessary steps for calculations.
- Submit electronically in PDF format.

Question 1: Transmission and Propagation Delay

A file of size **80 Mbit** is transmitted over a **10 Mbit/s** link. The link distance is **2000 km**, and the propagation speed is **200,000 km/s**. (20 points)

(a) Calculate the **transmission delay** and **propagation delay**. Which delay is more significant in this scenario, and why? (10 point)

(b) If the link bandwidth increases to **100 Mbit/s**, how do transmission and propagation delays change? Which delay is more significant? (10 point)

Question 2: Impact of Packet Size on Delay

A **12 Mbit** packet is transmitted over a **100 Mbit/s** link that is **500 km** long. The propagation speed is **200,000 km/s**. (20 points)

(a) Calculate the **transmission delay** and **propagation delay**. Which delay is more significant in this scenario, and why? (10 points)

(b) If the packet size is reduced to **4 Mbit**, how do transmission and propagation delays change? Which delay is more significant? (10 points)

Question 3: Queuing Delay and Traffic Intensity

A router has an **output link capacity of 20 Mbit/s** and receives traffic from multiple sources at an average rate of **16 Mbit/s**. Each packet is **1 Mbit** in size. (20 points)

(a) What is the traffic intensity (La/R) at the router? What's the current queuing delay? (10 points)

(b) If the average arrival rate increases to **22 Mbit/s**, what happens to the queuing delay? (10 points)

Question 4: End-to-End Delay in a Multi-Hop Network

A packet of **16 Mbit** is transmitted across **three links** in a network.

- Each link has a bandwidth of **50 Mbit/s**.
- Each link has a distance is **1000 km**, with propagation speed **200,000 km/s**.
- Assume **no queuing or processing delay**.

(a) Compute the **transmission delay per link** and **propagation delay per link**. (10 points)

(c) Compute the **total end-to-end delay**.(10 points)

Question: Throughput and Bottleneck Analysis

A file of size **50 Mbit** needs to be transferred from a server to a client over a network path consisting of two links:

- **Link 1**: Transmission rate of **10 Mbit/s**
- **Link 2**: Transmission rate of **5 Mbit/s**

Assume that the file transfer follows a store-and-forward packet-switching approach, meaning each packet must be fully received at an intermediate router before being forwarded to the next link.

1. Identify the **bottleneck link** in this network path and explain why it is considered the bottleneck. (5 points)
2. Calculate the **average end-to-end throughput** of the data transfer.(5 points)
3. Determine the **total time required to transfer the file** under the assumption that the bottleneck link governs the transmission speed. (5 points)
4. If **Link 2's transmission rate is upgraded to 15 Mbit/s**, how does this affect the overall throughput? Justify your answer. (5 points)