

Assignment 1

1. (1%) Perform a traceroute between source and destination both in Taiwan at three different hours of the day.
 - (a) Find the average and standard deviation of the round-trip delays at each of three hours.
 - (b) Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?
 - (c) Try to identify the number of ISP networks that traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP.
 - (d) In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?
 - (e) Repeat the above for a source in Taiwan and destination in North America. Compare the intra-continent and inter-continent result.

According to your experiments the result will be different.

2. (1%) In this problem we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is one link between Host A and B; its transmission rate is 2 Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packets bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

Grouping into packets: $\frac{56 \times 8}{64 \times 10^3} = 7 \text{ ms}$ ($\frac{56 \times 8}{64 \times 2^{10}} = 6.84 \text{ ms}$)

Transmission delay: $\frac{56 \times 8}{2 \times 10^6} = 0.224 \text{ ms}$ ($\frac{56 \times 8}{2 \times 2^{20}} = 0.214 \text{ ms}$)

Total time = $7 + 0.224 + 10 = 17.224 \text{ ms}$ (17.054 ms)

3. (1%) Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station. Assume a propagation speed of $2.4 \cdot 10^8$ meters/sec.

- (a) What is the propagation delay of the link?

Suppose the distance between the satellite and the base station is D .

$$d_{prop} = \frac{D}{2.4 \times 10^8} \text{ sec.}$$

- (b) What is the bandwidth-delay product, $R \cdot d_{prop}$?

$$R \times d_{prop} = \frac{D}{2.4 \times 10^8} \times 10^7 = \frac{D}{24} \text{ bits}$$

- (c) Let x denote the size of the photo. What is the minimum value of x for the microwave link to be continuously transmitting?

$$x = 60 \times 10^7 = 6 \times 10^8 \text{ bits}$$

4. (1%) Consider sending a large file of F bits from Host A to Host B. There are three links (and two switches) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 80 bits of header to each segment, forming packets of $L = 80 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.

$$\text{Let } F(S) = \frac{80+S}{R} \times 3 + \left(\frac{F}{S} - 1\right) \times \frac{80+S}{R} = \left(\frac{F}{S} + 2\right) \times \frac{80+S}{R}.$$

$$\text{Let } \frac{d}{dS}F(S) = 0 \Rightarrow \frac{-F}{S^2} \times \frac{80+S}{R} + \left(\frac{F}{S} + 2\right) \times \frac{1}{R} = 0 \Rightarrow S^2 - 40F = 0 \Rightarrow S = \sqrt{40F}.$$

5. (1%) Design and describe an application-level protocol to be used between an automatic teller machine and a banks centralized computer. Your protocol should allow a users card and password to be verified, the account balance (which is maintained at the centralized computer) to be queried, and an account withdrawal to be made (that is, money disbursed to the user). Your protocol entities should be able to handle the all-too-common case in which there is not enough money in the account to cover the withdrawal. Specify your protocol by listing the messages exchanged and the action taken by the automatic teller machine or the banks centralized computer on transmission and receipt of messages.

**ATM
Machine**

**Banks
centralized
computer**

