

Problem 1 [20 Pts]

Consider the problem of transmitting one file of K bits. We are comparing packet switching and circuit switching.

For the circuit-switched approach, it takes 1 second to set up the circuit. Once the circuit is set up, the transmission occurs at 1Mbps and the signals take 50ms from the source to the destination.

For the packet-switched approach, the network transports the information as packets of 1kbits along lines with a transmission rate of 1Mbps; however, each packet must contain additional information that amounts to 100 bits. We neglect the packet switching delays. The signals again take 50ms from the source to the destination.

- Calculate the delays to deliver the file using circuit-switching.
- Assume that in packet switching one sends one packet, waits until we get an acknowledgement (assume that this takes 55ms after the packet has been completely received by the destination), then sends the next packet, and so on. Calculate how long it takes to deliver the file.
- Assume that we use packet switching but that we send all the packets back to back, without waiting for acknowledgments. Calculate how long it takes to deliver the file.
- For what values of K is approach (a) faster than approach (c)?

Problem 2 [30 Pts]

Network functions can either be implemented in the end hosts or in the network devices (such as routers and switches). For each of the following network functions, state whether it should be implemented in the end hosts or in the network devices, and briefly justify your answer.

- packet retransmission
- security
- address lookup and routing decisions
- multicasting (sending the same data to multiple hosts)
- error detection/correction
- congestion control

Problem 3 [25 Pts]

Perform a Traceroute between a source and destination on the same continent, and another Traceroute between a source and destination on different continents, at three different hours of the day (a total of 6 Traceroutes).

- Find the average and standard deviation of the round-trip delays at each of the three hours.
- Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?
- Try to identify the number of ISP networks that the Traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as a part of the same ISP. In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?

Problem 4 [25 Pts]

Consider sending voice from Host A to Host B over a packet-switched network (for example, Internet phone). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 48-byte packets. There is one link between Host A and B; its transmission rate is 1 Mbps and its propagation delay is 2 ms. 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 packet's bits to an analog signal. What is the maximum time that 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)?