EE3204/EE3204E CCN-I (Part 1) : Semester 1, 2012-13

Tutorial 1 - Problems and Solutions

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1. Suppose a 100 Mbps link is being set up between the earth and a new lunar colony. The distance from the moon to the earth is approximately 385,000 km, and data travels over the link at the speed of light (3×10^8 m/s). A camera on the lunar base takes pictures of the earth and saves them in digital format to disk. Suppose *Mission Control* on earth wishes to download the most current image, which is 25 MB. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished? Determine the effective throughput and throughput rate for the above case.

<u>Solution:</u>

Transmission time = 25 MB / 100 Mbps = 2.097 s

Propagation time from the earth to lunar base = 385,000 km / 3×10^8 m/s = 1.283 seconds

RTT = 2×1.283 = 2.566 seconds.

The transfer time includes the propagation time for the request to go from the earth to lunar base, image transmission time, and propagation time from the lunar base to the earth. Therefore, the transfer requires 1 RTT plus transmission time = 2.566+2.097 = 4.663 seconds.

Effective Throughput = Message size / Message transfer time

= 25 MB/ 4.663 = 44.974 Mbps

Throughput rate = Throughput/Bandwidth = 44.974/100 = 0.44974 which is numerically the same as link utilization or link efficiency.

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2. Determine the width and length of a bit on a 1 Mbps link, where the propagation speed on the link is 2×10^8 m/s.

Solution:

Bit width = bit time = 1/ bandwidth = $1/10^6$ sec = 1 μs.

Bit length = bit time× propagation speed = $1\times10^{-6}\times2\times10^8$ m = 200 m

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3. A 1024×1280 display supports 16 different colors. How long would it take to transmit one screen over a 64 kbps link?

Solution:

Four bits are required to represent a pixel to support 16 colors. Therefore the display requires transmission of 1024×1280×4 bits. The transmission time is 1024×1280×4/64000 = 81.92 seconds

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4. A 20km long link is able to hold only ½ bit in one direction. What is the bandwidth of the link? Assume that the propagation speed on the link is 2×10^8 m/s.

Solution:

Number of bits that can be held = (propagation) delay × bandwidth

Therefore, bandwidth = No of bits held on the link / propagation time

$= 0.5 / (20000/[2\times10^8]) = 5$ kbps

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5. A disadvantage of a broadcast network is that the capacity is wasted due to multiple hosts attempting to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with probability *p* during each slot. What fraction of the slots is wasted due to collisions only?

p = probability that a host attempts to use the channel in a slot

q_0 = probability that no host attempts to use the channel in a slot

q_1 = probability that exactly one host attempts to use the channel in a slot

q = probability for collision occurrence in a slot

Collision occurs when two or more hosts attempt to use the channel during a slot. Therefore,

$q = 1 – [q_0 + q_1]$

$\quad = 1 – [(1-p)^n + n \times p \times (1-p)^{n-1}]$

6. Calculate the total time required to transfer a 1000 KB file in the following cases, assuming an RTT of 100 ms, a packet size of 1 KB of data, and an initial 2×RTT of "handshaking" before data is sent.

   (a) The bandwidth is 1.5 Mbps, and data packets can be sent continuously.
   (b) The bandwidth is 1.5 Mbps, but after we finish sending each data packet we must wait one RTT before sending the next.
   (c) The bandwidth is infinite, meaning that the transmit time is zero, and up to 20 packets can be sent per RTT.
   (d) The bandwidth is infinite, and during the first RTT we can send one packet, during the second RTT, we can send two packets, during the third RTT we can send four packets, and so on.

<u>Solution:</u>

Number of packets = 1000, RTT = 100 ms

Packet transmission time = 1KB/1.5 Mbps = 5.461 ms

(a) Total time (T) required is initial RTTs plus transmission time of 1000 packets plus propagation time (for 1000th packet) from sender to receiver plus propagation time from receiver to sender (for acknowledgement). Therefore, T = 2 RTTs+ 1000×5.461 ms + RTT = 5.761 seconds.

(b) T = 2 RTTs + 1000 × packet transmission time + 1000 RTTs

   = 100.2+5.461 = 105.661 seconds.

(c) Infinite bandwidth ⇒ zero transmission time. In one RTT, 20 packets are sent.

   T = 2+ 50 RTTs = 52×100 ms = 5.2 seconds.

(d) Infinite bandwidth $\Rightarrow$ zero transmission time. After initial handshaking of 2 RTTs,

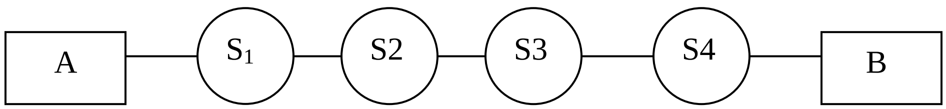
$1+2+4+\ldots+2^{n-1} = 2^n - 1$ packets will be sent in n RTTs.

For 1000 packets, n=10,

Therefore T = (n+2) RTT = 12×100 ms = 1.2 seconds

7. Calculate the latency (from first bit sent to last bit received) for the following:

(a) A packet of 5000 bits is sent over a 10 Mbps Ethernet from node A to node B through four store-and-forward switches in the path as shown in the following figure. Assume that each link introduces a propagation delay of 10 μs, and that the switch begins retransmitting immediately after it has finished receiving the packet.



Solution:

Packet transmission time = 5000bits/10Mbps = 500 μs.

Propagation delay on one link = 10 μs.

The packet traverses 5 links. It needs to be transmitted at 5 nodes (1 source and 4 switches). Therefore, latency = 5×10 + 5×500 μs = 2.55 ms.

(b) Same as (a), but 5000 bits are sent in 5 packets each carrying 1000 bits. The packets are transmitted continuously with no time gap between two consecutive packet transmissions.

Solution:

Packet transmission time = 1000bits/10Mbps = 100 μs.

Propagation delay on one link = 10 μs.

Node A completes transmission of last packet at 5×100 = 500 μs. Then the last packet needs to transmitted at each of the 4 switches. This packet experiences propagation delay at each of the five links.

Therefore, latency = 500 + 4×100 + 5×10 μs = 950 μs

(c) Same as (a), but assume that each switch implements “cut-through” switching: It is able to begin retransmitting the packet immediately after receiving the first 200 bits.

Solution:

The packet is delayed for a period of “packet transmission” time at the source and is delayed for a period of 200 bits time at each of the 4 switches. The packet experiences propagation delay at each of the five links.

200 bit delay = 200bits/10Mbps = 20 μs

latency = $500 + 4\times20 + 5\times10$ μs = 630 μs