ECEN4533 Final Exam 2 May 2011

1) It is the year 2111. You are about to transmit a large 20 MB application file to a Facebook pal on the planet Jupiter, currently $664(10^9)$ meters away, using a 100 Mbps inter-planetary Internet link. Link packets can support 8,000 application bytes, and can be transmitted back to back. Your smart phone is using TCP, with each TCP packet requiring 67 bytes of overhead (7 B Point-to-Point protocol, 40 B IPv6, and 20 B TCP). End device processing time is negligible.

[20] Assuming error free transmission, determine the minimum TCP Window size (in Bytes) necessary to ensure the link is fully loaded. [Answer - 438.9 G bits]

2) An engineering company claims they've developed an ultra-wideband system that allows 1 Gbps speeds over a 50 km binary phase-shift keyed radio frequency link using a bandwidth of 200 MHz, 3000 B packets, and a receiver signal-to-noise ratio of 71.

[20] Is this claim believable? Explain. [Believable. Channel Capacity indicates the system can theoretically move up to 1.234 Gbps.. A demo would be nice though.]

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3) An M/M/1 queue averages 13 packet arrivals every microsecond, and is capable of servicing 48 average sized packets every microsecond. The average packet size is known to be 450 bytes.

3a [15] On average, how many packets will be in the queue? [0.1006 packets]

3b [10] **Compute** the output line speed. [172.8 Gbps]

3c [15] Suppose the probability density function of the "time a packet spends in the switch" is Gaussian Distributed with a mean equal to the average time E[T] spent in the switch and standard deviation equal to 1/9th that value, i.e. E[T]/9. **Compute** P(a packet spends more than 21 nanoseconds in the switch). [0.9915]

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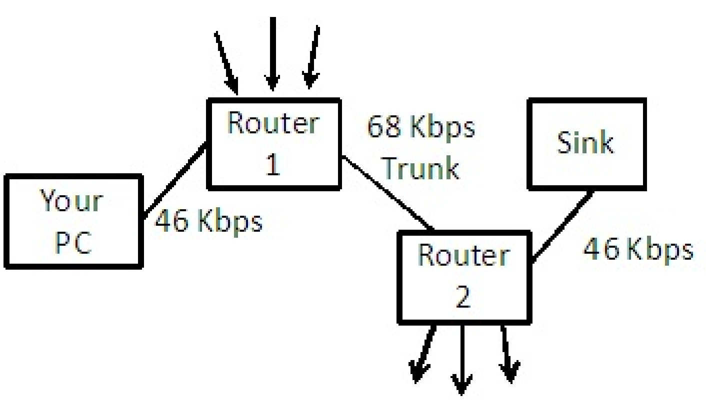
4) In the error-free full duplex network shown to the right, at times t = 91 msec, 104 msec, and 199 msec, the trailing edge of an 800 B packet enters Router 1 from one of the lines on the top, destined to exit one of the lines on the bottom of Router 2. These three packets constitute cross traffic.



While this is going on, your PC is moving two 800 byte packets (7B PPP,

20B IPv4, 20B TCP) to the information sink. These packets are injected back-to-back onto the 46 Kbps link commencing at time t = 0. An ACK is immediately generated by the sink upon receipt of each of these packets. Propagation delays for all links are 1 msec. All Routers are First In, First Out. Processing delays on all devices can be ignored.
[35] **Compute** the Round Trip Times (RTT) for each of these two ACK's as recorded by your PC. The clock for the nth RTT starts when the nth packet is injected onto the 46 Kbps link and stops when the trailing edge of the ACK for that packet is received by your PC. [RTT(1) = 0.5394 seconds, RTT(2) = 0.5885 seconds]

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5) A packet network is transmitting packets over a noisy 720 Kbps wireless Low Earth Orbiting Satellite link that results in corrupted and discarded packets 14% of the time. The average packet size (including overhead) is 750 bytes. ACK's are 50B. The link distance is 530 Km (329.3 miles).
5a [20] Clearly if the packet is transmitted once there will be an 86% chance it will be received correctly. **Compute** the number of times that a specific packet will have to be transmitted in order to insure it is received correctly with probability ≥ 0.97. [Two transmissions will insure it is received with probability 0.9804]
5b [15] **Compute** the throughput that can be expected on this link if Stop and Wait is used. [418.1 Kbps]