Problem 1

a) We can use Hartley"s law to figure this out. Recall that $C = 2B\log_2(M)$ bit/s, where $B = 8.0 \times 10^7$ Hz, C is at least 6.4×10^8 bps, and M is the modulation value which we can find in the table. We can see that the following modulation schemes produce the following bandwidths:

$$\text{BPSK: } 1.6 \times 10^8 \times 1 = 1.6 \times 10^8\text{Hz}$$

$$\text{QPSK: } 1.6 \times 10^8 \times 2 = 3.2 \times 10^8\text{Hz}$$

$$\text{8PSK: } 1.6 \times 10^8 \times 3 = 4.8 \times 10^8\text{Hz}$$

$$\text{16-QAM: } 1.6 \times 10^8 \times 4 = 6.4 \times 10^8\text{Hz}$$

So, the simplest modulation scheme that achieves 640 Mbps is 16-QAM.

b) Given two signal strength measurements, we can use the power equation to create the following:

$$dBm_1 - dBm_2 = 10\log_{10}(\frac{P_1}{0.001}) - 10\log_{10}(\frac{P_2}{0.001})$$

$$dBm_1 - dBm_2 = 10\log_{10}(\frac{P_1}{P_2})$$

If dBm_1 corresponds to signal strength, and dBm_2 corresponds to system noise, then the equation becomes the following:

$$Signal_{dBm} - Noise_{dBm} = SNR_{dB} = 10(\log_{10}(\frac{S}{N})$$

Rearranging, we get:

$$\frac{S}{N} = 10 \wedge (\frac{SNR_{dB}}{10})$$

The $SNR_{dB} = -78 - (-95) = 17$, so $\frac{S}{N} = 10^{1.7} \approx 50.1187$.

c) Recall Shannon's equation: $C = B\log_2(1 + \frac{S}{N})$. The highest bitrate we can acheive is:

$$C = (8.0 \times 10^7 \text{ Hz})(\log_2(5.1.1187)) = 4.5406 \times 10^8\text{bps}$$

Modulation is bounded by $\sqrt{1 + \frac{S}{N}} = \sqrt{51.1187} \approx 7.1497$. So, the best modulation scheme we can use is QPSK, which has $M = 4$ and acheives 320 MBps.

d) To get 640 MBps, M must be at least 8 (see part A). So:

$$\sqrt(1 + \frac{S}{N}) \geq 8 \implies 1 + \frac{S}{N} \geq 64 \implies \frac{S}{N} \geq 63$$

Using the power equation we derived in part b:

$$10\log_{10} 63 - 95 = Signal_{dBm} = -77.0066$$

Using the power equation given to us:

$$10 \wedge (\frac{Signal_{dBm}}{10}) \times 0.001$$

Plugging in the old signal power and the new signal power, we get:

$$Signal_{dBm} = 1.9925 * 10^{-11}\mathrm{W}$$

$$OldSignal_{dBm} = 1.584 * 10^{-11}\mathrm{W}$$

So, we must increase power by a factor of approximately 1.257.

Problem 2

a) Being on the same broadcast domain means that all nodes in the domain are reachable from any other node via a broadcast.

b) True: This increases throughput because hosts don't need to wait to send packets; they can just send the package and let the switch manage a queue of packets. Because of this, there's less downtime for each host, since they can send a packet without necessarily needing the receiving node to be available.

b) One advantage is that a randomized exponential backoff scheme reduced contention, as nodes will attempt to send data less frequently if the connection is too crowded. Because of this, nodes will sleep for longer and longer amounts of time, which means that fewer nodes are wasting their time trying to send data when they cannot. One downside is that this scheme can create long wait times for arbitrary nodes, since the backoff is exponential and somewhat random, whereas in the time-based scheme, nodes are guaranteed to be able to send data at a regular frequency.

Problem 3

a) TCP is responsible for overall transmission of data, whereas the link-layer reliable is responsible for link-to-link transport. It's possible that when a packet is transmitted, it goes through multiple nodes. If one of these nodes where to crash after it receives a packet and before it forwards it, it's possible the packet never reaches its end point, but also never violated link-layer reliability. Thus, we would need TCP's reliable delivery to guarantee reliability for uploading a file.

b) If the link-layer isn't fully-reliable, and if it often drops packets, then TCP will need to resend packets frequently. This isn't especially efficient, which makes the reliable delivery useful since it improves on the efficiency.