15-441
Question Set #1

1) What is preferable, a 10KHz media with a SNR of 20, or a 20KHz media with 3dB of noise (N:S, not S:N)? Why? Please show any work.

Assuming a binary encoding…

*NyquistLimit-10 = 2*10KHz = 20kbps*
*NyquistLimit-20 = 2*20KHz = 40kbps*

*ShannonLimit-10 = 10KHz * Log-2 (1 + 20) = 44Kbps*

3db = 10 Log-10 (NSR)
SNR =1/ 2
*ShannonLimit-20 = 20KHz * Log-2 (1 + 1/2) = 12Kbps*

…although the raw bandwidth wins without noise, Shannon’s Limit is the more restrictive. Given the noise, we should take the small, but cleaner, band.

2) The typical analog voice line has a limited bandwidth, approximate 4KHz. Assuming that the codec produces 8-bit binary samples, how many concurrent calls can be supported by a 1MHz media? Why? Please show any work.

4KHz signal must be sampled at 8KHz.
Each sample requires 8-bits
So, we must transmit 64Kbps

A 1MHz media can support a binary bit-rate of 2Mbps

31 calls = 2Mbps/64bps

3) Assume that a mobile phone provider wants to improve the service quality on their "all digital mobile-to-mobile network" by offering CD-quality, mono channel, sound with a bandwidth of up to 44.1KHz at 16 bits per sample. Given that the existing system supports a bandwidth of up to 3.6KHz at 1-byte per sample, how much will they need to expand their network capacity to handle the sample call volume?

44.1KHz would need to be sampled at 88.2KHz
Each sample would be 16 bits
The required bit-rate would be 1411.2bps = 16bits/sample x 88.2KHz

3.6KHz analog signal requires a 7.2KHz sampling rate
Each sample is 8 bits
The required bit-rate is 57.6Kbps = 8bits/sample x 7.2Kbps

The network would need 20x the capacity: 20 = 1411.2bps / 7.2kbps

4) Under what circumstances would Pure Aloha be preferable to Slotted Aloha.

Very low contention. Waiting for a timeslot increases latency. If there is very little contention, this is reducing a collision window that is not likely to have a real impact.

5) What would be the likely impact on a typical network of changing the IEEE 802.3 or Ethernet standard to use no delay instead of an exponential backoff? What about a simple linear backoff? Why?

No delay would completely break the network. Once a collision occurred, it would keep occurring until the colliding stations timed out – there would be nothing to prevent the tie from repeating.

Simple linear backoff would not break as badly. But, it would do a lot less than exponential backoff to spread the bursts out into the quiet times – it wouldn't pull the transmissions out as far as fast.

6) Consider the design of a 1Gbps CSMA/CD protocol for use over a copper-cable run with a maximum length of 1km. Assume that signals propagate through the cable at a rate of 0.7c, a.k.a. 210,000km/s. What is the minimum frame size? How do you know?

The round trip time is $4.76 \times 10^{-6}s = 1km/210{,}000km/s$
This means that the cable is 4762 bits long $= 1Gbps \times 4.76 \times 10^{-6}s$
So, the round trip distance is 9523 bits
…the frame size must be at least this, or collisions can't be heard during transmission, a requirement for collision detection.

7) Now, repeat question #6, but assume the protocol is CSMA, but does **not** involve *collision detection*.

No collision detection means no minimum frame size – we don't need to listen while transmitting.

8) In class, one detail of link layer protocols, including Ethernet, that we never mentioned is the *inter-frame gap*. Senders are required to pause between sending frames. This pause results in this gap between frames – they are not back-to-back. In some sense, this wastes valuable network time. What is the purpose of this gap?

This gap was designed to give the receiver time to process one frame before having to process the next.

9) The Ethernet standard dates back to the early 1970s. The specification is for an inter-frame gap of 96 bit-time, which is the amount of time it takes to send 96 bits. Several things have evolved in computers and networks since then. If the standard were developed from a "blank slate" today, do you think this delay would be the same or larger or smaller? Why? In answering, we are most concerned with the factors that you are considering and how they fit into your model – not you ultimate assessment.

The two major factors are the processing power and memory speed on the interface and the speed of the network. The increase in processor/memory speed favors a smaller gap. The increase in bit-rate favors a larger gap. This is as much of an answer as we graded.

Interesting in my mind is that processor power has increased about 200x and memory speeds about 12x(but seemingly more, given caching improvements). The bit rate has increased 1000x.

10) Neither Ethernet, nor similar CSMA/CD protocols, are commonplace on fiber optic media. Why?

Light travels in one direction. It is inherently point-to-point, not broadcast.