**Assorted Numerical Problems on Computer Data Networks**

**Chapter 1:**

*1. A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, a h-byte header is attached. What fraction of the network bandwidth is filled with headers?*

**Fraction of the network bandwidth is filled with headers:**

From the given data, a system contains n-layers protocol hierarchy and “h” bytes of data are added at each layer.

• So the total number of header bytes is https://media.cheggcdn.com/study/ff8/ff8efaf5-a456-41e0-a233-431f470f9082/13319-1-16P-i1.png; therefore, the space wasted on the headers of the layers is https://media.cheggcdn.com/study/6f9/6f915a10-9e48-4b10-aaa2-4d20c88c1bc0/13319-1-16P-i2.png.

• Each message generated by the application is M-bytes long; so add “M” with total number of header bytes.

o Thus, the total message size is https://media.cheggcdn.com/study/c34/c34759e4-5aca-44ba-9d26-9b1a97400fba/13319-1-16P-i3.png.

• Divide the total number of header bytes by total message size to calculate the fraction of bandwidth wasted on headers.

https://media.cheggcdn.com/study/d35/d3599a23-a003-415e-a285-f118d0d5eb39/13319-1-16P-i4.png

*2.* *A factor in the delay of a store-and-forward packet-switching network is how long it takes to store and forward a packet through a switch. If switching time is 10micro-sec, is this likely to be a major factor in the response of a client-server system where the client is in New York and the server is in California? Assume the propagation speed in copper and fiber is 200,000 km/second, or 200 m/micro-second, and the distance between New York and California is 5000 km.*

The speed of propagation being 200,000 km/sec means that in 10 micro-sec, a signal can travel 2 kms. Even if we have 50 switches in the path between the client and the server, we are looking at an equivalent of 100kms of extra path to be covered. This is 2% of the total distance (of 5000kms) to be covered. So it may not be considered as a huge overhead!

*3. A client-server system uses a satellite network, with the satellite at a height of 40,000km. What is the best case delay in response to a request?*

The network protocol of such a message exchange requires the request to cover a roundtrip distance of 80,000 kms and same with the response. Therefore with a total of 160,000 kms to be covered and the speed of light in air being 300,000 km/sec, the time taken to traverse a distance of 160,000 kms will be secs = .533 secs = 533 msecs

*4. The total number of bits a link can carry at one time is the bandwidth-delay  
product. The delay of a link is its length m divided by the propagation speed s, so the  
bandwidth delay product is R ·m/s  
  
The width of each bit is the length of the link divided by the number of bits it can carry, so = s/R*

**Chapter 2:**

*1. A noiseless 4-Khz channel is sampled every 1 msec. What is the maximum data rate?*



*2. Television channels are 6MHz wide. How many bits/sec can be sent over if 4-level digital signals are used? Assume a noiseless channel.*

Nyquists MDR = 2H lg V bps = 2\*6\*106\*lg (22) bps = 2\*6\*106\*2 bps = 24\*106 bps = 24Mbps

*3. If a binary signal is sent over a 3-Khz channel whose SNR is 20dB, what is max achievable MDR?*

20 dB = 10 log10 (S/N) -> Therefore raw S/N = 100

Shannon’s MDR = H\*log2 (1+ S/N) bps = 3\*103\* log2 (101)bps ~ 3\*103\* log2 (210)bps ~ 3\*103\* 10 bps ~30Kbps

Calculate for Nyquist too!

*4. 10 signals each requiring 4000Hz are multiplexed on to a single channel using FDM. How much minimum bandwidth is required for the multiplexed channel assuming guard bands are 400 Hz wide?*



*5. Compare the delay in sending an x-bit message over a k-hop path in a circuit switched network and in a lightly loaded packet switched network. The circuit set-up time is s-secs, the propagation delay is d-secs per hop, the packet size is p-bits and the data rate is b-bps. Under what conditions does the packet network have a lower delay?*

