SYSC4700 Winter 2011 Term Exam Solutions

Question 1 [18 points] – Acronyms

a) MPLS: Multiprotocol Label Switching
b) FDMA: Frequency Division Multiple Access
c) POTS: Plain Old Telephone Service (or System)
d) CDMA: Code Division Multiple Access
e) VoIP: Voice over IP (Internet Protocol)
f) ATM: Asynchronous Transfer Mode

Question 2 [39 marks] – Short Questions

a) The smart grid is the fusion of telecommunications and informatics with the power/electricity grid.
b) Benefits of the smart grid:
    a. Saves energy/Helps to manage consumption
    b. Reduces costs
    c. Improves reliability of the system
    d. Improves the way electricity is routed (intelligent switches along power lines)
    e. Establishes two-way communications between hydro companies and consumers to improve the management of electricity and make it dynamic, in real-time
    f. Helps to integrate more types of electricity generators into the grid: Wind turbines, diesel, photo-voltaic cells, etc.
    g. Improves safety and security: Monitors and controls power substations, transformers, transmission lines, etc.
c) Names of the following layers in the 7-layer OSI model:
    a. Layer 1: Physical
    b. Layer 2: Data Link
    c. Layer 3: Network
d) Three reasons why businesses prefer IP over TDM:
    a. Easier and cheaper maintenance: Integration of data and voice onto one network
    b. Lower operating costs: Integration of remote offices over a common corporate data network, rather than through PSTN. Single Dial Plan.
    c. Access from anywhere: Power users such as Teleworker and sales 'Road Warrior'. Global Access
    d. Lower product costs: Integration of a voice application onto a central server, e.g. voice mail, means reduced number of devices. The remote sites no longer need their own local VM.
    e. Security and resiliency: In NY (September 11th) the IP infrastructure kept running; the PSTN didn't
    f. Future applications will be data centric, e.g. "Presence"
    g. Displacement of current TDM systems and businesses

e) Most common signalling protocol for VoIP: **SIP (Session Initiation Protocol)**
f) What is the main cause for delay in VoIP networks when compared to conventional wired telephone networks (which are TDM based)?

From slide 39 of the VoIP lecture: The largest contributor to delay is the jitter buffer. The second-largest contributor is packetization (i.e. accumulation) delay: the time taken to fill a packet with encoded speech. All other delays are relatively minor.

The purpose of a jitter buffer ("leaky bucket") is to compensate for jitter. Jitter is the variation in delay when receiving voice packets. The variation in delay happens due to statistical multiplexing in packet-switched networks, where resources are shared and therefore can never be guaranteed for any particular user. In contrast, circuit-switched (TDM) telephone networks provide guaranteed resources to each user at regular, fixed time intervals. Therefore, variation in delay is not a concern in TDM networks.

A jitter buffer, while removing jitter from the packet stream, introduces the largest source of delay in VoIP.

g) What are the three steps in pulse code modulation (PCM)?
    a. Sampling (Filtering was also accepted as a correct answer for the first step)
    b. **Quantizing**
    c. **Encoding**

Question 3 [30 marks] – Power Calculations in Wireless Communications

$$P_{tA} = P_{tb} + 5\ db$$

$$P_{tA} = P_{tb} * 10^{0.5} = 3.16 * P_{tb}$$

Assume distance between the user and BS_A is x, since the distance between the two BSs is 1500, then the distance between the user and BS_B is $1500 - x$

$$P_{rA} = P_{tA} * \left(\frac{\lambda}{4\pi}\right)^2 * \frac{1}{x^{3.5}} = P_{tb} * 10^{0.5} * \left(\frac{\lambda}{4\pi}\right)^2 * \frac{1}{x^{3.5}}$$

$$P_{rB} = P_{tB} * \left(\frac{\lambda}{4\pi}\right)^2 * \frac{1}{(1500 - x)^{3.5}}$$

$$At\ the\ handoff\ point\ P_{rA} = P_{rB}$$

$$P_{tB} * 10^{0.5} * \left(\frac{\lambda}{4\pi}\right)^2 * \frac{1}{x^{3.5}} = P_{tB} * \left(\frac{\lambda}{4\pi}\right)^2 * \frac{1}{(1500 - x)^{3.5}}$$

$$10^{0.5} * \frac{1}{x^{3.5}} = \frac{1}{(1500 - x)^{3.5}}$$

$$10^{0.5} = \frac{x^{3.5}}{(1500 - x)^{3.5}} = \left(\frac{x}{(1500 - x)}\right)^{3.5}$$

Take log both sides:

$$0.5 * \log 10 = 3.5 * \log \frac{x}{(1500 - x)}$$

Divide both sides by 3.5

$$1/7 = \log \frac{x}{(1500 - x)}$$

Take inverse log (10^)

$$10^{1/7} = \frac{x}{(1500 - x)}$$

$$(1500 - x) * 10^{1/7} = x$$

$$1500 * 10^{1/7} = x\,(1 + 10^{1/7})$$

$$x = \frac{1500 * 10^{1/7}}{(1 + 10^{1/7})} = 872.2508\ meters$$

Question 4 [25 marks] – High Quality Audio through Wireless

a)

65536-level quantizer → 16 bits/sample/channel

48KHz sampling rate → 48000 samples/second

(8 channels)*(16 bits/sample/channel) = 128 bits/sample

Rate = (128 bits/sample) * (48000 samples/second) = 6114000 bits/second = **6.114 Mbps**

b)

Assuming a spectral efficiency of 1 sym/sec/Hz:

$R = B*\log_2 M$

So, $B = R/\log_2 M$

For 16-QAM, M = 16 so $\log_2 M = 4$

B = (6.114 Mbits/second) / (4 bits/sec/Hz) = **1.536 MHz**