ITS323 – Practice 2

Introduction to Data Communications, Semester 1, 2012

Prepared by Steven Gordon on 31 July 2012
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Question 1 [6 marks]

You have a twisted pair Ethernet LAN cable connecting two computers directly together. The NICs in each computer support a data rate of 100Mb/s. You have a 1GB file to transfer from one computer to the other using TFTP. TFTP, which uses UDP as a transport protocol, adds a 4B header to each message. Each message carries 512 Bytes of data. Assume packets are sent as fast as possible, ignoring an acknowledgments or other (non-header) overheads.

(a) Draw a protocol stack, labelling each layer, for one of the computers.

Answer. *TFTP*

UDP

IP

(IEEE 802.2 Logical Link Control)

IEEE 802.3 Ethernet MAC

IEEE 802.3 Ethernet PHY

(b) How long does it take to transfer the file?

Answer. *Data can be sent by the Physical layer across the cable at a rate of 100Mb/s. The 1GB file must be sent, as well as all the headers (and trailers) added by the protocols in the stack. The application layer protocol, TFTP, divides the 1,000,000,000 Bytes into messages no larger than 512 Bytes. Hence there are 1,953,125 messages. TFTP adds a 4 Byte header to each message and delivers them, one after another, to the transport layer protocol, UDP. UDP adds a 8 Byte header to each message, creating a segment with 512 Bytes of data and 12 Bytes of header (TFTP 4 Bytes; UDP 8 Bytes). Each segment is sent to the network layer protocol, IP, which adds a 20 Byte header. IP sends each datagram (now 512 Bytes of data and 32 Bytes of header) to the IEEE 802.3 Ethernet MAC which adds a 14 Byte header and 4 Byte trailer. Each 562 Byte frame is sent to the Physical layer protocol, IEEE 802.3, and transmitted one after another across the link at a rate of 100Mb/s. (We have assumed that the physical layer protocol adds not headers—this is not always a valid assumption).*

There are 1,953,125 frames, each with 562 Bytes of data, to be sent at a rate of 100 Mb/s. Therefore it takes 87.8125 seconds to transfer the file. Comparing the file sent against the total number of bytes sent, the efficiency of the data transfer is 91.10%.

(c) If the NICs supported Gigabit Ethernet, what is the throughput of the file transfer?

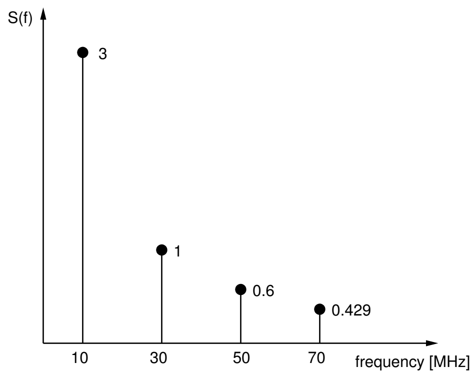
Answer. *As in part (b), there are 1,953,125 frames, each with 562 Bytes of data to be sent. This time the data rate is 1Gb/s. The time to transfer the file is 8.78125 seconds. This efficiency is still 91.10%. The throughput is 911.032Mb/s.*

Question 2 [2 marks]

A device transmits a signal with power of 20dBm. The signal passes through a 17dB amplifier. The cabling from transmitter to receiver (via the amplifier) has a loss of 3dB. What is the receive power?

Answer. $P_{rx} = 20dBm + 17dB - 3dB = 34dBm = 10^{3.4}mW = 2.512W$

Question 3 [4 marks]



(a) What is the signal bandwidth?

Answer. *The signal has components with frequencies 10, 30, 50, and 70 MHz. The bandwidth is therefore 70-10 = 60MHz.*

(b) What is the signal period?

Answer. *Each component is a multiple of 10MHz. The fundamental frequency, and therefore signal frequency is 10MHz. The period is the inverse of the frequency, i.e. 0.1us.*

(c) Write an equation for the signal in the time domain.

Answer. $s(t) = 3\sin(20 \times 10^6 \pi t) + \sin(60 \times 10^6 \pi t) + 0.6\sin(100 \times 10^6 \pi t) + 0.429\sin(140 \times 10^6 \pi t)$

Question 4 [2 marks]

An encoding scheme maps 8 bits of digital data into 1 signal element.

(a) In a noise-free environment with a bandwidth of 10MHz, what is the maximum theoretical data rate possible? [3 marks]

Answer. *With 8-bits to 1 signal element, 256 different levels (signal elements) are needed to represent any sequence of bits. Therefore with Nyquist capacity:* $C = 2B\log_2(M) = 2 \times 10 \times 10^6 \times \log_2(256) = 160Mb/s$

(b) If the level of noise was measured to be -27dBm and the received signal strength of 2.041mw for a communications channel with bandwidth of 10MHz, what is the maximum theoretical data rate possible?

Answer. *A noise level of -27dBm is equivalent to* $10^{-2.7}$ mW*. Therefore using Shannon capacity:* $C = B\log_2(1SNR) = 10 \times 10^6 \times \log_2(1 + \frac{10^{-2.7}}{2.041}) = 100Mb/s$

(c) In the noisy channel of part (b) what is the number of bits per signal element needed to achieve the maximum theoretical data rate?

Answer. *Here we make some approximations. Even though we know the channel has noise, we will apply Nyquist's capacity equation to determine the number of levels needed.*

$C = 2B\log_2(M)$

$100 \times 10^6 = 2 \times 10 \times 10^6 \log_2(M)$

Therefore $M = 32$*. We need 32 levels, i.e. 5 bits per signal element.*