

## ECE 361 Midterm Solution

### Problem 1.

- 1) Click in browser application.
- 2) Initiating HTTP
  - Need TCP
  - DNS (Cached or contact DNS server)
  - TCP setup (three-way hand-shake)
    - SYN signal
    - IP packet {src: (2,2), dest: (1,1), protocol type}
    - (ARP)
    - Ethernet (p, r2)
    - Physical layer
    - Ethernet @ router
    - Needs routing
    - Ethernet (r1, s)
    - Physical
    - Ethernet @ server
    - IP
    - TCP (SYN, ACK)
  - Second handshake
  - Third handshake
- 3) HTTP GET
  - Pass to TCP
  - Form IP packet and ...
- 4) Server prepare 200 OK
  - Pass to TCP
  - Form IP packet and ...
- 5) Server send file
  - Multiple segments ...
- 6) Display Image

### Problem 2.

**2a.**

*Determine the maximum bit rate*

less than 100MHz      5V → 2V  
greater than 100MHz    5V → 0V

Therefore we have  $2 \times 100\text{M} = 200\text{M}$  symbol per second

Since there are  $16 = 2^4$  levels  
We have 4 bits per symbol.

In short, we have a system with  $200\text{M}$  symbol/second  $\times$  4 bits/symbol = **800Mbps**

*Determine the maximum amplitude of the noise that can be handle by the receiver*

The received signal can be in the range of  $-2\text{V}$  to  $+2\text{V}$

We divide this range into 16 levels.

The voltage difference between two consecutive levels is  $[2\text{V} - (-2\text{V})]/16 = 0.25\text{V}$

If the noise amplitude is smaller than half of this difference i.e  $(0.25\text{V}/2 = \mathbf{0.125\text{V}})$ , the receiver can decode the signal correctly.

**2b.**

<i>Layer</i>	<i>error correction/detection scheme</i>	<i>number of bits</i>
Network Layer		500 bits
Data Link layer	add 32bits CRC	532bits
Physical Layer	$2 \times$	1064 bits

For every 500 bits, you have to transmit 1064 bits

Therefore, the information bit rate is  $(500/1064) \times 800\text{Mbps} = \mathbf{376\text{Mbps}}$

**2c.**

Each user requires a bit rate of 25Mbps.

Therefore, the *total number of user supported by the system* is  $376\text{M}/25\text{M} = \mathbf{15}$ .

Each user requires a bit rate of 25Mbps.

Each user will transmit the video in bursts of 1Mbit of video content at a time.

Therefore we require 25 frames in one second.

i.e. A frame occupies  $1/25 = 0.04$  second

Since the raw bit rate of the channel is 800Mbps.

The size of a frame is  $0.04\text{s} \times 800\text{Mbps} = \mathbf{32\text{Mbit}}$

Verify: Since there are 15 users, the number of information bits in a frame is 15Mbits

After coding, the number of bits transmitted is  $15\text{Mbits} \times (1064/500) = 31.42 \text{ Mbit}$ , which is smaller than the derived frame size. Thus, it is fine.

**2d.**

We have bandpass channel of bandwidth of  $B$  MHz.

Therefore we have  $B$  M symbol per second (not  $2B$  M symbol per second in this case)

Again,  $16 = 2^4$  constellation points give us 4 bits per symbol.

So, the system can support a bit rate of  $4B$  bps.

The required bit rate is 40Mbps  $\rightarrow$  **B = 10MHz**

We have 100MHz of bandwidth, and each user uses 10MHz of bandwidth, the **maximum number of user handled by the system = 10**

### **Problem 3.**

(a)

Number of frames:  $500 * 10^6 * 8 / 1000 = 4 * 10^6$

Propagation Distance =  $d = 10 * 10^3$  meters

Propagation Speed =  $c = 3 * 10^8$  meters/second

Transmission rate =  $R = 15 * 10^6$  bits/second

Processing Delay =  $t_{proc} = 50 * 10^{-6}$  seconds

$t' =$  time to send frame + receive ACK

$$= 1032/R + 50/R + 2*d/c + t_{proc}$$

$$= 188.8 * 10^{-6} \text{ seconds}$$

$t_o =$  time to send entire file

$$= (\text{Number of frames}) * t'$$

$$= 755.2 \text{ seconds}$$

(b)

Probability of failure =  $P_{fail} = 0.2$

Number of frame transmissions before success =  $1/(1-P_{fail}) = 1/0.8$

Therefore, expected amount of time to transmit file =  $t_o/0.8$

(c)

Using Selective Repeat the approximate time to transmit a file without errors is

$$t_o = 500 * 8 * 10^6 / (15 * 10^6) = 266.67 \text{ seconds}$$

With errors, the time increases to

$$t_o / 0.8$$

(d)

We can have hop-by-hop and end-to-end ARQ protocols running using data link layer and transport layer respectively. So there are five different ARQ protocols that could be operating:

A-C, A-C', C-B, C'-B (data link layer) + A-B (transport layer)