Review Questions

R11) R_1 = Transmission Rate Between the Sending Host and the Switch

R_2 = Transmission Rate Between the Switch and the Receiving Host

(bps)

- Exactly one Packet Switch
- Store and Forward Packet Switching

d_{trans} = Total end-to-end delay to send a packet = ?

L = length of packet (bits)
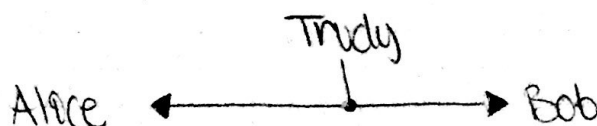
$d_{trans} = \dfrac{L}{R}$ (definition)

$d_{trans} = \dfrac{L}{R_1} + \dfrac{L}{R_2} = \boxed{\dfrac{L(R_1 + R_2)}{R_1 R_2}}$

$\underset{\substack{\text{delay} \\ \text{through the first} \\ \text{transmission}}}{\nearrow}$ + $\underset{\substack{\text{delay} \\ \text{through the second} \\ \text{transmission}}}{\nearrow}$ = $\underset{\substack{\text{delay through the} \\ \text{entire process/} \\ \text{transmission occurring}}}{}$

R28)

Trudy

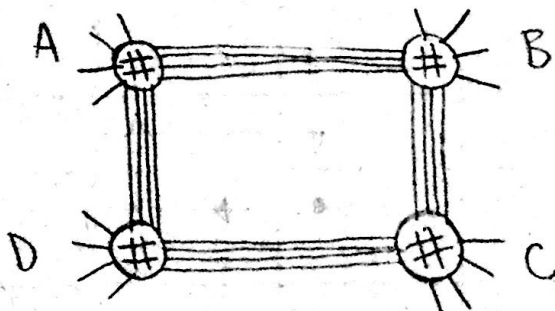Alice $\longleftrightarrow$ Bob

- Trudy able to capture what is being sent and she can send whatever she wants

Malicious Things Trudy Can Do:

· IP Spoofing : Send packets with false addresses

· Packet "Sniffing" : Broadcast media, Reads/Record all packets passing by/being sent

Problems

P4) Circuit-Switched Network (Figure 1.13)

A — B
D — C

- A simple circuit-switched network consisting of four switches and four links

a) 4 links between each pair of switches, so 4 links for each 4 pairs of switches...   Movement in one-direction through the network here

$4 \times 4 = \boxed{16 \text{ Maximum Simultaneous Connections}}$

b) 4 Connections from A → B → C
And another...
4 Connections from A → D → C

4 + 4 = | 8 Maximum Simultaneous Connections |

c) <u>Yes, we can route these calls</u>:

- 4 connections between A and C
- 4 connections between B and D

through the four links to accommodate all eight connections.

For between switches A and C:

2 connections from A → B
2 connections from B → C
and...
2 connections from A → D
2 connections from D → C

For between switches B and D:

2 connections from B → A
2 connections from A → D
and...
2 connections from B → C
2 connections from C → D

So when combined for the overview of what's happening/connected...

2 connection from A → B
4 connections from A → D
4 connections from B → C
2 connections from B → A
2 connections from D → C
2 connections from C → D

P8) 3 Mbps Link   Each user only transmits
150 Kbps Transmitting   10% of the time

a) $\dfrac{3 \text{ Mbps}}{150 \text{ Kbps}} = \dfrac{3000 \text{ Kbps}}{150 \text{ Kbps}} = $ | 20 users | when circuit-switching is used

b) "Each user transmits only 10 percent of the time"

$$P(\text{Given user is transmitting}) \cdot 0.1$$

c) $n = 120$ users $p = 0.1$

Binomial Distribution:

$$P(x) = \left(\frac{n!}{(x! \, (n-x)!}\right) p^x \cdot (1-p)^{n-x}$$

$$P(x=n) = \left(\frac{120!}{(n! \, (120-n)!}\right) (0.1)^n \cdot (1-0.1)^{120-n}$$

$$\boxed{P(x=n) = \left(\frac{120!}{(n! \, (120-n)!}\right) (0.1)^n (0.9)^{120-n}}$$

d) $P(x \geq 21) = ?$

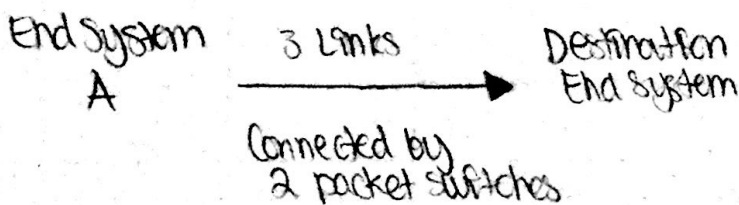$$P(x=21) = \left(\frac{120!}{(21! \, (120-21)!}\right) (0.1)^{21} (0.9)^{120-21}$$

$$P(x=21) = \left(\frac{120!}{(21! \, (99)!}\right) (0.1)^{21} (0.9)^{99}$$

$$P(x=21) = 0.00414$$

So...

$$\boxed{P(x \geq 21) \text{ less than or equal to } 0.00414}$$

P10) Packet of length = L

End System   3 Links   Destination
    A   ———————————▶   End System

Connected by
2 packet switches

Length = d_i
Propagation Speed = s_i

Transmission Rate of Link i = R_i $i = 1, 2, 3$

Packet Switch Delays Each Packet = d_{proc}

No Queuing Delays

Total End-to-End Delay for the Packet?

$d_{nodal} = d_{proc} + \cancel{d_{queue}} + d_{trans} + d_{prop}$

$$d_{trans} = \frac{L}{R}$$
$$d_{prop} = \frac{d}{S}$$

$d_{trans_1} + d_{prop_1} + d_{proc} + d_{trans_2} + d_{prop_2} +$

$d_{proc} + d_{trans_3} + d_{prop_3} = d_{total}$

$$d_{total} = \frac{L}{R_1} + \frac{d_1}{S_1} + d_{proc} + \frac{L}{R_2} + \frac{d_2}{S_2} + d_{proc} + \frac{L}{d_3} + \frac{d_3}{S_3}$$

$$\boxed{d_{total} = 2\, d_{proc} + L\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) + \frac{d_1}{S_1} + \frac{d_2}{S_2} + \frac{d_3}{S_3}}$$

$L = 1500 \text{ bytes} = 12000 \text{ bits}$

$S = 2.5 \times 10^8 \text{ m/s}$

$R = 2 \text{ Mbps} = 2 \times 10^6 \text{ bps}$

$d_{proc} = 3 \text{ msec} = 3 \times 10^{-3} \text{ s}$

$d_1 = 5 \times 10^6 \text{ m}$
$d_2 = 4 \times 10^6 \text{ m}$
$d_3 = 1 \times 10^6 \text{ m}$

$$d_{total} = 2(3\times10^{-3}) + (12000)(3)\left(\frac{1}{2\times10^6}\right) + \left(\frac{1}{2.5\times10^8}\right)(5+4+1)(10^6)$$

$$\boxed{d_{total} = 0.064 \text{ s}}$$

P33) F bits   Host A → Host B   - 3 Links
                ↳ Segments of   - 2 Switches
    R = R bps   S bits each   - No Queuing Delays (d_{queue})
                  + 80 bits   - Disregard Propagation Delay
                Packets → L = 80 + S bits   (d_{prop})

S = ? bits to minimize the delay of the moving file

Number of Packets = $\frac{F}{S}$ L = 80 + S bits

First calculating the overall delay.

To get the first packet through along with the idea that every packet after the first reaches to Host B every $\frac{S+80}{R}$ seconds:

$$3\left(\frac{L}{R}\right) + \left(\frac{F}{S} - 1\right)\left(\frac{L}{R}\right) = \text{Total Delay}$$

$$3\left(\frac{80+S}{R}\right) + \left(\frac{F}{S} - 1\right)\left(\frac{80+S}{R}\right)$$

$$\left(\frac{80+S}{R}\right)\left(3\left(\frac{F}{S} - 1\right)\right)$$

$$\left(\frac{80+S}{R}\right)\left(\frac{F}{S} + 2\right) \to$$ Now use this delay formula in order to find where on its graph the value of the equation is the smallest.

- So one way, is where the slope = 0, by making the derivate of the equation equal to zero in terms of S.

$$\frac{d(\text{total delay})}{dS} = \frac{80F}{SR} + \frac{8F}{8R} + \frac{160}{R} + \frac{2S}{R}$$

$$= \left(\frac{80F}{R}\right)\left(\frac{1}{S}\right) + \frac{F}{R} + \frac{160}{R} + \left(\frac{2}{R}\right)(S)$$

$$= \left(\frac{80F}{R}\right)(S)^{-1} + 0 + 0 + \left(\frac{2}{R}\right)(S)$$

$$\frac{\left(\frac{2}{R}\right)}{\left(\frac{80F}{R}\right)} = \frac{-\left(\frac{80F}{R}\right)(S)^{-2}}{-\left(\frac{80F}{R}\right)} + \frac{\left(\frac{2}{R}\right)}{-\left(\frac{2}{R}\right)}$$

$$\frac{2R}{80FR} = (S)^{-2} \quad \to \quad \frac{1}{S^2} = \frac{2}{80F} \quad \to \quad \frac{1}{S^2} = \frac{1}{40F}$$

$$\sqrt{S^2} = \sqrt{40F} \qquad \boxed{S = \sqrt{40F}} \quad \text{(bits)}$$

Additional Questions

$R = R$ bps
$L = L$ bits

Packet Arrival Rate = A packets/s
Traffic Intensity = $I = \frac{L \cdot A}{R}$

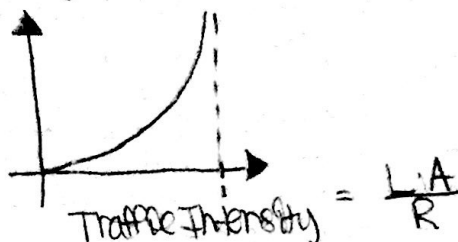a) $d_{\text{queue average}} = ?$ when $I > 1$ and $I \leq I$

$R = R$ bps
$L = L$ bits
$I = \frac{L \cdot A}{R}$

$\left(\frac{\text{bits ahead}}{\text{rate}}\right) = $ queueing delay

$\frac{L \cdot A}{R} \rightarrow 1$: delay become large

$\frac{L \cdot A}{R} > 1$: more "work" arriving than can be serviced, average delay infinite!

Average Queueing Delay

Traffic Intensity $= \frac{L \cdot A}{R}$

b) $d_{total\ average} = d_{queue\ average} + d_{trans\ average}$

$d_{trans} = \frac{L}{R}$

$d_{total\ average} = d_{queue\ average} + \frac{L}{R}$