

1) a)  $X$  = the number of times sender transmits a packet for it to be acknowledged.

$$E[X] = \sum_i P(X > i) = 1 + (1-\alpha) + (1-\alpha)^2 + \dots = \frac{1}{1-\alpha} = \frac{1}{\alpha}$$

Where  $\alpha = \underbrace{(1-p)^n}_{P(\text{pkt gets to n})} \underbrace{(1-p)}_{P(\text{ACK gets to sender})} = (1-p)^{n+1}$

$$\therefore E[X] = \frac{1}{(1-p)^{n+1}}$$

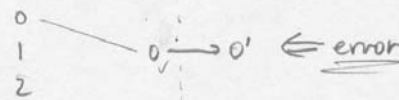
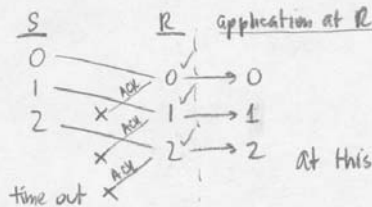
eg.  $P(X > 2) = \underbrace{(1-\alpha)}_{P(\text{sender does not receive ACK 1st time})} \underbrace{(1-\alpha)}_{P(\text{sender does not receive ACK 2nd time})} \cdot 1$

b)  $\alpha = (1-p)^{n-i+1}$   $\therefore$  from above,  $\frac{1}{\alpha} = (1-p)^{-n+i-1}$

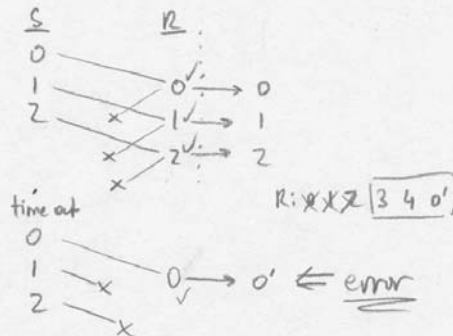
$P(\text{pkt gets from } i \text{ to } n \text{ and ACK gets to sender})$

c) max rate =  $\frac{W}{T}$  pkts/unit time (this is Little's Law)

2) a) S: [0 1 2] 0' 1' 2'  
R: [0 1 2] 0' 1' 2'  
 $w=3$   $m=w=3$



b) S: [0 1 2] 3 4 0' 1' 2'  
R: [0 1 2] 3 4 0' 1' 2'  
 $w=3$   $m=2w-1=5$



3) a) worst case for GBN: all pkts are received but the first  
 $X$  = the number of transmissions

GBN:  $E[X] = w \cdot (1 + p_1 + p_1^2 + \dots) = w \cdot \frac{1}{1-p_1}$

$\nwarrow$  GBN sends whole window

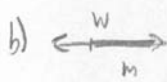
SR:  $E[X] = 1 \cdot (1 + p_2 + p_2^2 + \dots) = \frac{1}{1-p_2}$

$\nwarrow$  SR just sends packet

$$3) a) \frac{w}{1-p_1} < \frac{1}{1-p_2}$$

$$-p_1 > w(1-p_2) - 1$$

$$\underline{p_1 < 1 - w(1-p_2)}$$



SR:  $E[N] = m(1-p_2)$    
pkts sent P(getting through)

$$E[S] = m \quad \frac{E[N]}{E[S]} = 1 - p_2$$

$$GBN: E[N] = m(1-p_1)$$

$$E[S] = w \quad \frac{E[N]}{E[S]} = \frac{m(1-p_1)}{w}$$

GBN sends whole window

if  $\frac{m(1-p_1)}{w} > 1 - p_2$  then use GBN (minimizes the number of transmissions)

$$\underline{m > (1-p_2)w / (1-p_1)}$$