Digital Communication I

Q1

psq3
IML

a) send p bits every $2\tau + \frac{P}{B}$

$\therefore$ throughput is $\frac{P}{2\tau + P/B} = \frac{B}{2\tau\frac{B}{P} + 1}$

b) ~~succ~~ no retrans $(1-\epsilon)\left[2\tau + \frac{P}{B}\right]$

1 retrans, $\epsilon(1-\epsilon)\left[\frac{P}{B} + T + 2\tau + \frac{P}{B}\right]$

2 retrans, $\epsilon^2(1-\epsilon)\left[\frac{P}{B} + T + \frac{P}{B} + T + 2\tau + \frac{P}{B}\right]$

$\therefore$ expected time for one packet is

$$2\tau + \frac{P}{B} + \sum_{i=0}^{\infty} (1-\epsilon)\epsilon^i \left(\frac{P}{B} + T\right) i$$

$$\simeq 2\tau + \frac{P}{B} + \epsilon\left(\frac{P}{B} + T\right)$$

$\therefore$ throughput is approx

$$\frac{P}{2\tau + (1+\epsilon)\frac{P}{B} + \epsilon T} = \frac{B}{\frac{B}{P}(2\tau + \epsilon T) + 1 + \epsilon}$$

This assumes timeout starts after packet is transmitted

c) FEC reduces ϵ, therefore increases throughput (must consider effect on B though)

d) ratio of data size to code size (ie rate of sending data compared to coded data)

e) $\epsilon_{new} = \epsilon^2$, $B_{new} = rB$ where r is code rate.

new throughput is

$$\frac{rB}{\frac{rB}{P}(2\tau + \epsilon^2 T) + 1 + \epsilon^2} \simeq \frac{rB}{\frac{rB}{P}2\tau + 1}$$

$$\therefore \frac{rB}{\frac{rB}{P}2\tau + 1} \geqslant \frac{B}{\frac{B}{P}(2\tau + \epsilon T) + 1 + \epsilon}$$

$$r\left[\frac{B}{P}(2\tau + \epsilon T) + 1 + \epsilon\right] \geqslant \frac{rB}{P}2\tau + 1$$

$$\frac{B}{P}r\epsilon T + r + r\epsilon \geqslant 1$$

$$r \geqslant \frac{1}{\frac{B}{P}\epsilon T + 1 + \epsilon} \simeq \frac{1}{\frac{B}{P}\epsilon T + 1}$$

f) with delay $\Delta\tau$, throughput becomes

$$\frac{rB}{\frac{rB}{P}(2\tau + \Delta\tau) + 1}$$

, ie reduces throughput — parallel the encoding

could pipeline coder ...