[a b c d]

4.2.2.

The following ARQ protocol is considered:

- Sending frame continuously
- On rcv incorrect: nothing
- On rcv correct: sends ACK
- On rcv ACK: sender starts sending next frame continuously
- T_{Tx} and error prob. are negligible for ACKs

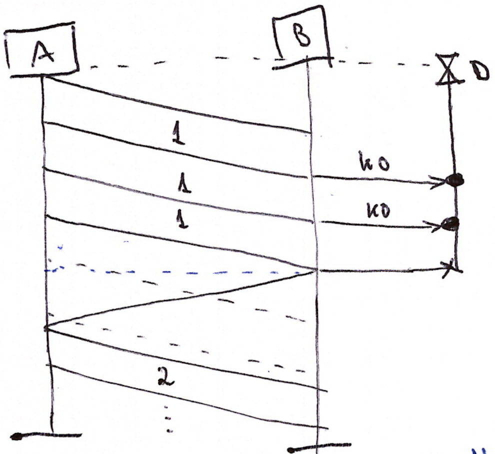
Answer:

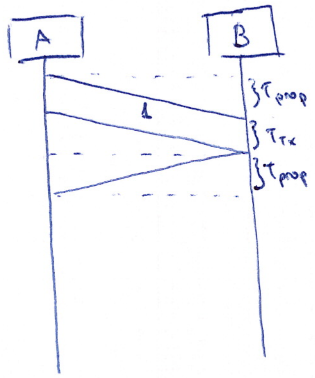
a) Calculate the efficiency of this protocol based on ~~on~~ frame error prob. P_e and on $a=\frac{T_{prop}}{T_{Tx}}$

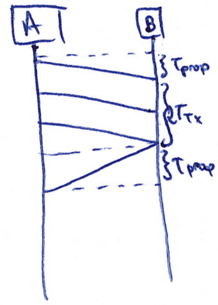
b) Is the efficiency > or < than ~~S&W~~ S&W? Reason the answer

c) ~~for~~ For which P_e is eff. > GBN?

d) Calculate avg. time from tx start of a frame until correct receipt (D)







a) $P(N_{att}=1)=\overbrace{(1-P_e)}^{\text{No err}}$; $P(N_{att}=2)=\overbrace{P_e}^{\text{err}}\overbrace{(1-P_e)}^{\text{No err}}$; $P(N_{att}=k)=P_e^{k-1}(1-P_e)$

$T_{tot}(N_{att}=1)=2T_{prop}+T_{Tx}$; $T_T(N_{att}=2)=2T_{prop}+2T_{Tx}$; $T_T(N_{att}=k)=2T_{prop}+kT_{Tx}$

$$T_{avg}=\sum_{k=1}^{\infty}P(N_{att}=k)\cdot T_T(N_{att}=k)=\sum_{k=1}^{\infty}P_e^{k-1}(1-P_e)(2T_{prop}+kT_{Tx})=(1-P_e)\left(2T_{prop}\sum_{k=0}^{\infty}P_e^{k}+T_{Tx}\sum_{k=1}^{\infty}kP_e^{k-1}\right)=$$

$$=(1-P_e)\left(\frac{2T_{prop}}{1-P_e}+\frac{T_{Tx}}{(1-P_e)^2}\right)=2T_{prop}+\frac{T_{Tx}}{1-P_e}$$

$$\eta=\frac{T_{Tx}}{T_{avg}}=\frac{T_{Tx}}{2T_{prop}+\frac{T_{Tx}}{1-P_e}}=\boxed{\frac{1}{(1-P_e)^{-1}+2a}}=\frac{1-P_e}{1+2a(1-P_e)}$$

b) It is more efficient than the equivalent system using S&W ($\mu_{SW}=\frac{1-P_e}{1+2a}$) because the $(1-P_e)$ factor in the denominator makes it smaller, making the efficiency higher. In this protocol, we remove the need for negative acknowledgement and the delays it brings.