

Problem 2 (b) answer

Consider that the sender is transmitting a single frame. Let T be the completion time (i.e., the time required to transmit a single frame.) Then,

$$(\text{throughput}) = \frac{(\text{frame size})}{E[T]}$$

where $E[T]$ is the expected value of T . Let i be the number of retransmissions. Then,

$$E[T] = RTT + \sum_{i=0}^{\infty} P_i \times T_i$$

where P_i is the probability of having i retransmissions and T_i is the time taken for i retransmissions. It is easy to see that $T_i = i \times RTT$; additional $i \times RTT$ is required for i retransmissions. Let's observe P_i (i.e., the probability of having i retransmissions) for small i .

- $P_0 = (1 - p)$ is the probability that the first frame (i.e., the initial transmission) was successfully delivered. There will be no retransmission.
- $P_1 = p(1 - p)$ is the probability that the first frame is failed (with the probability p) and the retransmission was successful.

Thus, $P_i = p^i(1 - p)$ which means up to the i -th transmissions were failed and the $(i + 1)$ -th transmission was successful. We have,

$$\begin{aligned} E[T] &= RTT + \sum_{i=0}^{\infty} P_i \times T_i \\ &= RTT + \sum_{i=0}^{\infty} p^i(1 - p)iRTT \\ &= RTT(1 + (1 - p) \sum_{i=0}^{\infty} ip^i) \\ &= RTT(1 + \frac{p}{1-p}) \end{aligned}$$

Thus,

$$(\text{throughput}) = \frac{(\text{frame size})}{RTT(1 + \frac{p}{1-p})}$$

You can use the same logic to come up with the throughput formula with the ack frame failure probability s . Do it yourself and come to ask if there are any questions. (Hint : $P_0 = (1 - p)(1 - s)$)