1 ARQ

1.1

\[ P_{\text{err}}^{\text{pkt}} = 1 - P(\text{packet is not in error}) \]
\[ = 1 - P(\text{All bits of packet are not in error}) \]
\[ = 1 - (1 - P_{\text{BER}})^{8B_1} \]

where \( B_1 \) = length of the packet in bytes

Similarly,

\[ P_{\text{err}}^{\text{ack}} = 1 - (1 - P_{\text{BER}})^{8B_2} \]

where \( B_2 \) = length of ack in bytes.

1.2

\[ P_{\text{PE}} = P(\text{single corrupt packet is received}) \times P(\text{CRC matches the packet content}) \]
\[ = P_{\text{err}}^{\text{pkt}} \times 2^{-32} \]

1.3

\[ P_{\text{suc}} = P(\text{packet received successfully}) \times P(\text{ACK received successfully}) \]
\[ = (1 - P_{\text{err}}^{\text{pkt}}) \times (1 - P_{\text{err}}^{\text{ack}}) \]

Also,

\[ P_{\text{EE}} = 1 - P_{\text{suc}} - P_{\text{PE}} \quad (1) \]
OR

\[ P_{EE} = P(\text{pkt in error}) + P(\text{pkt is correct}) \times P(\text{ack in error}) - P(\text{packet in error but accepted}) \]

\[ P_{EE} = P_{\text{pkt err}} + (1 - P_{\text{pkt err}}) P_{\text{ack err}} - P_{\text{PE}} \quad (2) \]

On simplifying (1), it can be shown (1) = (2).

1.4

No. of attempts for each frame on average

\[ N_{\text{avg}} = 1 + P_{EE} + P_{EE}^2 + \ldots \]
\[ = \sum_{i=0}^{\infty} P_{EE}^i \]
\[ = \frac{1}{1 - P_{EE}} \]

1.5

\[ P(\text{corrupt frame is accepted after several attempts}) \]

\[ P_{RE} = P_{PE} + (P_{EE} \times P_{PE}) + (P_{EE}^2 \times P_{PE}) + \ldots \]
\[ = P_{PE} \times N_{\text{avg}} \]

1.6

\[ P(\text{attempts} > N_{\text{max}}) = 1 - P(\text{attempts} \leq N_{\text{max}}) \]
\[ = 1 - ((1 - P_{EE}) + (1 - P_{EE}) P_{EE} + (1 - P_{EE}) P_{EE}^2 + \ldots \ldots + (1 - P_{EE}) P_{EE}^{N_{\text{max}}-1}) \]
\[ = 1 - (1 - P_{EE}) (1 + P_{EE} + P_{EE}^2 + \ldots + P_{EE}^{N_{\text{max}}-1}) \]
\[ = 1 - (1 - P_{EE}) \left(\frac{P_{EE}^{N_{\text{max}}-1} + 1}{P_{EE} - 1} - 1\right) \]
\[ = 1 + P_{EE}^{N_{\text{max}}} - 1 \]
\[ = P_{EE}^{N_{\text{max}}} \]
1.7

\[ P(\text{less than 10 attempts}) = 1 - P(\text{greater than 10 attempts}) = 1 - P_{EE10} \text{......from 1.6} \]

\[ = 1 - (P_{pkt} + (1 - P_{pkt})P_{ack} - P_{PE})^{10} \text{......from 2} \]

\[ = 1 - (P_{pkt} - P_{pkt}2^{-32})^{10} \text{...... from 1.2} \]

\[ = 1 - (P_{pkt})^{10}(1 - 2^{-32})^{10} \]

The graph is appears in figure 1.

Figure 1: Prob. of sending a frame in less than X attempts vs. Pkt. err. prob.