

Problem 1

Problem 2

- (a) 100000001011010000011000000100010100000011100000001
(b) 01001100000000

Problem 3

- (a) --1-011-001 \rightarrow 10100111001
(b) Syndrome: 010. The second bit is incorrect.

Problem 4

If the CRC were appended as a header, it would need to be computed before the message is sent onto the link. By attaching it to the end, we can compute the CRC while transmitting the message.

Problem 5

We can easily compute the round-trip time for a single packet-acknowledgement sequence by adding up the transmission and propagation delays (we are ignoring the processing and queueing delays):

$$\text{rtt} = d_{mt} + d_{mp} + d_{at} + d_{ap}$$

where d_{mt} is the transmission delay for the message packet, d_{mp} is the propagation delay for the packet, and likewise for the acknowledgement. We can now make the observation that transmission delay is b/C and the propagation delay for both the file packets and the acknowledgement packets is $d \cdot 5 \times 10^{-6}$. The equation now becomes

$$\text{rtt} = \frac{b}{C} + \frac{100}{C} + 10 \cdot d \times 10^{-6}$$

This is only for a single packet, but we can multiply it by the number of packets, $10^6/b$, to find the total time for the whole file.

$$\text{time} = \frac{10^6}{b} \cdot \text{rtt}$$

Total bits transmitted is the size of the file plus the number of acknowledgement bits sent: $10^6 + 10^8/b$. Assuming throughput includes bits from ACKs.

- (a) $\text{rtt} = 10^{-4} + 10^{-5} + 10^{-4}$. Now, multiply by the number of packets: $10^4 \text{rtt} = 1 + 0.1 + 1 = 2.1\text{s}$. The throughput is $(10^6 + 10^6)/2.1 \approx 952$ kbps.
(b) $\text{rtt} = 2 \times 10^{-5} + 10^{-5} = 3 \times 10^{-5}$. Multiplying by number of packets (10^4 again) yields a total time of 0.3 seconds. Throughput is $(10^6 + 10^6)/0.3 \approx 6.67$ Mbps.
(c) $\text{rtt} = 2 \cdot 10^{-4} + 2 \cdot 10^{-5}$. Multiply by number of packets, once again 10^4 , yields 2.2 seconds for the total time. Throughput is $(2 \cdot 10^6)/2.2 \approx 909$ kbps.
(d) $\text{rtt} = 2 \cdot 10^{-4} + 2 \cdot 10^{-6} + 2 \cdot 10^{-6}$. Total time is $100 \cdot \text{rtt} = 2 \cdot 10^{-2} + 4 \cdot 10^{-4} \approx 0.0204$ seconds. Throughput is $(10^6 + 10^4)/0.0204 \approx 49.5$ Mbps.