Midterm Review

Computer Networks 2025-2026

Hamming Code

You receive the following two code words:

I) 1011 0101 111
II) 0011 1001 101

Spaces are added for improved readability.

Both code words have been transmitted with a Hamming code for error correction. For each of these code words, determine if the receiver detects an error.

Hamming Code

I

```
10110101111
x x x x x x → 0
 xx  xx  xx → 0
   xxxx     → 0
       xxxx → 0
```

II

```
00111001101
x x x x x x → 0
 xx  xx  xx → 0
   xxxx     → 0
       xxxx → 1

Error in bit 8!
```

Shannon

Sort the following channels from left to right in **decreasing order** based on their maximum data rate.

1. A 8 MHz channel with a signal-to-noise ratio of 10 dB.
2. A 4 MHz channel with a signal-to-noise ratio of 40 dB.
3. A 2 MHz channel with a signal-to-noise ratio of 20 dB.

Shannon

1. 8 MHz, 10 dB → 8M × log(10) ≈ 24 Mbps
2. 4 MHz, 40 dB → 4M × log(10000) ≈ 52 Mbps
3. 2 MHz, 20 dB → 2M × log(100) ≈ 13 Mbps

2 > 1 > 3

Cyclic Redundancy Check

Consider the following messages and generator polynomials. The length of the generator polynomial is always 5:

(A) Message: 1100 0011 1101. Generator polynomial: $x^4 + x^3 + x^2 + 1$

(B) Message: 0110 1100 1001. Generator polynomial: $x^4 + 1$

What are the correct CRC check bits for both messages?

Cyclic Redundancy Check (A)

Message: 1100 0011 1101

Generator polynomial: $x^4 + x^3 + x^2 + 1 \rightarrow 11101$

```
11000011110100000
11101
  10101111010000
  11101
   1000111010000
   11101
    110011010000
    11101
      1001010000
```

```
1001010000
11101
 111110000
 11101
    100000
    11101
     11010
     11101
      0111
```

Cyclic Redundancy Check (B)

Message: 0110 1100 1001

Generator polynomial: $x^4 + 1 \rightarrow$ 10001

```
0110110010010000
 10001
  10100010010000
  10001
    101010010000
    10001
       1000010000
```

```
1000010000
10001
     110000
     10001
      10010
      10001
       0011
```

WiFi

Which of the following statements is **true**?

1. 802.11 uses a *Cyclic Redundancy Check (CRC)* to detect frame transmission errors.
2. 802.11 uses a *Network Allocation Vector (NAV)* to let other stations know for how long the channel will be occupied.
3. 802.11 uses *1-persistent CSMA* for medium access control.

Only statements 1 and 2 are true.

Collision Probability

Consider a busy channel and two stations using 1-persistent CSMA with binary exponential backoff. Both stations have a frame to send.

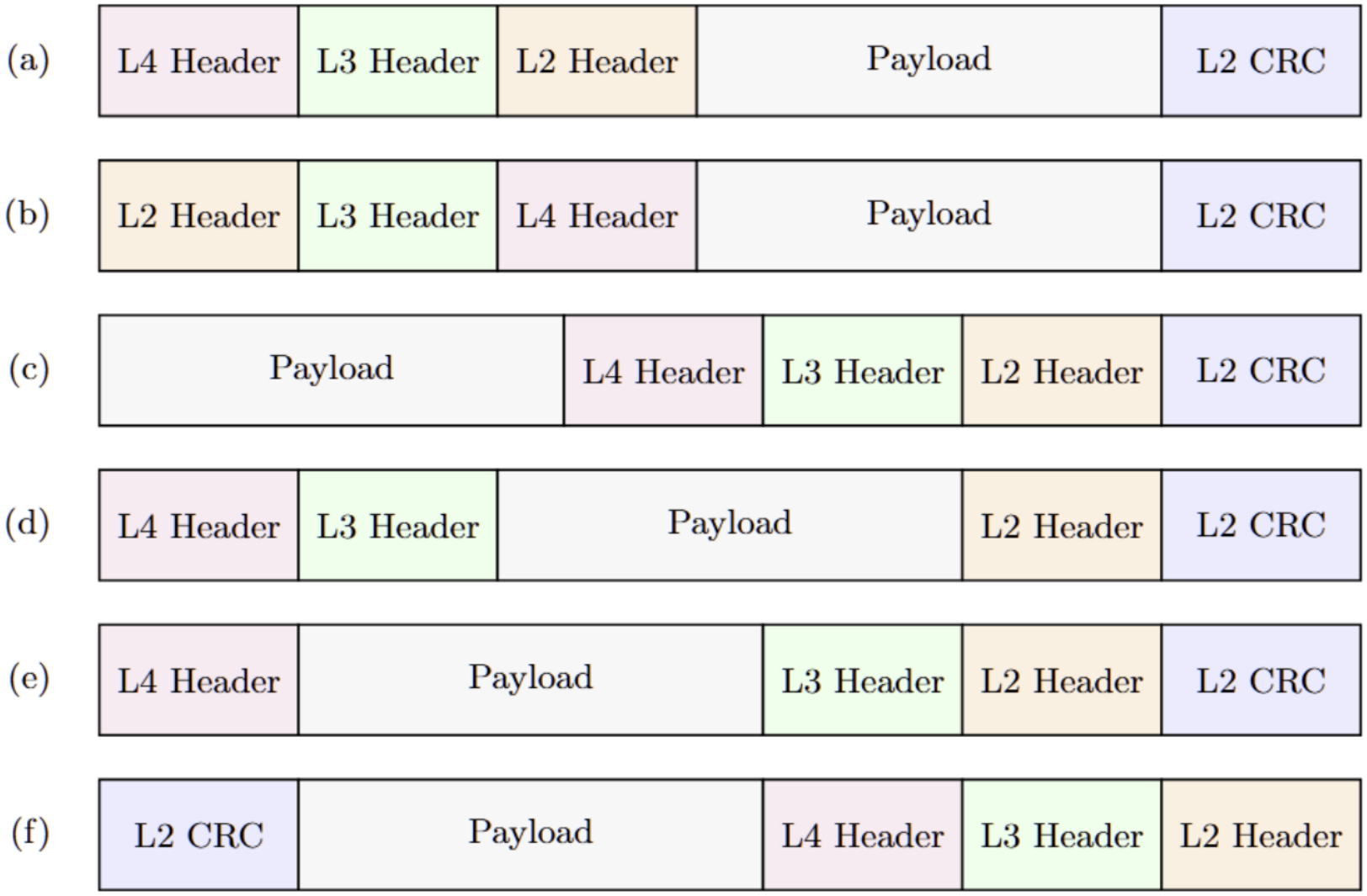
What is the probability that the contention period consists of exactly 2 collisions followed by a successful transmission on the third attempt?

1 (guaranteed collision) × ½ (2^{nd} try, window size 2) × ¾ (3^{rd} try, window size 4) = ½ × ¾ = 3/8

Layers

Which of these figures (a-f) shows the correct order in which bits are sent over the wire?

Assume bits are sent from left to right



Sliding Window

$$\frac{170 \times 10^6 \text{ bits per second}}{8500 \text{ bits per frame}} = 20000 \text{ frames per second}$$

You are using a sliding-window protocol with a window size of 67 frames and a fixed frame size of 8,500 bits over a channel with a propagation delay of 5 ms. The maximum data rate of the physical channel is 170 Mb/s.

What is the maximum link utilization you can achieve?

$$u \leq \frac{w}{1 + 2BD}$$

$$u \leq \frac{67}{1 + (2 \times 20000 \times 5 \times 10^{-3})}$$

$$u \leq \frac{67}{201} = \frac{1}{3}$$

Automatic Request reQuest

Transmit loop

Waits for event (i.e., ack) so flow control

Support retransmission

→ ARQ Transmit loop

```
1  def protocol():
2      next_frame_to_send = 0                    # seq number of next outgoing frame
3      buffer = from_network_layer()             # fetch first packet
4
5      while True:
6          s = Frame(
7              info=buffer,
8              seq=next_frame_to_send,
9          )
10
11         to_physical_layer(s)
12         start_timer(s.seq)                    # if answer takes too long, time out
13
14         event = wait_for_event()              # frame_arrival, cksum_err, or timeout
15
16         if event == "frame_arrival":
17             s = from_physical_layer()         # get the acknowledgement
18             if s.ack == next_frame_to_send:
19                 stop_timer(s.ack)             # turn the timer off
20                 buffer = from_network_layer()
21                 next_frame_to_send = 1 - next_frame_to_send  # flip 0 <-> 1
22         # On cksum_err or timeout: fall through
```

Ethernet

Which of the following statements about the switched Ethernet protocol discussed in the course are **true**?

1. It can reliably detect burst errors of up to 48 bits long.
2. It provides *reliable delivery*.
3. It uses 32-bit MAC addresses to identify the source and destination of frames.

None of these statements are true!