# CSE398: Network Systems Design


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# Outline

- Recap/discussion
  - Encapsulation, delay
- Encoding
- Framing
- Error detection
- Ethernet (802.3)
- Summary and homework

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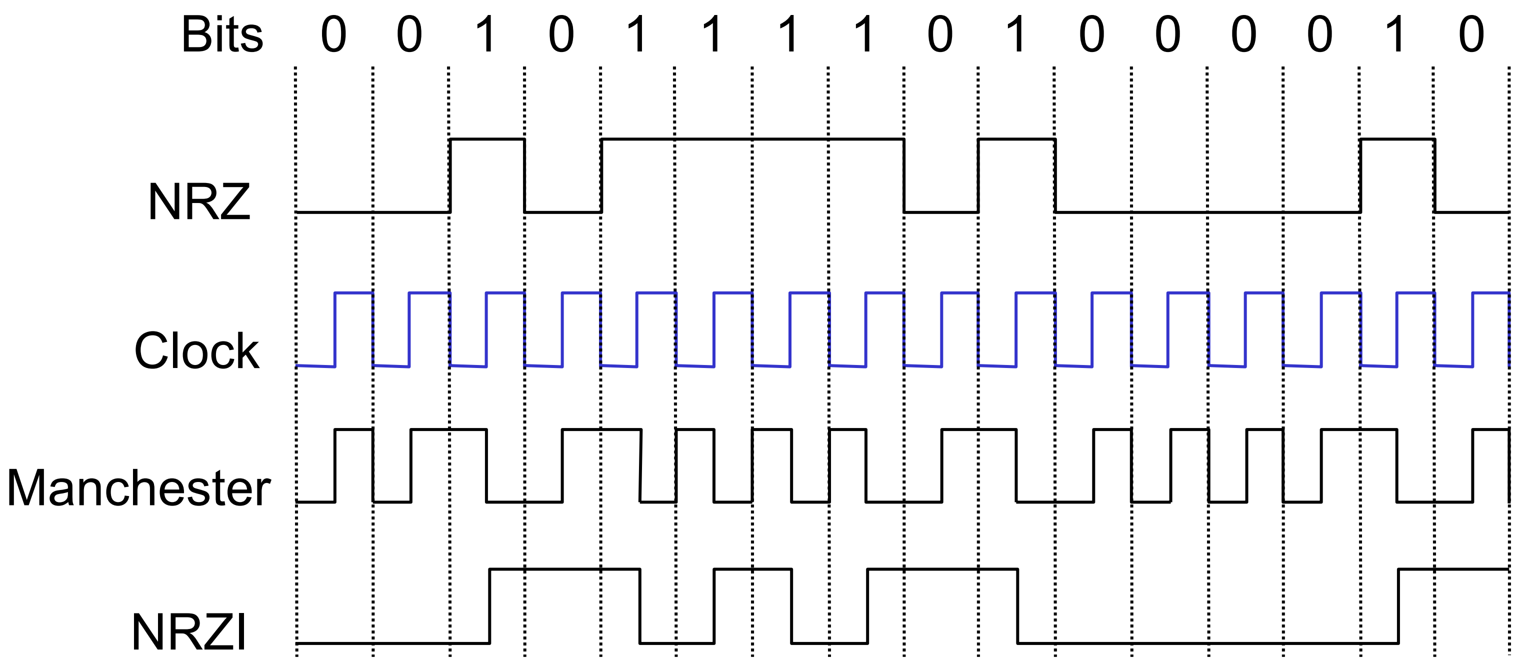
# Encoding

- Encode binary data onto signals
  - Non-return to zero (NRZ): 0 as low signal and 1 as high signal
  - Non-return to zero inverted (NRZI): a transition from current signal encodes a 1; staying at current signal encodes a 0
  - Manchester: exclusive-OR of the NRZ and the clock



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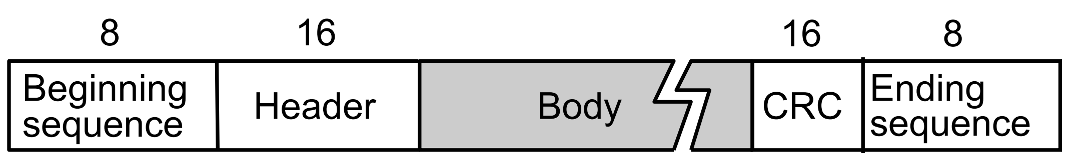
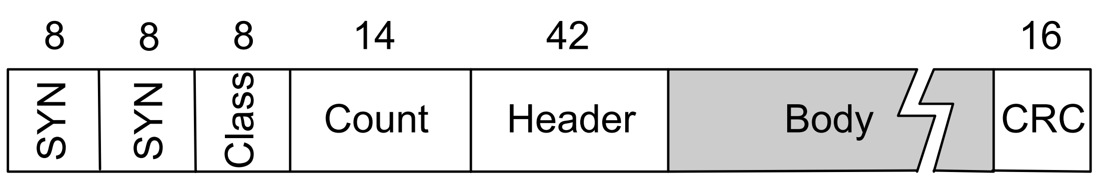
# Framing

- Break sequence of bits into a frame
- Typically implemented by network adaptor
- Byte-oriented approach
  - Sentinel: delineate frame with special pattern, e.g., 01111110; problem & solution
  - Byte-counting: include payload length as byte count in header; problem & solution
- Bit-oriented approach & clock-based approach



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# Error Detection

- Two-dimensional parity
  - Based on one-dimensional parity
  - Odd (or even) parity: set 8th bit to 1 if needed to give an odd (or even) number of 1s in the byte
  - Calculation for each bit position across each of the bytes contained in the frame: an extra parity byte for the entire frame

| | |
|---|---|
| 0101001 | 1 |
| 1101001 | 0 |
| 1000000 | 1 |

- Internet checksum algorithm
- CRC (Cyclic Redundancy Check)

# Internet Checksum Algorithm

- View message as a sequence of 16-bit integers; sum using 16-bit ones-complement arithmetic; take ones-complement of the result.

```
u_short
cksum(u_short *buf, int count)
{
    register u_long sum = 0;
    while (count--)
    {
        sum += ?; // *buf++, *buf, buf
        if (sum & 0xFFFF0000)
        {
            /* carry occurred, so wrap around */
            sum &= 0xFFFF;
            sum++;
        }
    }
    return ~(sum & 0xFFFF);
}
```

# Cyclic Redundancy Check

- Add $k$ bits of redundant data to an $n$-bit message
  - $k << n$, e.g., $k = 32$ and $n = 12{,}000$ (1500 bytes)
- Represent $n$-bit message as $n$-1 degree polynomial
  - e.g., MSG=10011010 as $M(x) = x^7 + x^4 + x^3 + x^1$
- Let $k$ be the degree of some divisor polynomial
  - e.g., $C(x) = x^3 + x^2 + 1$
- Transmit $P(x)$ that is evenly divisible by $C(x)$
  - Subtract remainder of $M(x)x^k/C(x)$ from $M(x)x^k$
- Is received bit-stream evenly divisible by $C(x)$?
- Selecting $C(X)$
  - All single-bit errors, as long as the $x^k$ and $x^0$ terms have non-zero coefficients.
  - All double-bit errors, as long as $C(x)$ contains a factor with at least three terms
  - Any odd number of errors, as long as $C(x)$ contains the factor $(x+1)$

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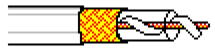
# Ethernet (802.3)

- CSMA/CD (Carrier Sense Multiple Access with Collision Detection)
- Broadcast

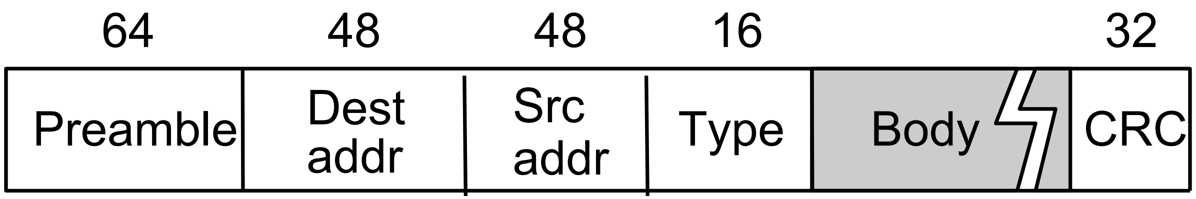
- MAC (Media Access Control)



- Fast Ethernet and Gigabit Ethernet
- Coaxial cable (500 m, impedance 50 Ohms) and 10BaseT (100 m)
- Repeater: maximum 4 (2500 m)

# Ethernet Frame

- Frame: bit-oriented, pre- & post-amble
- 14 byte header
- Unique Ethernet address belongs to each adaptor
  - 48-bit unicast address (24-bit assigned prefix), e.g., **`8:0:2b:e4:b1:2`**
  - Broadcast: all `1`s
  - Multicast: first bit is `1`
  - Promiscuous mode
- Body: from 46 bytes to 1500 bytes
- Type as demultiplexing key or length field



# Transmitter Algorithm in MAC

- If line is idle
  - Send immediately
  - Upper bound message size of 1500 bytes
  - Wait 9.6us between back-to-back frames
- If line is busy
  - Wait until idle and transmit immediately
- If collision
  - Jam for 32 bits, then stop transmitting frame
  - Minimum frame is 64 bytes [header (14) + 46 bytes of data + CRC (4)]
  - Delay and try again
    - 1st time: 0 or 51.2us
    - 2nd time: 0, 51.2, or 102.4us
    - 3rd time: 51.2, 102.4, or 153.6us
    - *nth* time: $k$ x 51.2us, for randomly selected $k$=0 … $2^n$ - 1
    - Exponential backoff
    - Give up after several tries (usually 16)

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# Homework

- Problem 1.2 has been posted at the Blackboard System. Due on Jan. 24 (upload it to Digital Drop Box) to before the class.

- 5-min discussion in the next class: Why jamming bits?