

# CS 640 Introduction to Computer Networks

## Lecture 3

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## Today's lecture

- Performance metrics
- Data link layer introduction

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## Performance Metrics

- Bandwidth: physical property of link
- Throughput: actual data transmitted per time unit
  - notation
    - KB =  $2^{10}$  bytes
    - Mbps =  $10^6$  bits per second
- Latency (delay)
  - time to send message from point A to point B
  - one-way versus round-trip time (RTT)
    - Latency = Propagation + Transmit
    - Propagation = Distance / Speed (of light)
    - Transmit = Size / Bandwidth
- Delays on Internet much greater (queuing)

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## Bandwidth versus Latency

- Relative importance
- Assume propagation delay is 100 ms
- Transfer 1 Kb, bw 1 Mbps
  - Latency:  $100 + 1$  (transmission delay) = 101 ms
- Transfer 1 Mb
  - Latency  $100 + 1000$  (transmission delay) = 1100 ms

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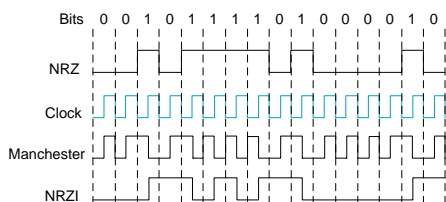
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## Physical layer

- Signal encoding and synchronization



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## Role of data link layer

- Service offered by layer 1: a stream of bits
- Service to layer 3: sending & receiving frames
- To achieve this layer 2 does
  - Framing
  - Error detection (rarely error correction)
  - Multiplexing
    - Media access control
    - Addressing (multiple access links)

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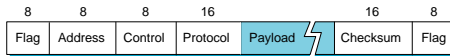
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## Framing 1 – sentinel approach

- Used by Point-to-Point-Protocol (PPP)
- Special characters for start and end of frame
- Use “byte stuffing” if they appear in body



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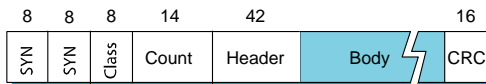
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## Framing 2 – byte counting approach

- Used by DECNET’s DDCMP
- Instead of “end of frame” character uses frame length field



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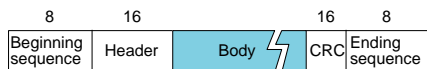
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## Framing 3 – bit oriented

- Frames delimited by special bit patterns
- HDLC uses “01111110”
- If “011111” occurs in body, sender inserts “0”



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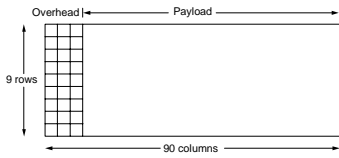
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## Framing 4 – clock based framing

- Used by protocols from the phone network
- Fixed size frames
- No escape codes



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