**L10: Protocols and Layering**

6.033 Spring 2007

[http://web.mit.edu/6.033](http://web.mit.edu/6.033)

Slides from many folks

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**Plan for studying network systems**

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**Last lecture: challenges**

- **Economical:**
  - Universality
  - Topology, Sharing, Utilization
- **Organizational**
  - Routing, Addressing, Packets, Delay
  - Best-effort contract
- **Physical**
  - Errors, speed of light, wide-range of parameters

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**Network Design**

**Problem**

- How do we organize design of a network?

**Solution:**

- layering of protocols

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**Layering of protocols**

- Layering is a particular form of abstraction
- The system is broken into a vertical hierarchy of protocols
- The service provided by one layer is based solely on the service provided by layer below

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**Layering tools for nesting**

- Each layer adds/ strips off its own header
- Each layer may split up higher-level data
- Each layer multiplexes multiple higher layers
- Each layer is (mostly) transparent to higher layers
Layering: The Internet

Multiplexing in the Internet

- Many applications, transports, and link protocols
- All use IP at the network layer

Where are these layers?

- Link and network layers are implemented everywhere
- The end-to-end layer (i.e., transport and application) is implemented only at hosts

Clever usages of layering

- Nesting layers to the extreme: tunneling
  - Run link layer over TCP (Virtual Private Network)
- Router uses TCP as transport for routing protocol (e.g., BGP)
- ...

Link Layer

Problem:
Deliver data from one end of the link to the other

Need to address:
- Bits
- Analog
- Framing
- Errors
- Medium Access Control (The Ethernet Paper)

Manchester encoding

- Each bit is a transition
- Allows the receiver to sync to the sender’s clock
Framing

- Receiver needs to detect the beginning and the end of a frame
- Use special bit-pattern to separate frames
  - E.g., pattern could be 1111111 (7 ones)
  - Bit stuffing is used to ensure that a special pattern does not occur in the data
  - If pattern is 1111111 Whenever the sender sees a sequence of 6 ones in the data, it inserts a zero (reverse this operation at receiver)

Error Handling

- Detection:
  - Use error detection codes, which add some redundancy to allow detecting errors
- When errors are detected
  - Correction:
    - Some codes allow for correction
  - Retransmission:
    - Can have the link layer retransmit the frame (rare)
  - Discard:
    - Most link layers just discard the frame and rely on higher layers to retransmit

This Lecture

- To cope with the complexity, the network architecture is organized into layers

- The link layer delivers data between two machines that are directly connected using a link