

L10: Protocols and Layering

6.033 Spring 2007

<http://web.mit.edu/6.033>

Slides from many folks



Plan for studying network systems

Sharing and challenges	7.A	Ethernet
Layering	7.B+C	End-to-end
Routing	7.D	Internet routing
End-to-end reliability	7.E	Network file system
Congestion control	7.F	NATs

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

Network Design

Problem

- How do we organize design of a network?

Solution

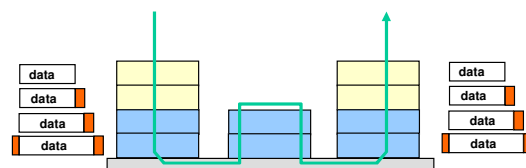
- layering of protocols

Layering of protocols

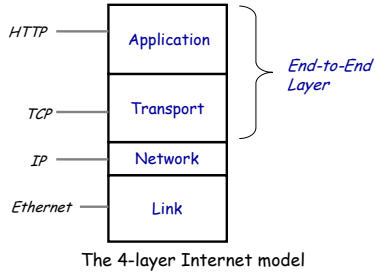
- Layering is a particular form of abstraction
- The system is broken into a **vertical hierarchy** of protocols
- The service provided by one layer is based **solely** on the service provided by layer below

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

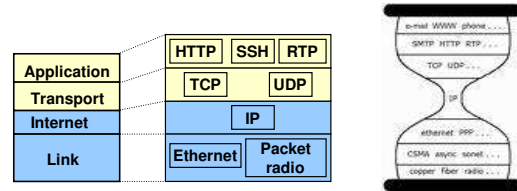


Layering: The Internet



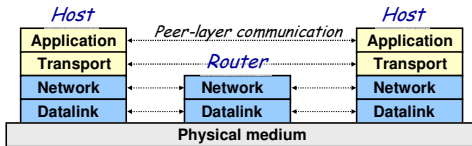
Multiplexing in the Internet

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



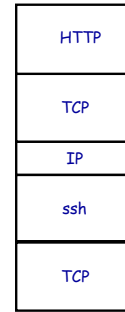
Where are these layers?

- 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

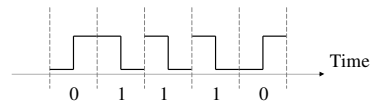


Problem:
Deliver data from one end of the link to the other

Need to address:

- Bits à Analog à Bits
- 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