6.033 Computer System Engineering

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L10: Protocols and Layering

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Some slides are from lectures by Nick Mckeown, Ion Stoica, Frans Kaashoek, Hari Balakrishnan, Sam Madden, and Robert Morris

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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

Network Design

Problem

- How do we organize design of a network?

Solution

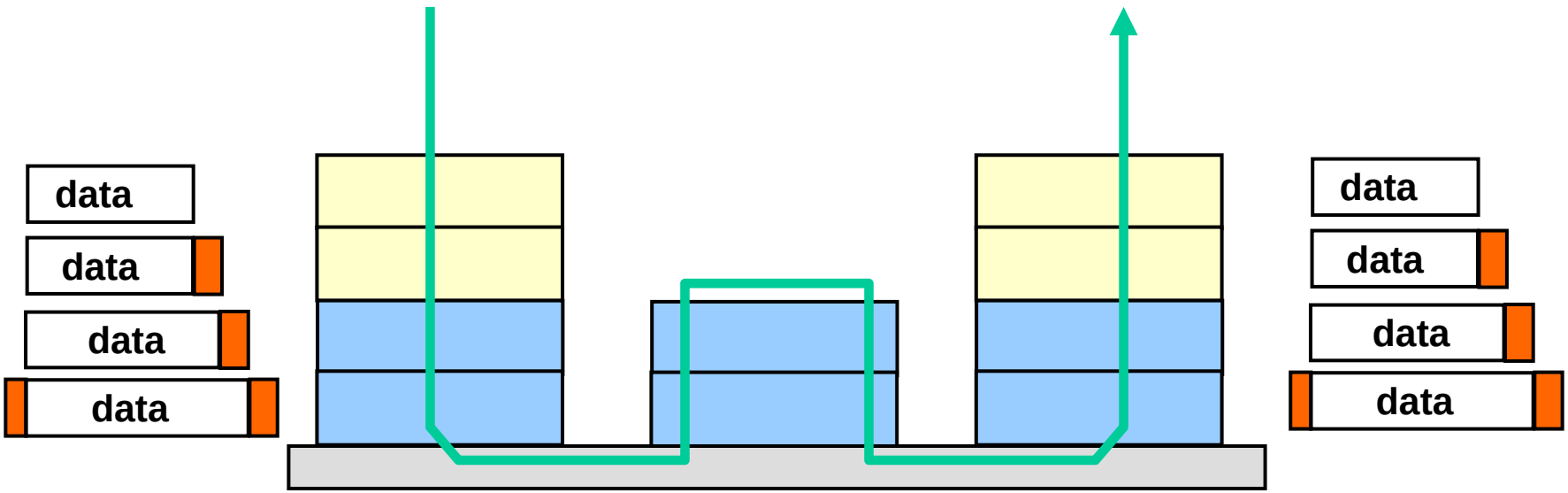
- layering of protocols

Layering of protocols

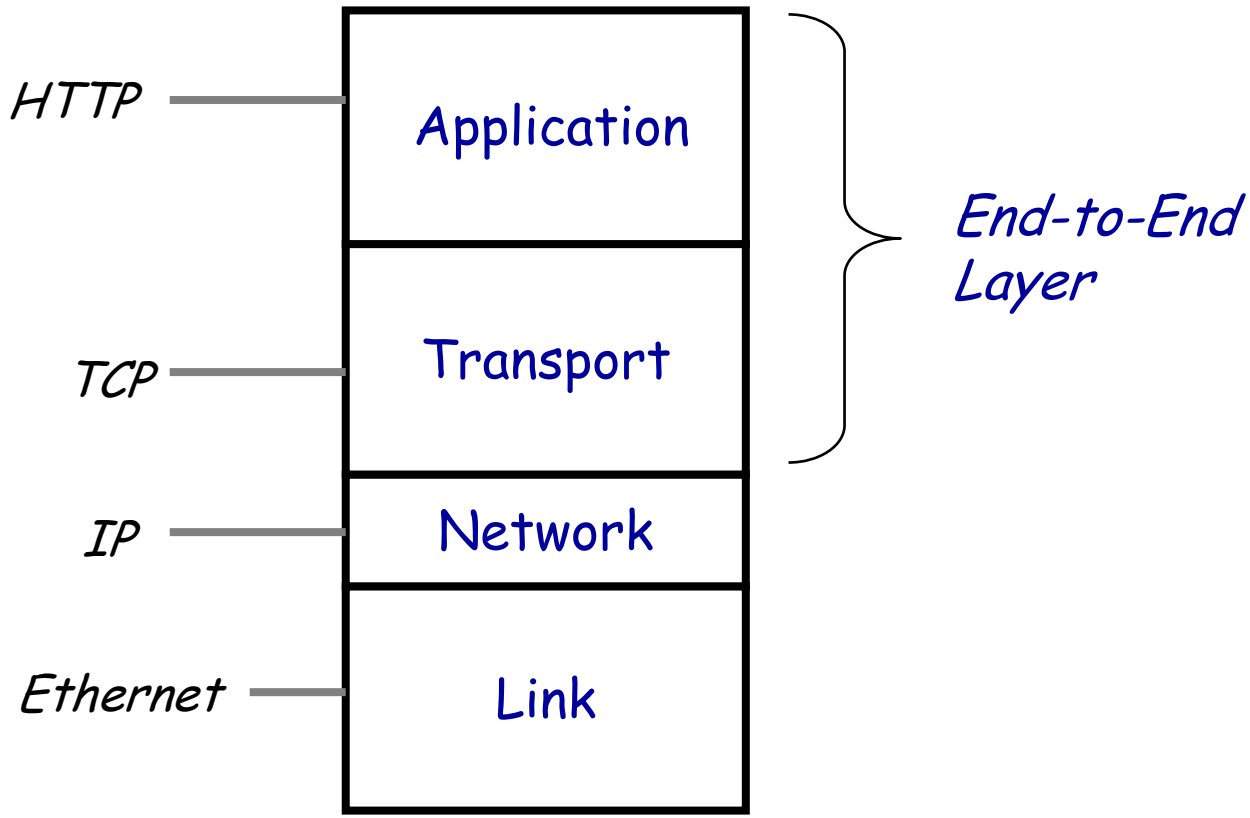
- Layering is a particular form of abstraction
- The system is broken into a vertical hierarchy of protocols
- The service provided by one layer is based solely on the service provided by layer below

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



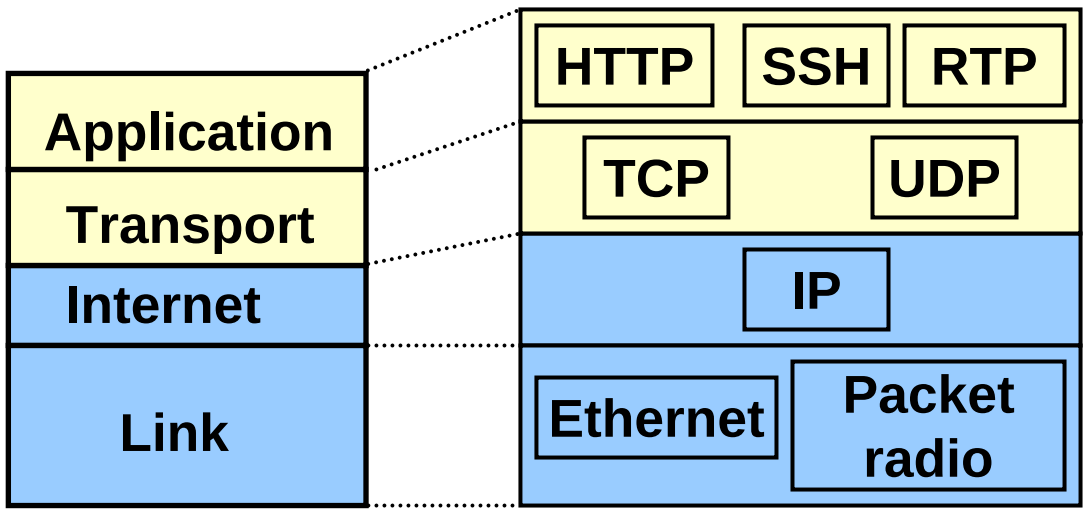
Layering: The Internet



The 4-layer Internet model

Multiplexing in the Internet

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



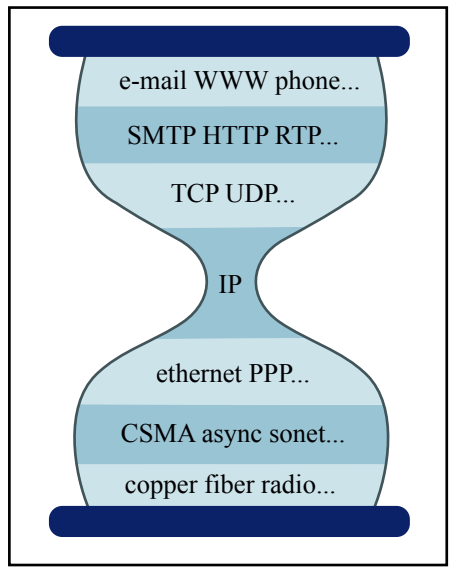
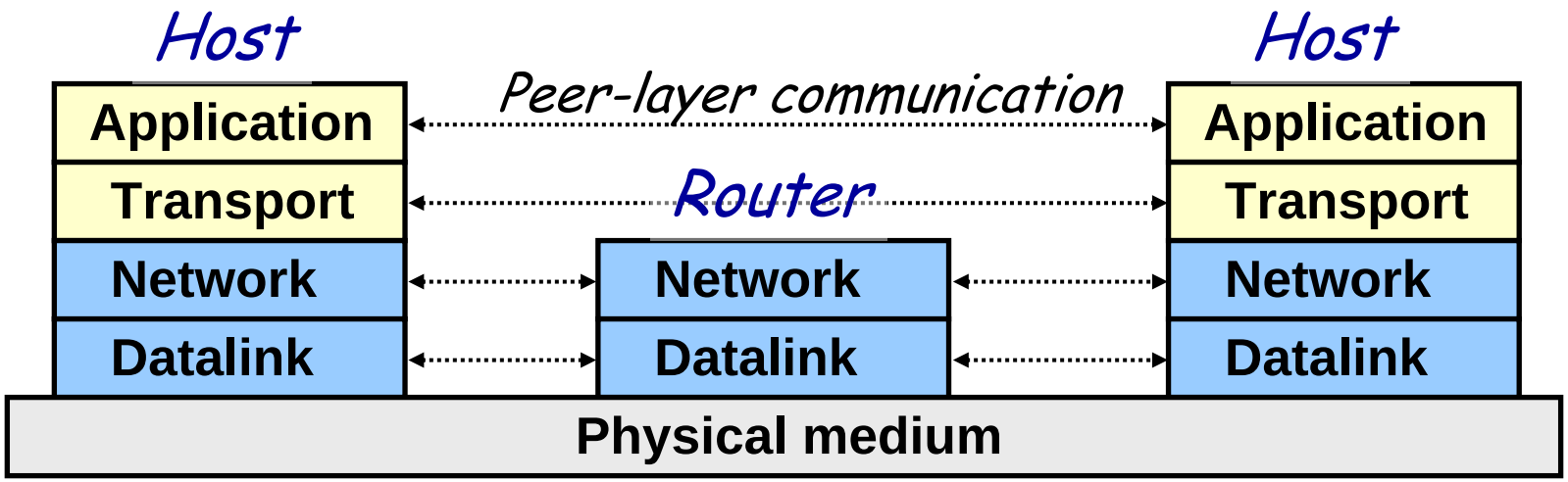


Figure by MIT OpenCourseWare.

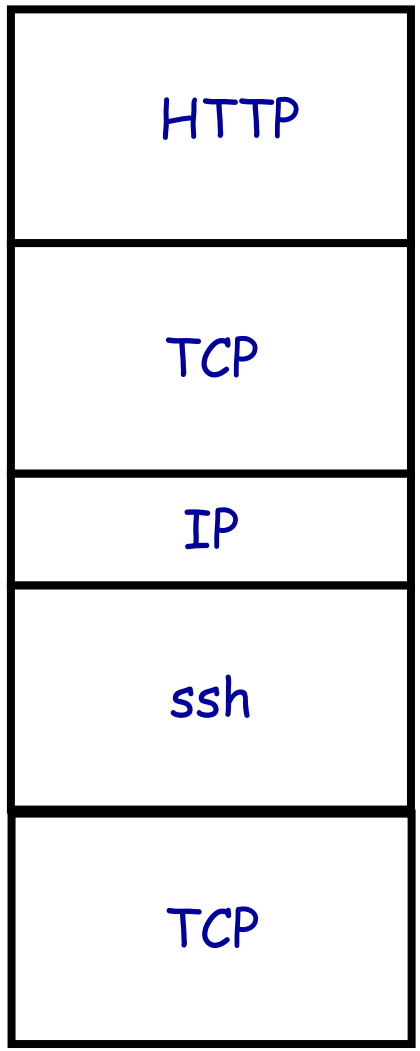
Where are these layers?

- 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

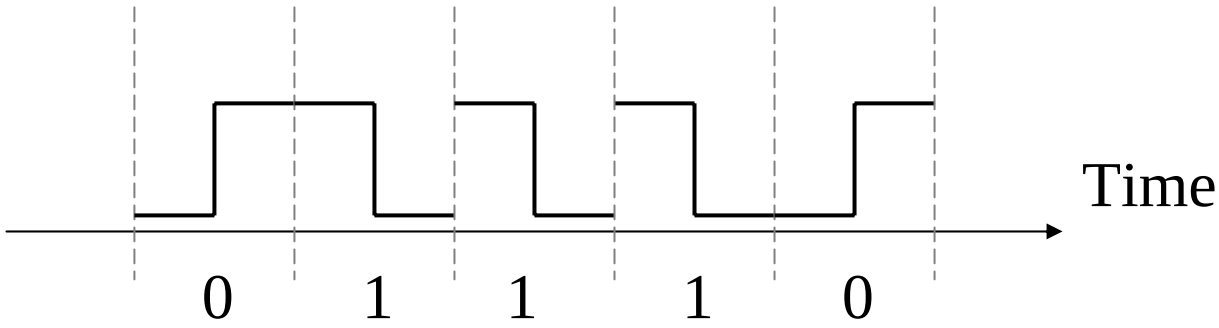
Problem:

Deliver data from one end of the link to the other

Need to address:

- Bits→ Analog → 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
  - Retransmition:
    - 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