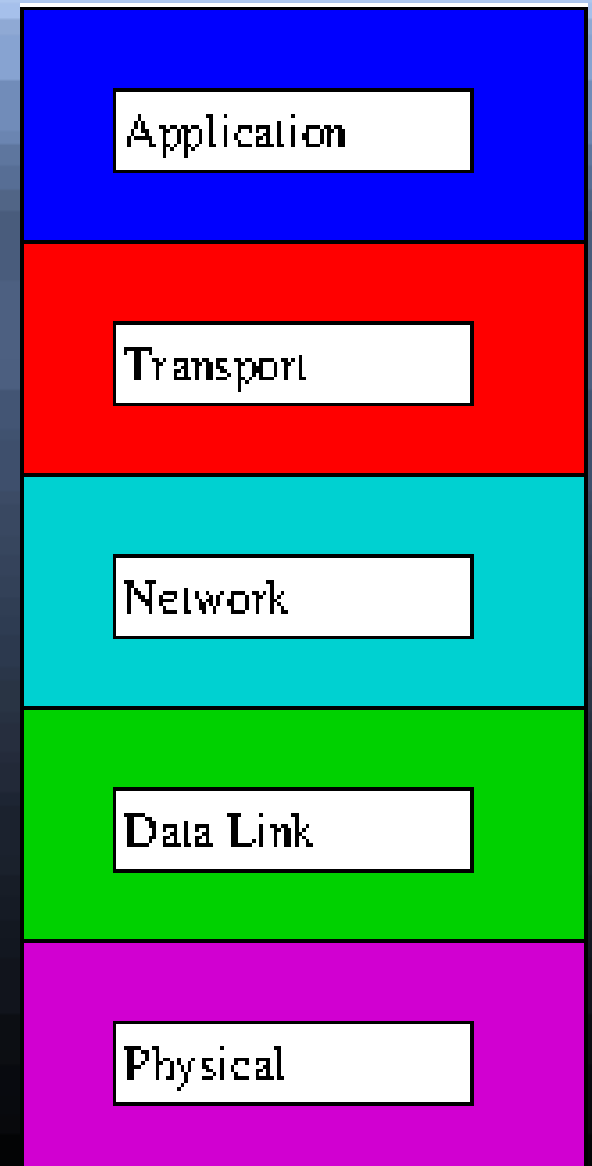


# ICS 451: Today's plan

- Layered Reference Models
- Specific layers:
  - physical
  - data link
  - network
  - transport
  - application
- Internet reference model
- OSI reference model

# Layered Reference Models

- “Each layer provides a service that is built above the underlying layer
  - and is closer to the needs of the application”
- The physical layer links devices so they can communicate
  - exchange bits



# Common Physical Layers

- Electrical
  - for Ethernet, serial, cable, etc.
  - signal carried by voltage or current
- Optic Fiber
  - multi-mode (cheaper, shorter distance), or
  - single-mode (more expensive, longer distance)
- Wireless
  - for WiFi, infrared, microwave, etc.

# Physical Layer Characteristics

- speed
  - in bits/second (not Bytes/second!!!!)
- modulation scheme
  - how are bits and signals encoded?
  - e.g. **on** for 1, **off** for 0: on-off-keying, OOK
- Physical layers have errors
  - can create, modify, or drop bits
  - hopefully not too often!!

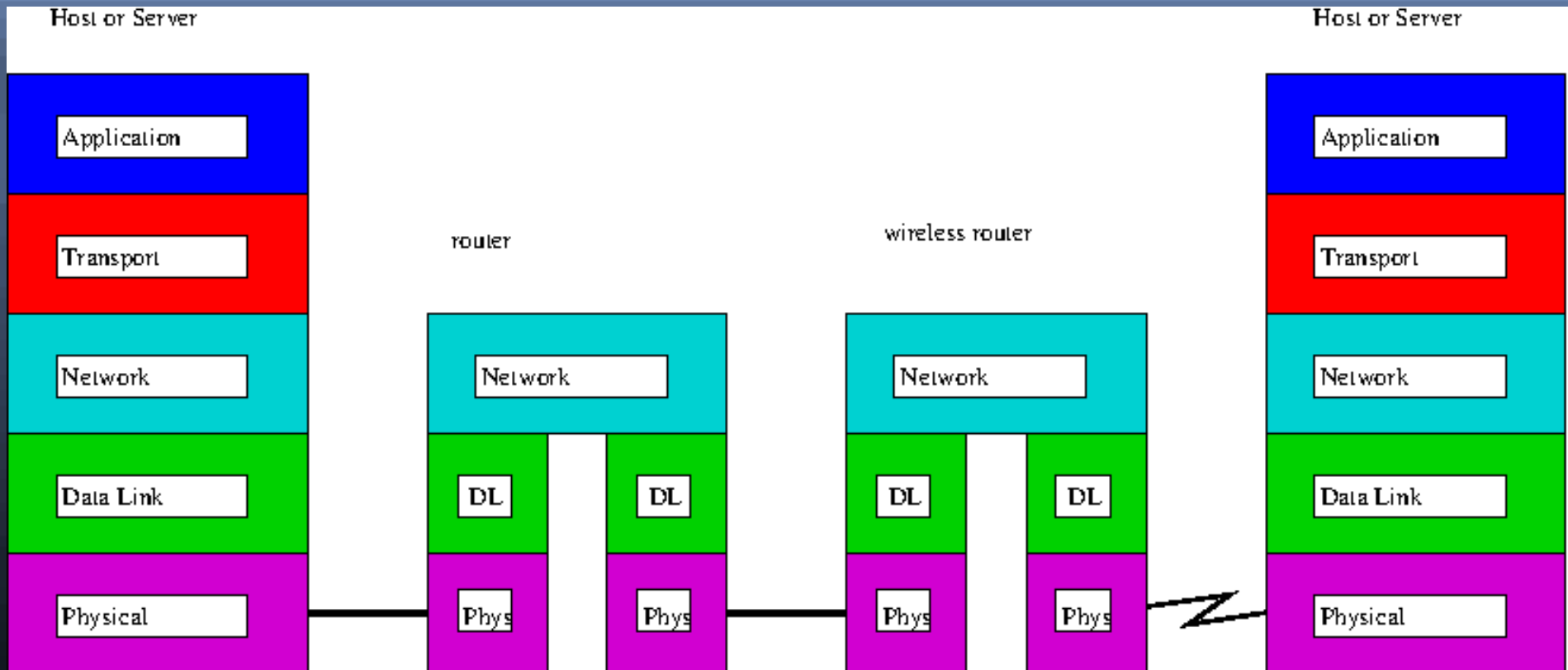
# Data Link Layer

- Provides exchange of frames between directly connected machines
- Can be connection-oriented or connectionless
- Data is given to the physical layer, which actually delivers it to the other machine
- Frame can be variable-length or fixed-length
  - Ethernet has variable-length frames
  - 46-1500 bytes long (60-1514 with header)

# Network Layer

- Provides exchange of packets also between machines that are not directly connected
- Each packet may have to be forwarded by one or more intermediate devices, called *routers*
- May only provide best-effort (unreliable) service
  - IP is best-effort

# Layers in the Internet



# Transport Layer

- Application demultiplexing (TCP ports)
- Adds reliability where needed
  - TCP provides reliable, connection-oriented byte streams
  - UDP provides best-effort, connectionless datagram service

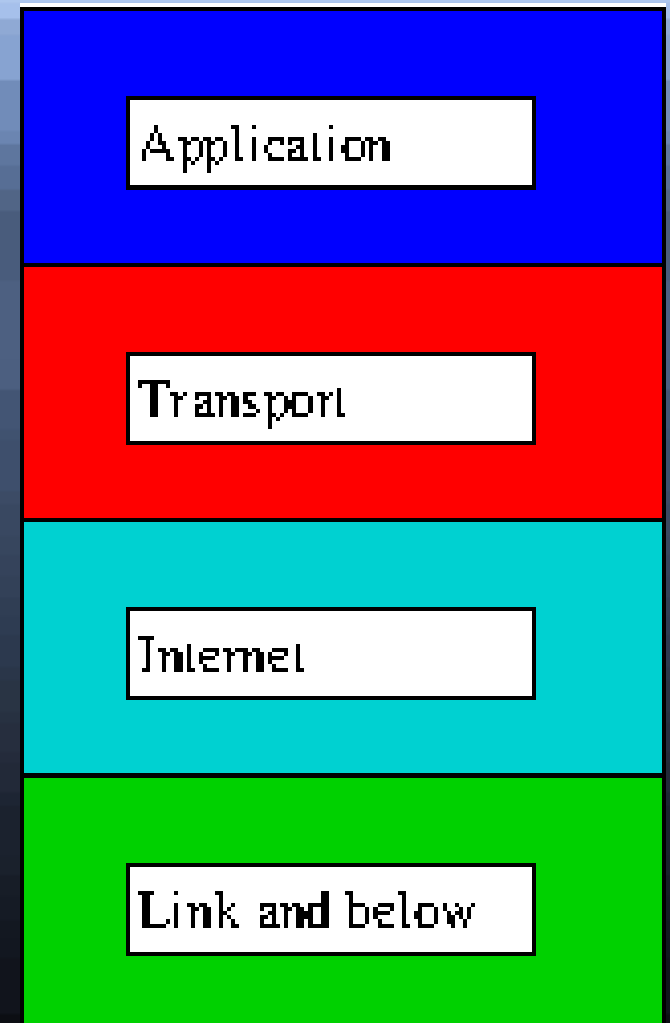


# Application Layer

- Everything that the application needs
  - that is not provided by the lower layers
  - textbook uses Application Data Unit (ADU) to designate the data exchanged at the application layer

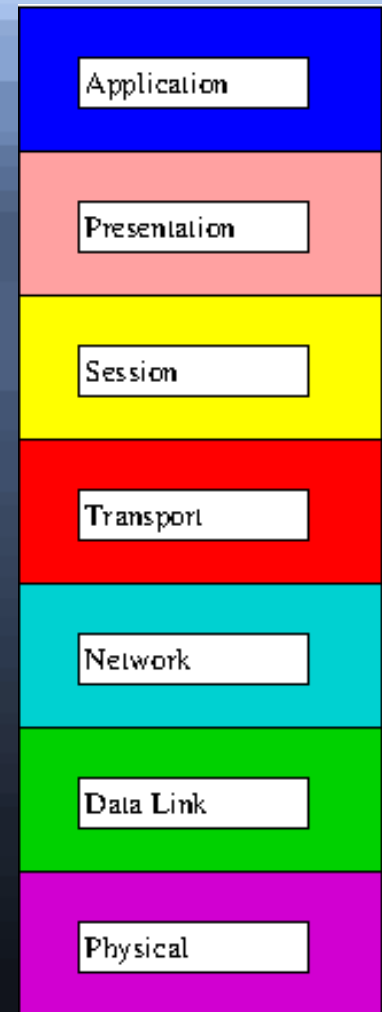
# Internet (TCP/IP) reference model

- Similar to 5-layer model, but
- The Link layer takes care of local delivery
- Practical model: describes how Internet protocols are actually defined



# OSI reference model

- Widely recognized as standard
- Similar to 5-layer model
  - plus session and presentation
- Session Layer is similar to TCP connections, but should recover from connection failures
- Presentation Layer provides standard encodings for data
  - e.g. MIME, ASN.1



# OSI vs Internet reference models

- The Internet model “folds” the Session and Presentation layers into the Application layer
- So applications are responsible for retrying connections
  - e.g. email keeps trying to send messages
- Applications decide how to represent data
  - e.g. email and HTTP use MIME (content-type) to describe data type and encoding