Networking

Marquette University, Fall 2021

Introduction

- https://www.youtube.com/watch?v=2GmLgoQBzUo

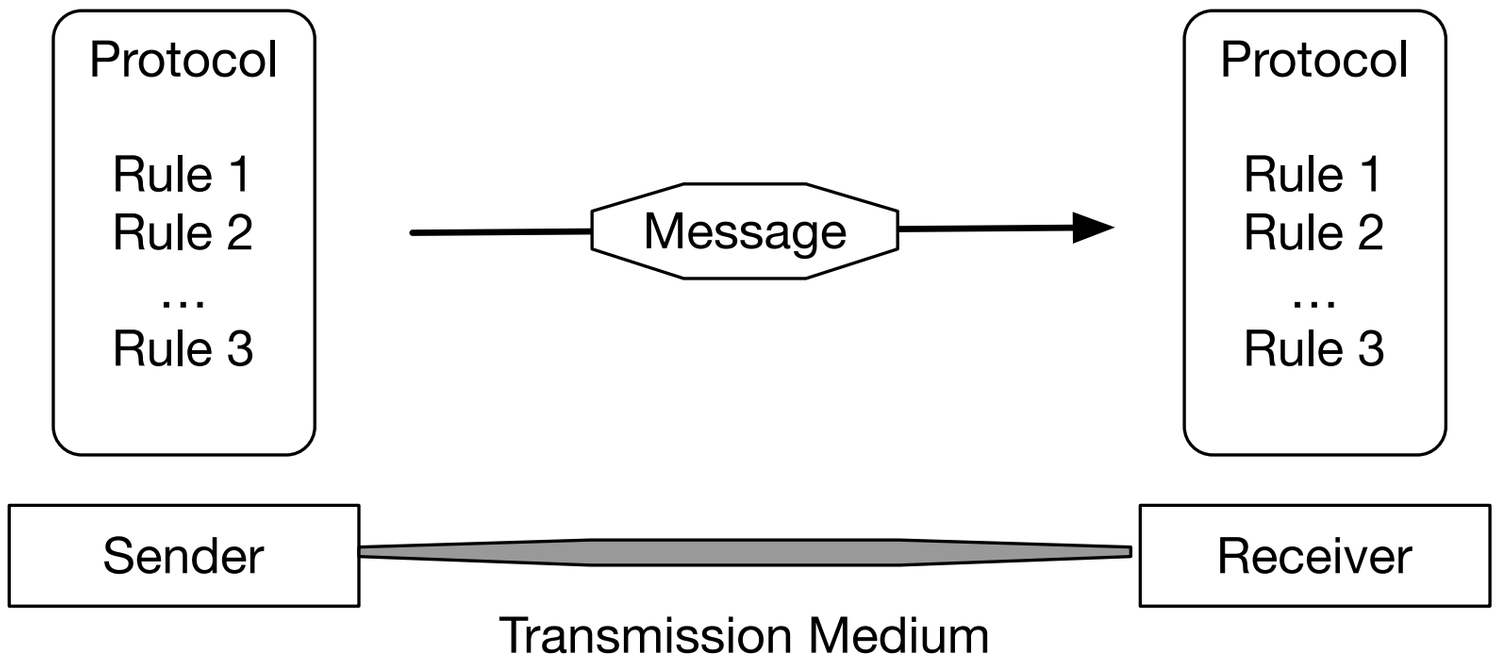
Data Communication

- Exchange of information between two entities
  - Properties
    - Delivery
    - Accuracy
    - Timeliness
    - Jitter

Data Communications Components

- A message has a sender and a receiver
- It uses a transmission medium
- The transmission follows several protocols

Data Communication Components



- Message
- Sender
- Receiver

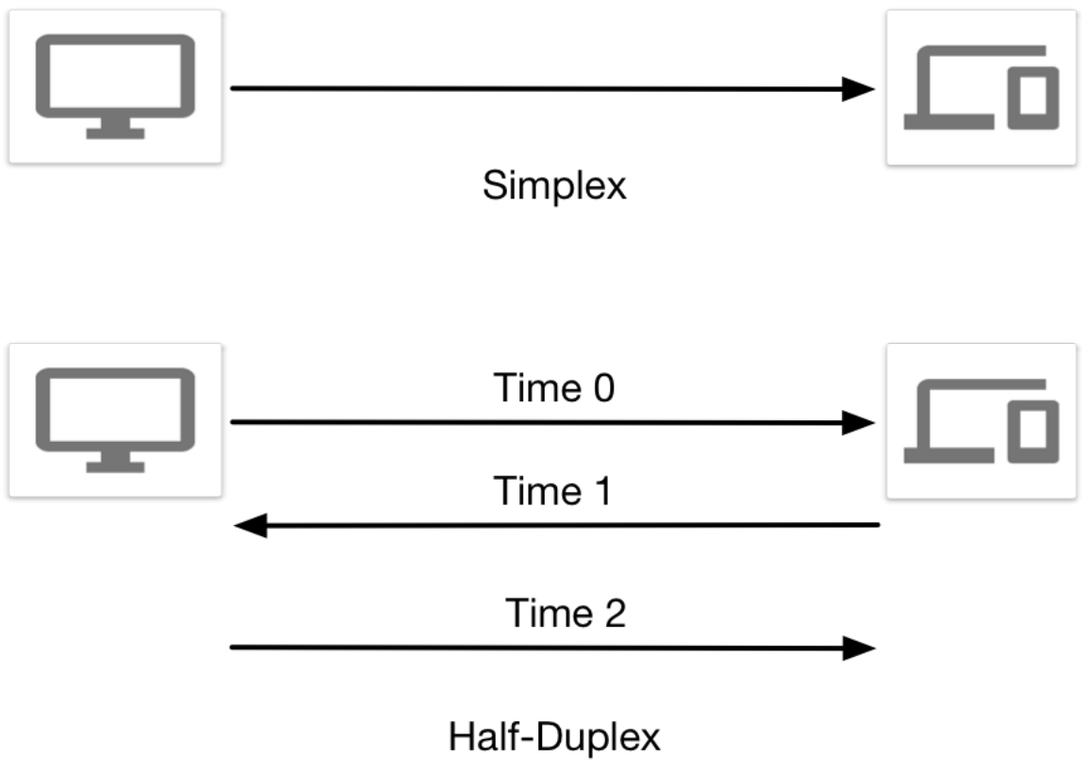
- Transmission Medium
- Protocol: A set of rules

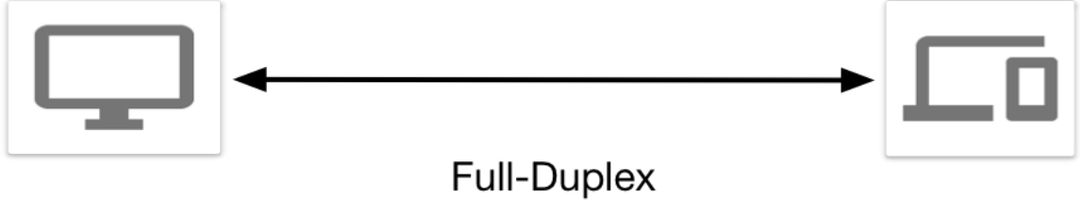
Data Representation

- Information comes in different forms
- Various formats for digital data
  - Text: Unicode, ASCII, Latin-1, utf-8
  - Numbers: base 1, base 2, IEEE floating point format
  - Images:
    - Resolution determines number of pixels
    - Each pixel contains various scales (e.g. 3×8 b for color)
  - Audio
  - Video

Data Flow Types

- Simplex mode:
  - Communication is one-directional
- Half-duplex:
  - Communication is one-directional for a time, then goes in the other direction
- Full-duplex:
  - Communication is bidirectional



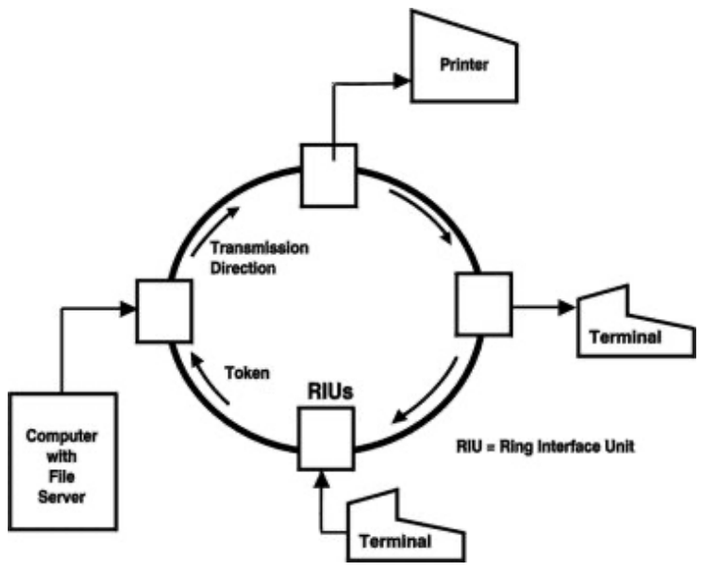


Networks

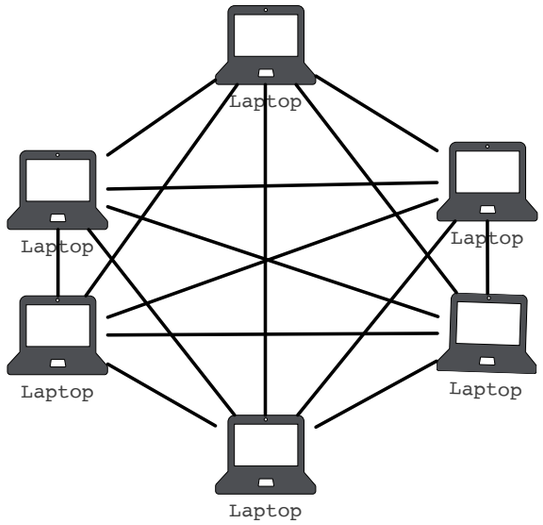
- Interconnection of a set of devices capable of communication
  - Hosts (end-points) vs. Connecting Devices (e.g. routers)
- Criteria
  - Performance
    - Throughput
    - Delay
  - Reliability
  - Security

Physical Structures

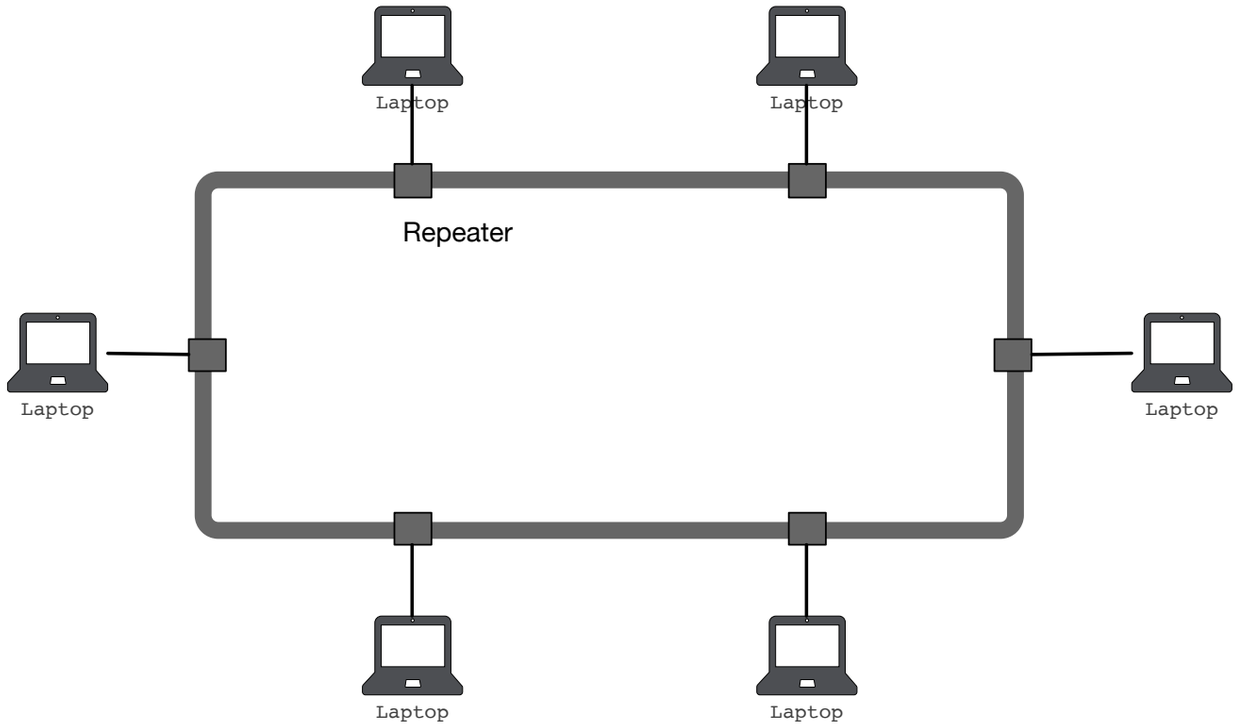
- Point-to-point links
  - Dedicated link between two devices
- Multi-point links:
  - More than two devices share a link
    - E.g. Token Rings (IBM / IEEE 802.5)
- Physical Topology
  - Two or more devices connect to a link
  - Two or more links form a topology



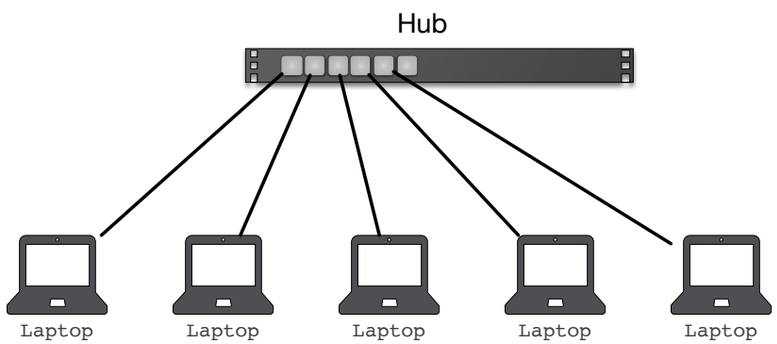
Simple Network Topologies



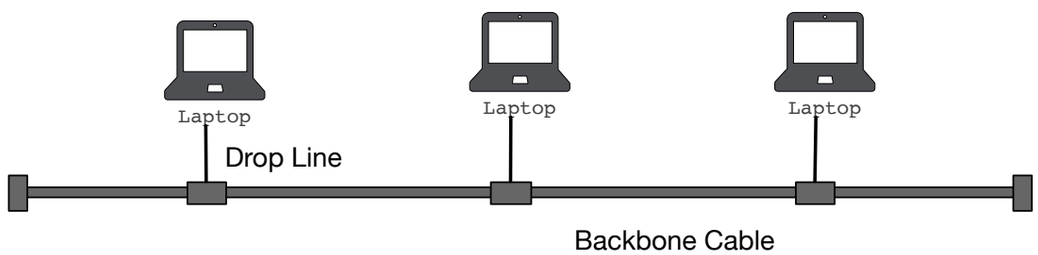
Mesh Topology



Ring Topology



Star Topology



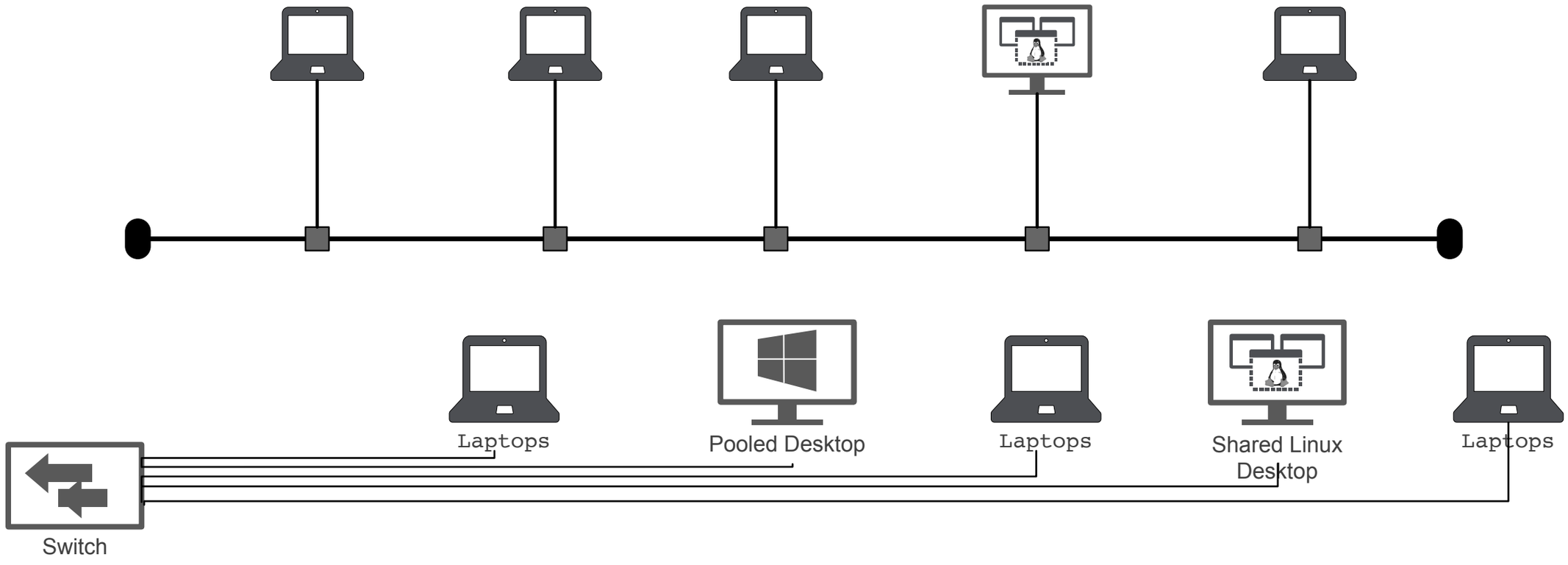
Bus Topology

Network Types

- Networks are limited by
  - throughput
  - delay (i.e. distance)
  - Local Area Networks
  - Wide Area Networks
  - Internets

Network Types

- LAN: Local Area Network
  - bus
  - switched

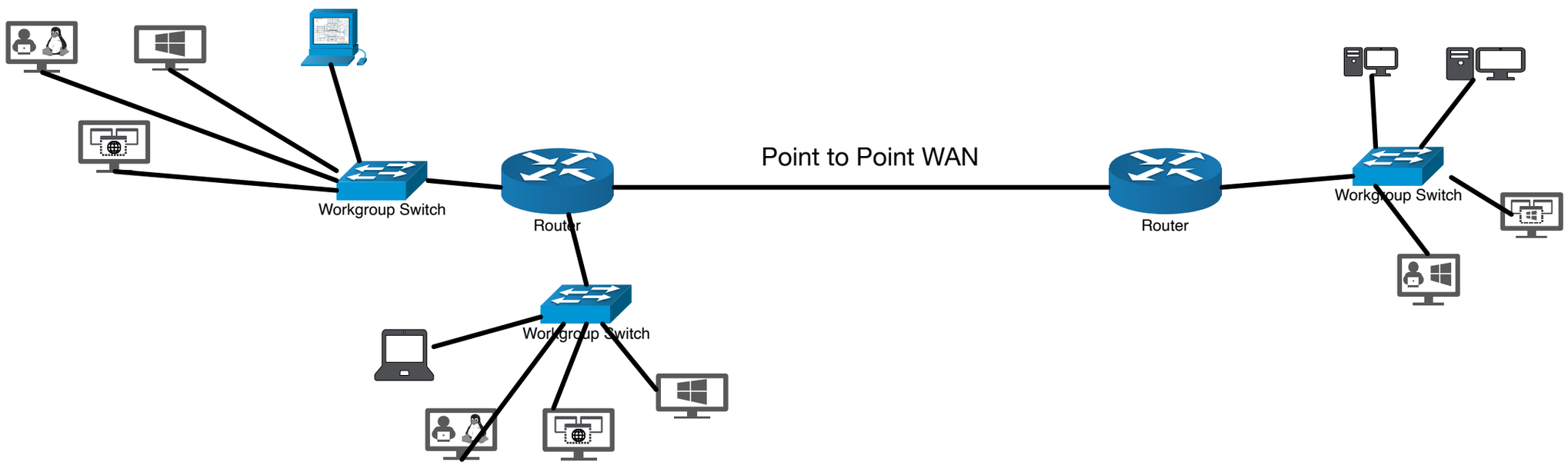


Network Types

- WAN: Wide Area Network
  - Point-to-point (two ends)
  - Switched WAN (used as backbone for Internet)

Network Types

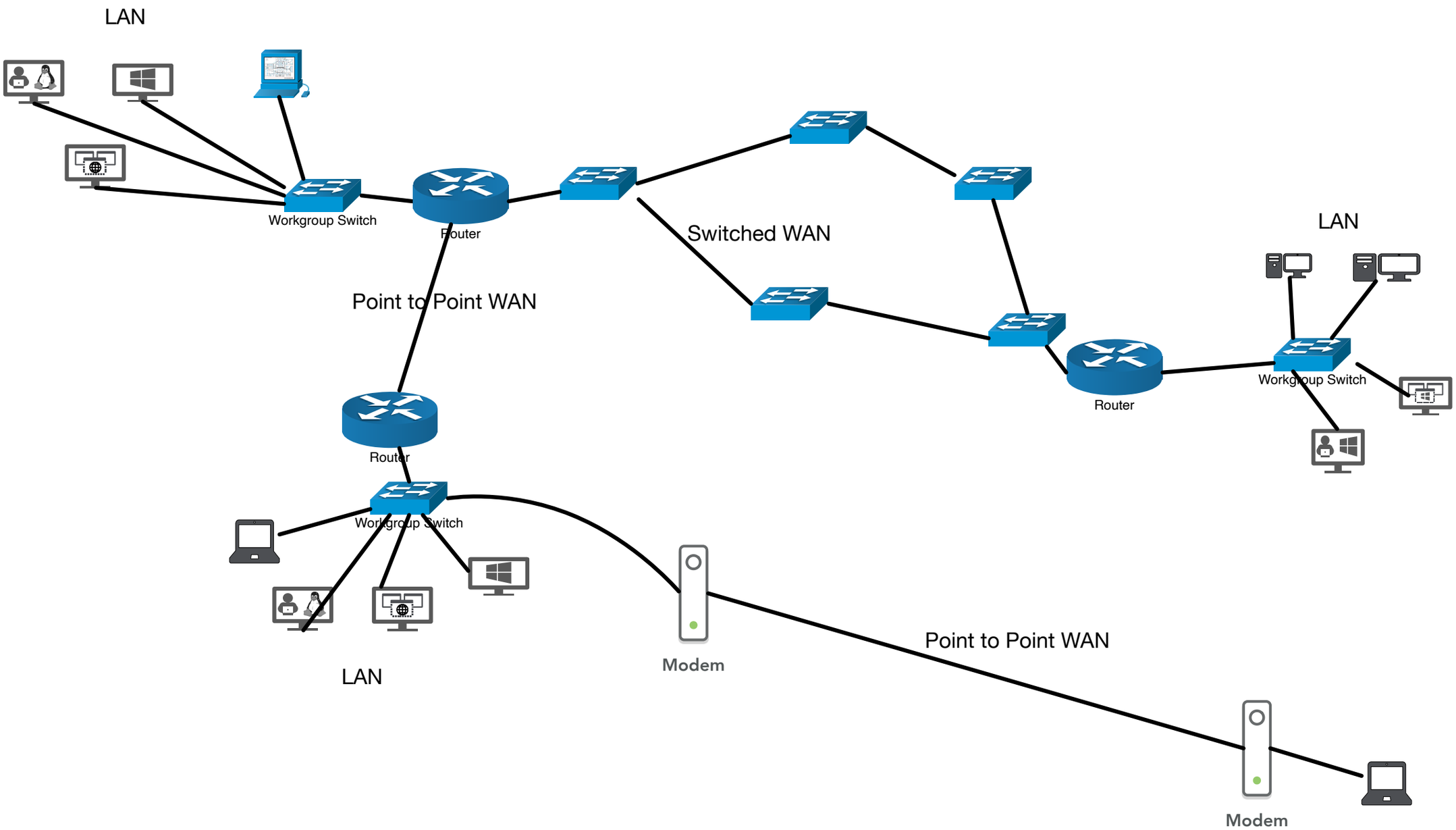
- Internets (with a small i) aka. internetworks
  - Connects several LANs or WANs
  - Circuit switched
  - Packet switched



Network Types

- Data communication
  - Data are bursty
  - No causality
  - More bandwidth = faster transmission
  - Data loss very bad
- Circuits
  - Data are streamed
  - Signals are causal
  - Signal has finite bandwidth
  - Some signal loss tolerable

Heterogeneous Network



Switching

- Switched networks (e.g. internet)
  - Switch forwards data from one network to another
  - Circuit switched networks
    - Dedicated network (*circuit*) is always available between two systems
- Packet switched networks
  - Instead of continuous connections
  - Use blocks of data: *packet*

Internet

- Internet (capital I)
  - Consists of thousands of interconnected networks
  - Has several backbones
    - Owned by Sprint, Verizon, ATT, NTT, ...
    - Connected via *peering points*
  - Has a larger number of *provider networks*
    - which use the backbones for a fee
    - connected to several backbones and possible other provider networks
  - Customer networks use the services of these ***Internet Service Providers***

Internet Standards

- Internet draft: Working document with no status and 6 month expiration date
- Request for Comment is next stage:
  - Proposed Standard
  - Draft Standard (needs at least two interoperable implementations)
  - Internet Standard: adhered by all
  - Historic: never passed or superseded
  - Experimental
  - Informational

Internet Standards

- RFC:
  - Required (must be implemented) e.g. TCP, IP
  - Recommended e.g. FTP, TELNET
  - Elective
  - Limited Use
  - Not recommended (only for historic RFC)

Internet Administration

- ISOC: Internet Society
  - formed 1992 to provide support for Internet standard process
- IAB: Internet Architecture Board
  - technical advisor to ISOC using
    - IETF: Internet Engineering Task Force
    - IERF Internet Research Task Force
  - Manages RFCs
  - External Liaison to other standards organizations

Protocol Layering

Layered Architecture

- Layering was invented to deal with complexity of software development
  - THE Operating System
- In Networking there are additional motivations
  - Plethora of underlying technologies and needs
  - Networking devices often do not need full functionality

Layered Architecture

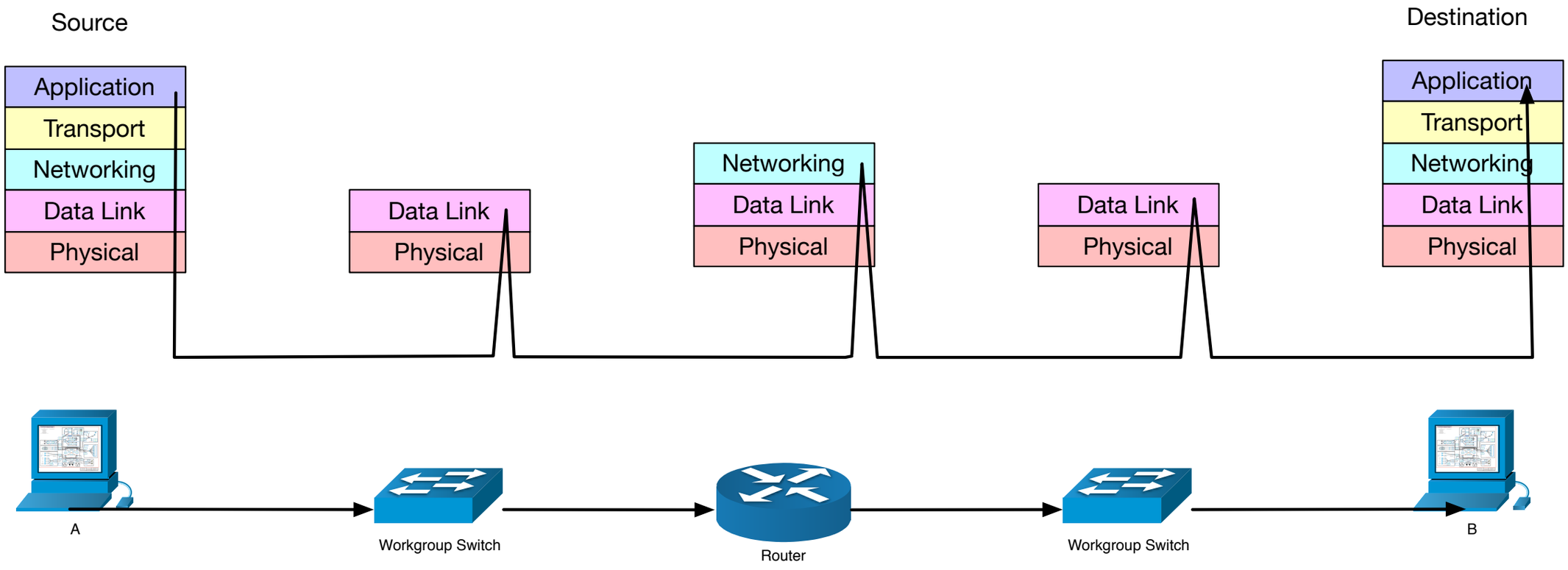
- Principles of protocol layering for networking

  1. Bidirectional communication implies that each layer needs to perform two opposite task, one in each direction
     - Listen
     - Talk
  2. Objects exchanged under each layer need to be identical

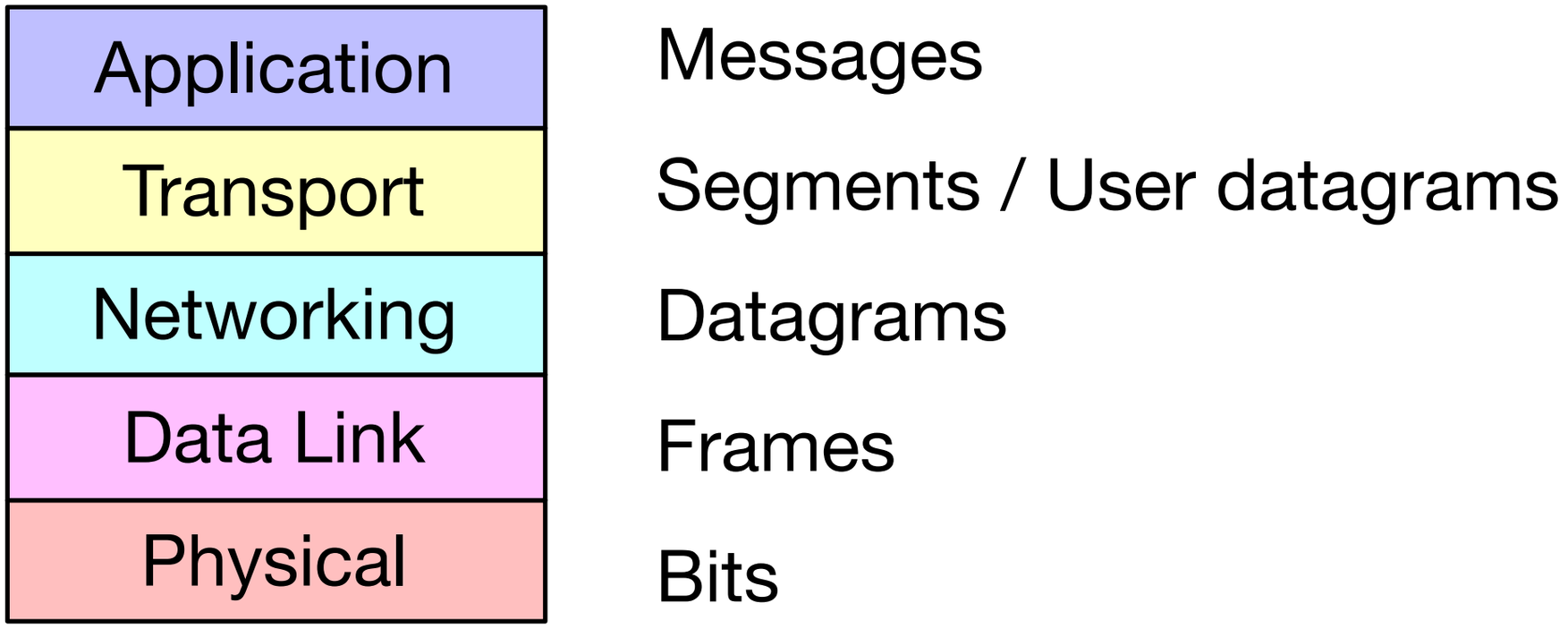
Layered Architecture

- TCP/IP stack
  - Application layer
  - Transport layer
  - Network layer
  - Physical layer

Layered Architecture



Layered Architectures



Physical Layer

- Carries individual bits in a frame across a link
  - Devices are connected by a transmission medium
    - Media have different characteristics
  - Bits are transformed into a signal

Data Link Layer

- Takes datagram and moves it as a frame across the link
- Different link layer protocols may provide different services
  - Error detection
  - Error correction

Network Layer

- Responsible for creating a connection between source and destination (end-to-end connection)
- IP - Internet Protocol
  - Connectionless
    - no flow control
    - no error control
    - no congestion control
- Auxiliary protocols: Internet Control Message Protocol, Internet Group Management Protocol, Dynamic Host Configuration Protocol, Address Resolution Protocol

Transport Layer

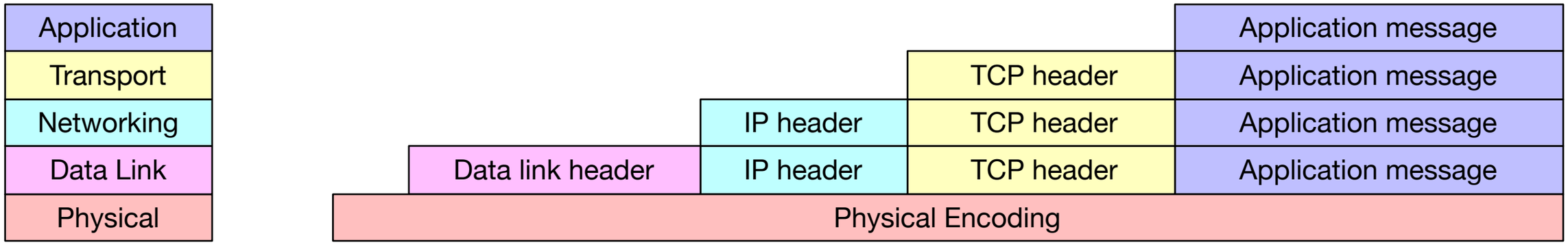
- Transmission Control Protocol
  - Provides flow control, error control, congestion control
- User Datagram Protocol
  - Connectionless without flow, error, and congestion control
- Stream Control Transmission Protocol
  - Designed for multimedia

Application Layer

- Two applications exchange messages
  - HTTP between browser and web-server
  - FTP
  - Telnet
  - SSH
  - SNMP
  - DNS
  - IGMP

Encapsulation

- Each layer adds a header (which could also be a tail or both) to a message

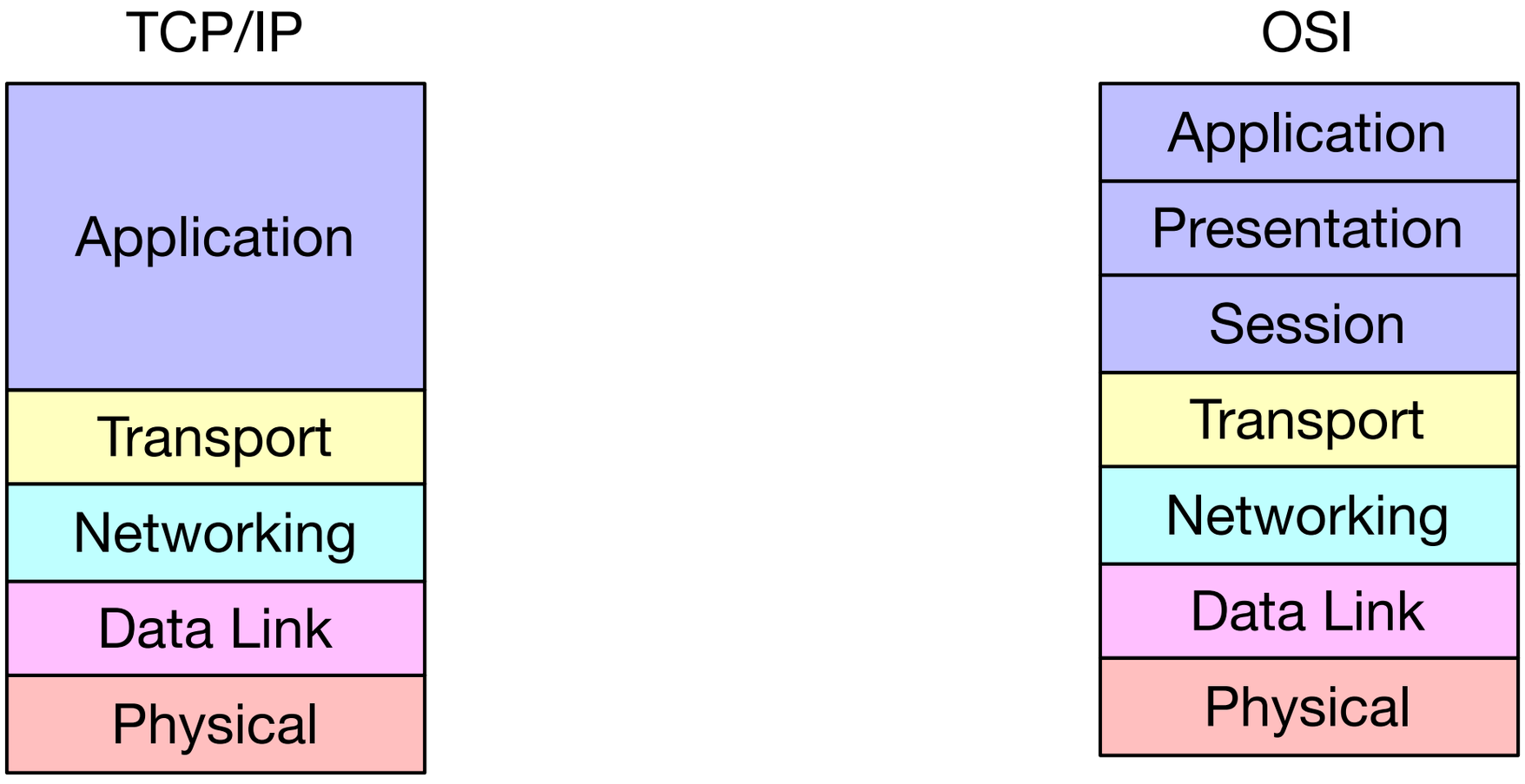


- For receiving, each layer strips its header

OSI Model

- Open Systems Interconnection (OSI) Model
  - After TCP/IP model (late 70s)
  - Established by International Organization of Standardization (ISO)
    - Came to late to change TCP/IP stack
    - Never defined some layers completely

OSI vs TCP/IP


TCP/IP
Application
Transport
Networking
Data Link
Physical
OSI
Application
Presentation
Session
Transport
Networking
Data Link
Physical

Internet Standards

- Proposed Standard
- Draft Standard (becomes RFC)
  - (after >1 successful interoperable implementations)
- **Internet Standard**
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