Client – Server Architecture

Networks Addressing Sockets

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Distributed systems

Independent machines work cooperatively without shared memory

They have to talk somehow

Interconnect is the **network**

Modes of connection

Circuit-switched

- dedicated path
- guaranteed (fixed) bandwidth
- [almost] constant latency

Packet-switched

- shared connection
- data is broken into chunks called packets
- each packet contains destination address
- available bandwidth $\leq$ channel capacity
- variable latency

What's in the data?

For effective communication

- same language, same conventions

For computers:

- electrical encoding of data
- where is the start of the packet?
- which bits contain the length?
- is there a checksum? where is it? how is it computed?
- what is the format of an address?
- byte ordering

Protocols

These instructions and conventions are known as **protocols**

Protocols

understand format of address and how to compute checksum

humans vs. whales
different wavelengths

versus

request web page

French vs. Hungarian

Layering

To ease software development and maximize flexibility:

- Network protocols are generally organized in **layers**
- Replace one layer without replacing surrounding layers
- Higher-level software does not have to know how to format an Ethernet packet
  - … or even know that Ethernet is being used

Layering

Most popular model of guiding (not specifying) protocol layers is

OSI reference model

Adopted and created by ISO

7 layers of protocols

OSI Reference Model: Layer 1

Transmits and receives raw data to communication medium.

Does not care about contents.

voltage levels, speed, connectors

1 **Physical**

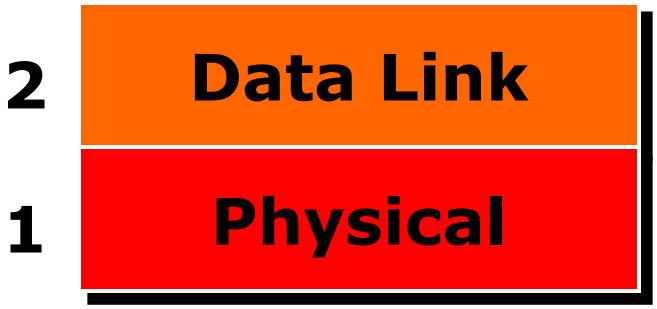
Examples: RS-232, 10BaseT

OSI Reference Model: Layer 2

Detects and corrects errors.

Organizes data into packets before passing it down. Sequences packets (if necessary).

Accepts acknowledgements from receiver.

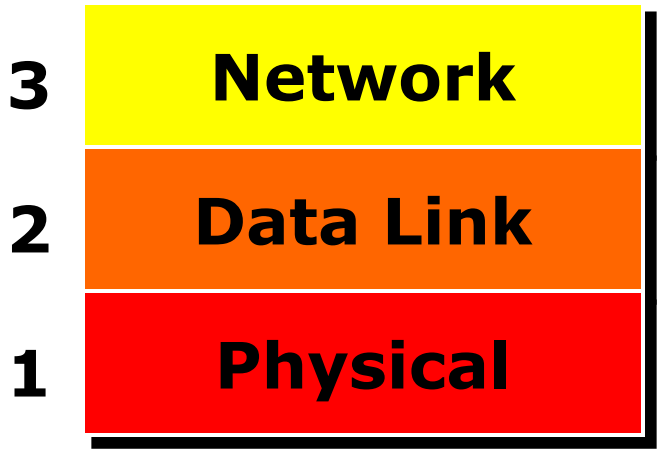


Examples: Ethernet MAC, PPP

OSI Reference Model: Layer 3

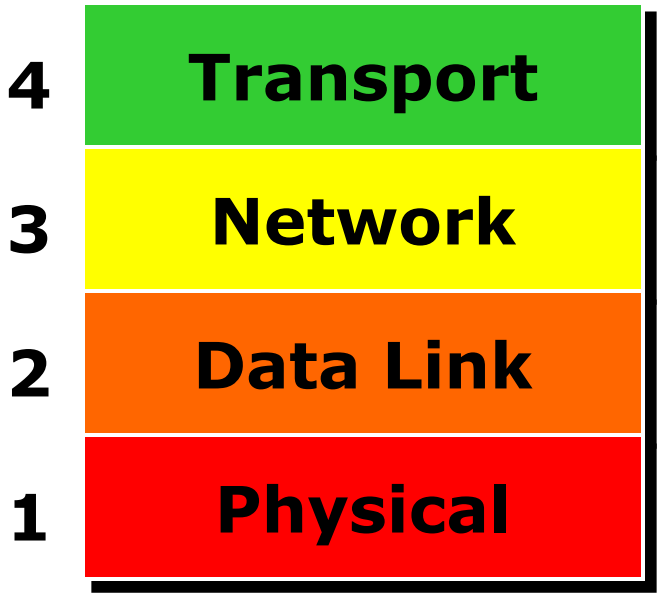
Relay and route information to destination.

Manage journey of packets and figure out intermediate hops (if needed).



Examples: IP, X.25

OSI Reference Model: Layer 4

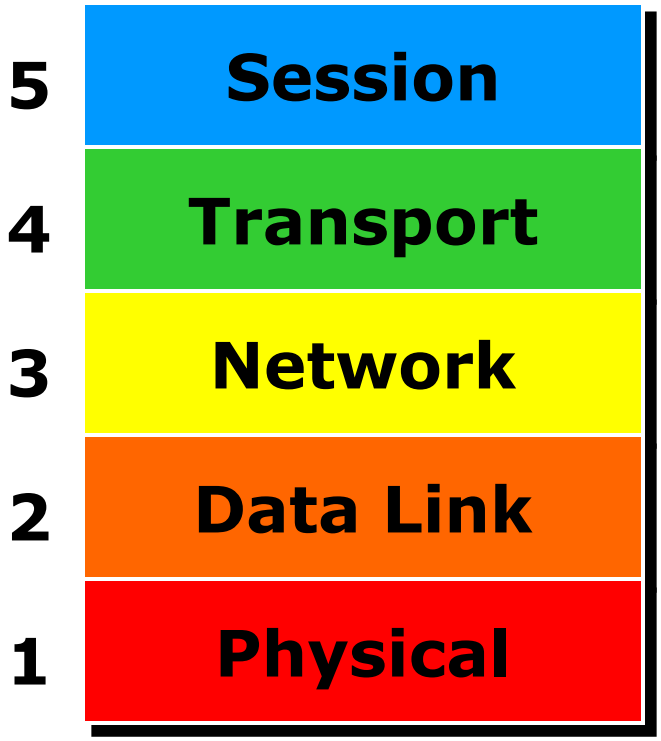


Provides a consistent interface for end-to-end (application-to-application) communication. Manages flow control.

Network interface is similar to a mailbox.

Examples: TCP, UDP

OSI Reference Model: Layer 5



Services to coordinate dialogue and manage data exchange.

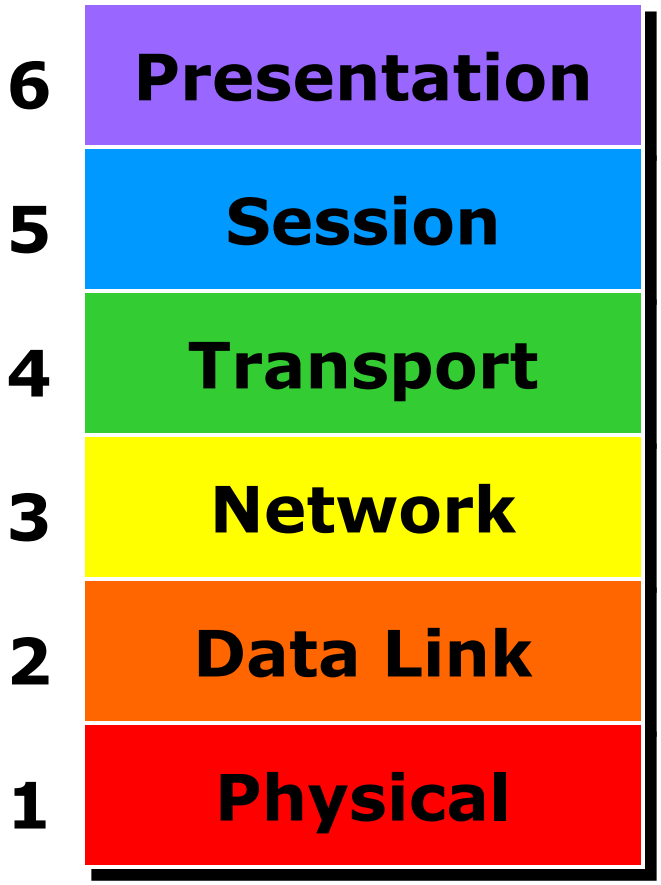
Software implemented switch.

Manage multiple logical connections.

Keep track of who is talking: establish & end communications.

Examples: HTTP 1.1, SSL, NetBIOS

OSI Reference Model: Layer 6



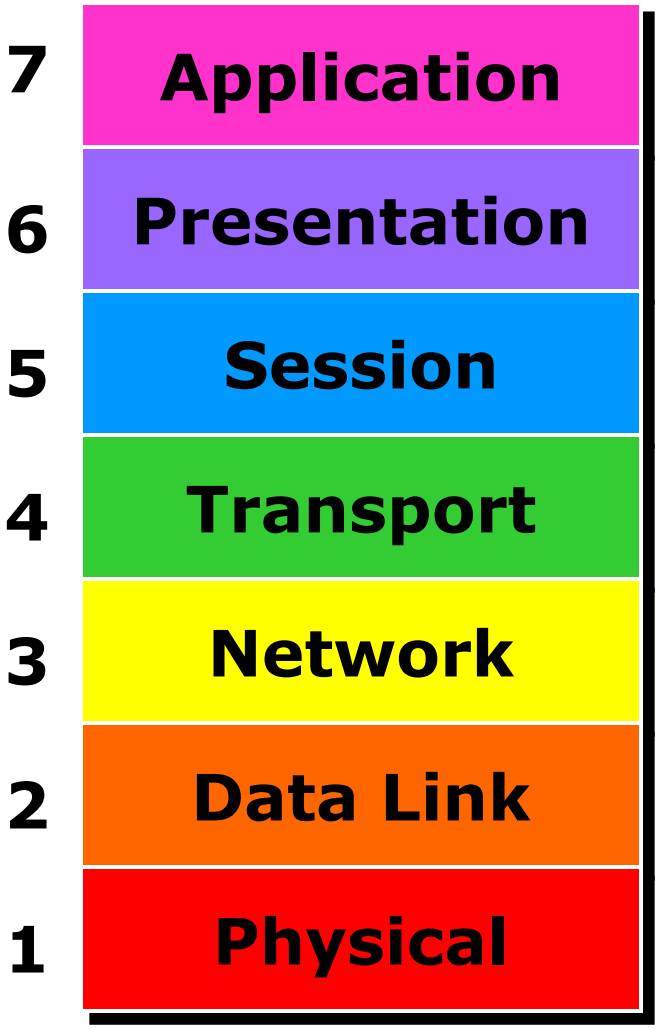
Data representation

Concerned with the meaning of data bits

Convert between machine representations

Examples: XDR, ASN.1, MIME, MIDI

OSI Reference Model: Layer 7



Collection of application-specific protocols

Examples:
email (SMTP, POP, IMAP)
file transfer (FTP)
directory services (LDAP)

Some networking terminology

Local Area Network (LAN)

Communications network

- small area (building, set of buildings)
- same, sometimes shared, transmission medium
- high data rate (often): 1 Mbps – 1 Gbps
- Low latency
- devices are peers
  - any device can initiate a data transfer with any other device

Most elements on a LAN are workstations

- endpoints on a LAN are called **nodes**

Connecting nodes to LANs

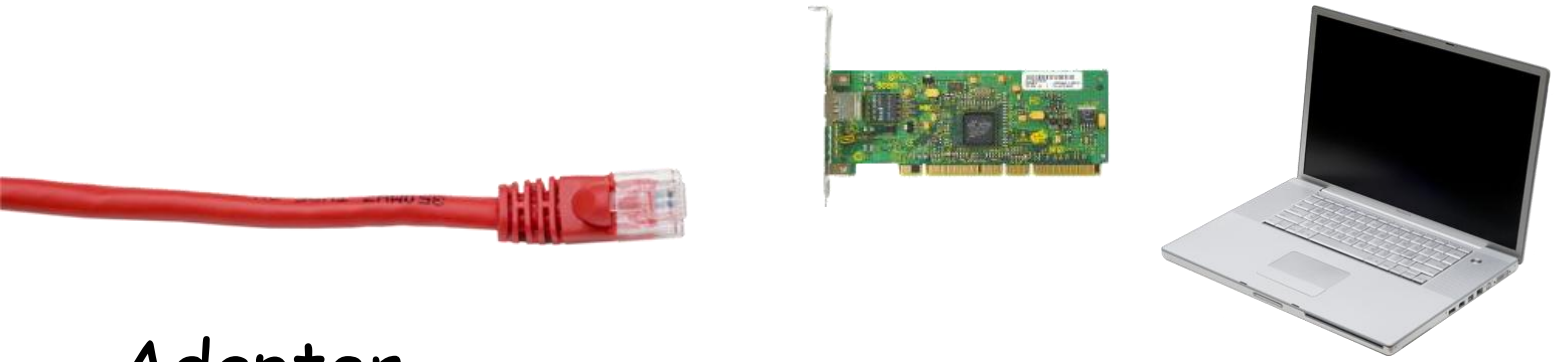
network

?

computer

Connecting nodes to LANs

network *computer*



Adapter

- expansion slot (PCI, PC Card, USB dongle)
- usually integrated onto main board

Network adapters are referred to as **Network Interface Cards** (**NICs**) or adapters or **Network Interface Component**

Media

Wires (or RF, IR) connecting together the devices that make up a LAN

Twisted pair

- Most common:
  - STP: shielded twisted pair
  - UTP: unshielded twisted pair
    (e.g. Telephone cable, Ethernet 10BaseT)

Coaxial cable

- Thin (similar to TV cable)
- Thick (e.g., 10Base5, ThickNet)

Fiber

Wireless

Hubs, routers, bridges

Hub

- Device that acts as a central point for LAN cables
- Take incoming data from one port & send to all other ports

Switch

- Moves data from input to output port.
- Analyzes packet to determine destination port and makes a virtual connection between the ports.

Concentrator or **repeater**

- Regenerates data passing through it

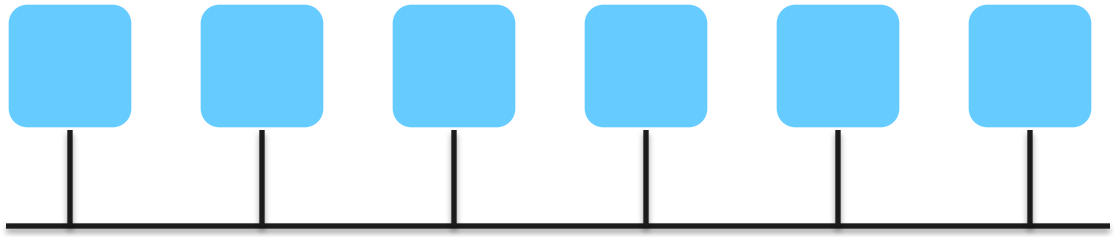
Bridge

- Connects two LANs or two segments of a LAN
- Connection at data link layer (layer 2)

Router

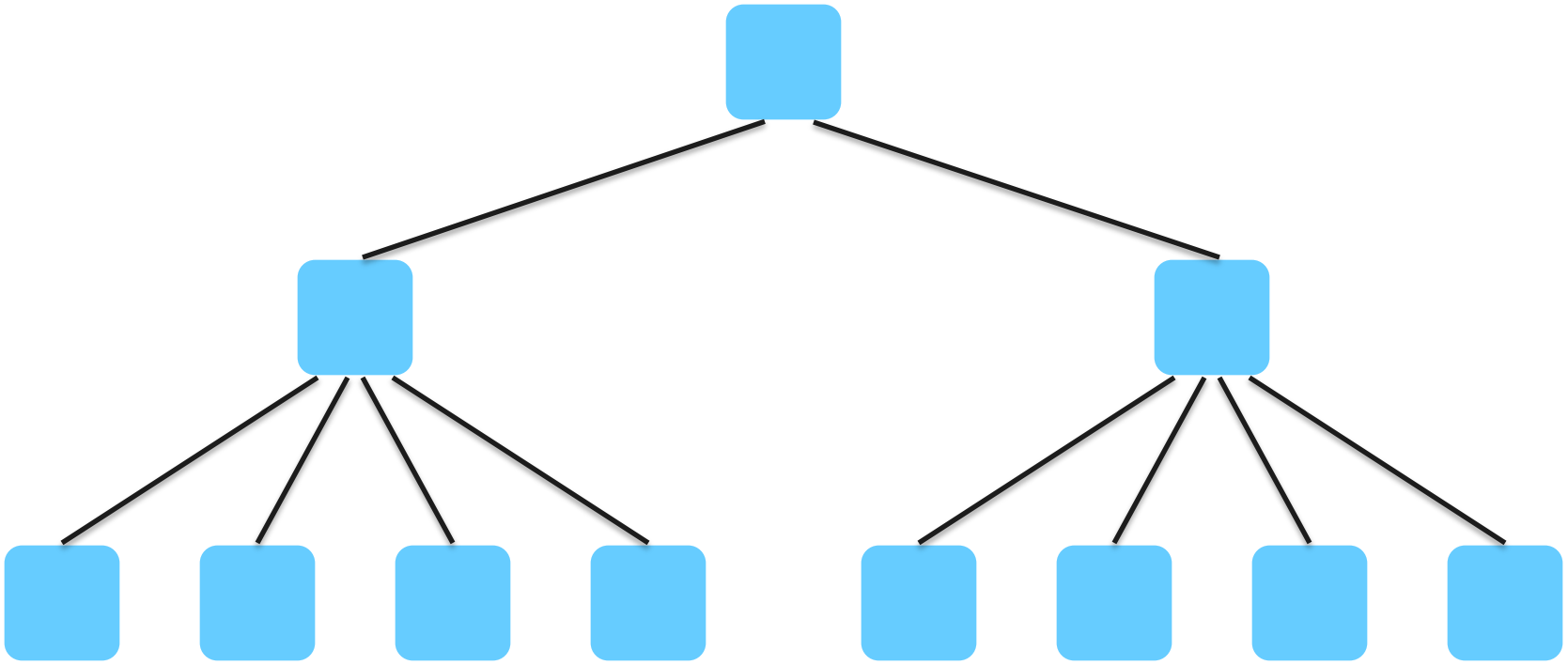
- Determines the next network point to which a packet should be forwarded
- Connects different types of local and wide area networks at network layer (layer 3)

Networking Topology



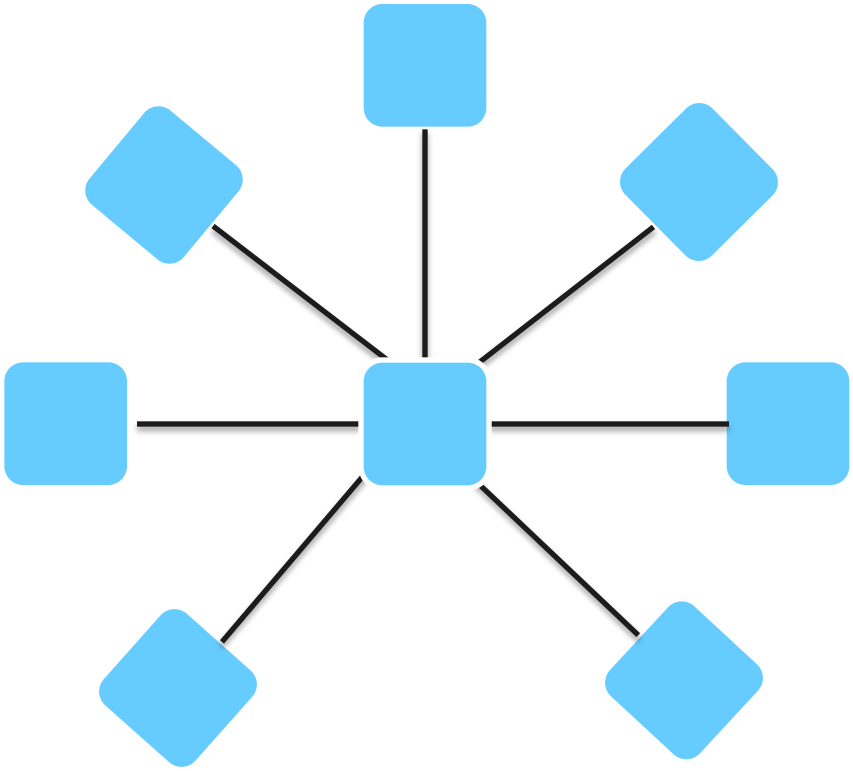
Bus Network

Networking Topology



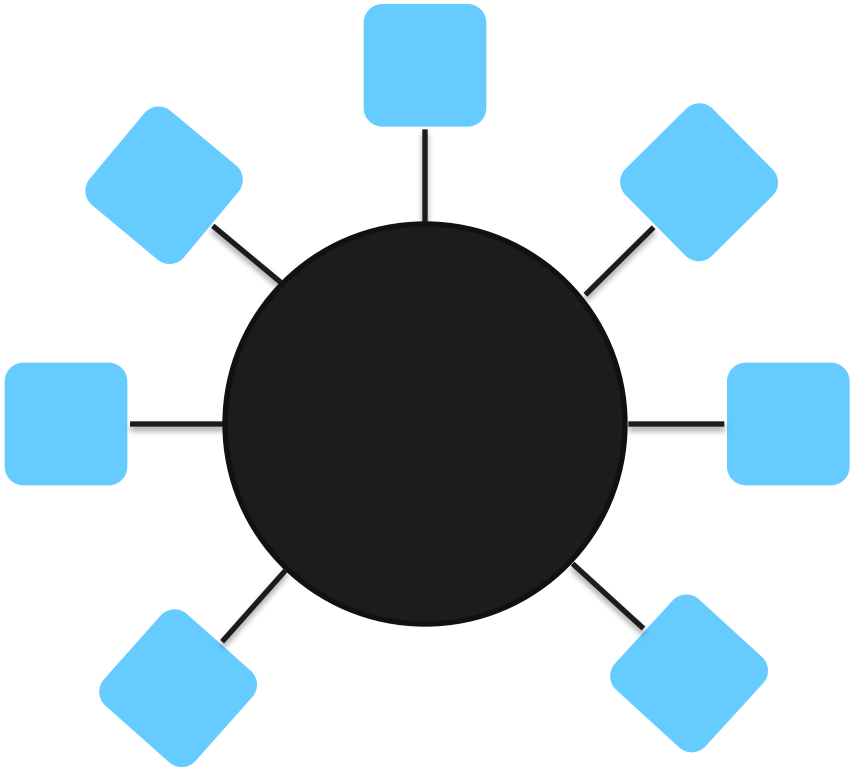
Tree Network

Networking Topology



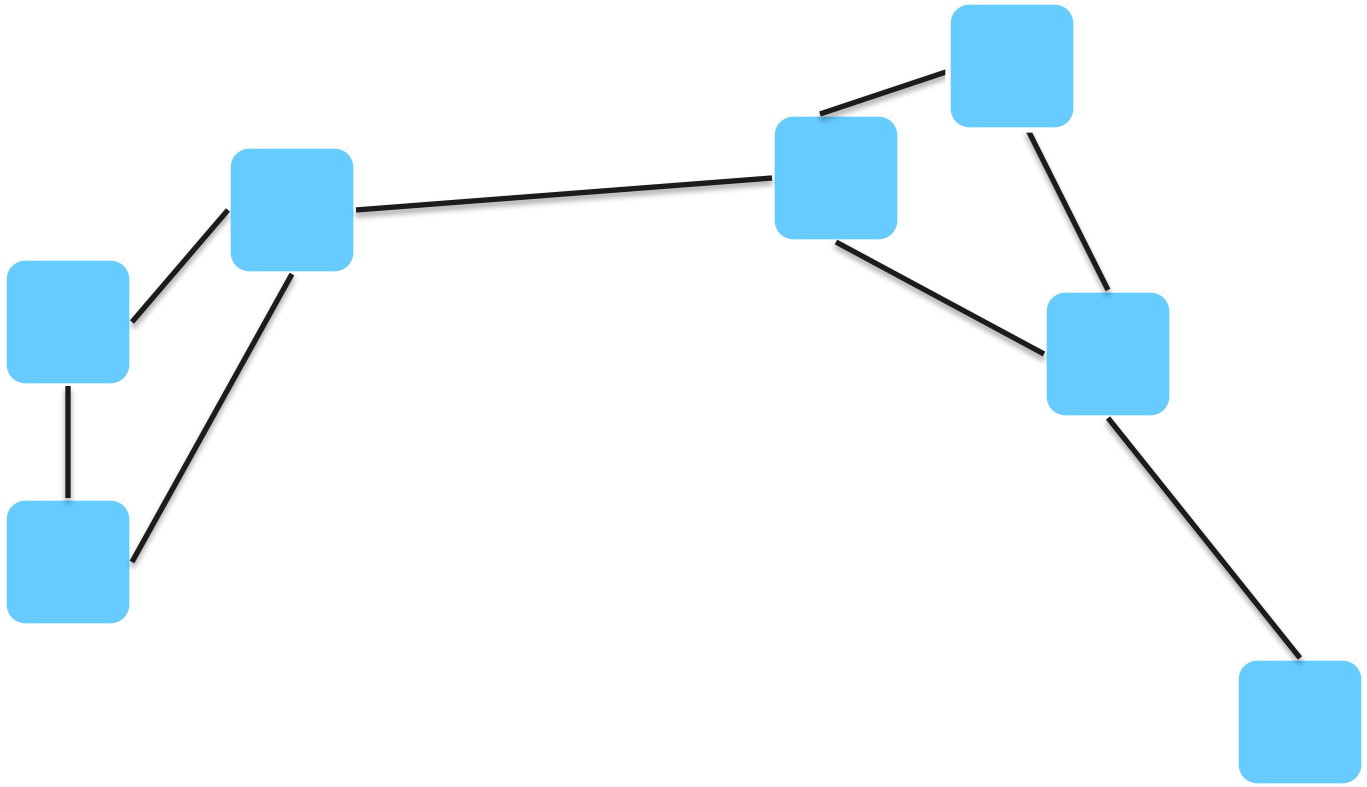
Star Network

Networking Topology



Ring Network

Networking Topology



Mesh Network

Transmission networks

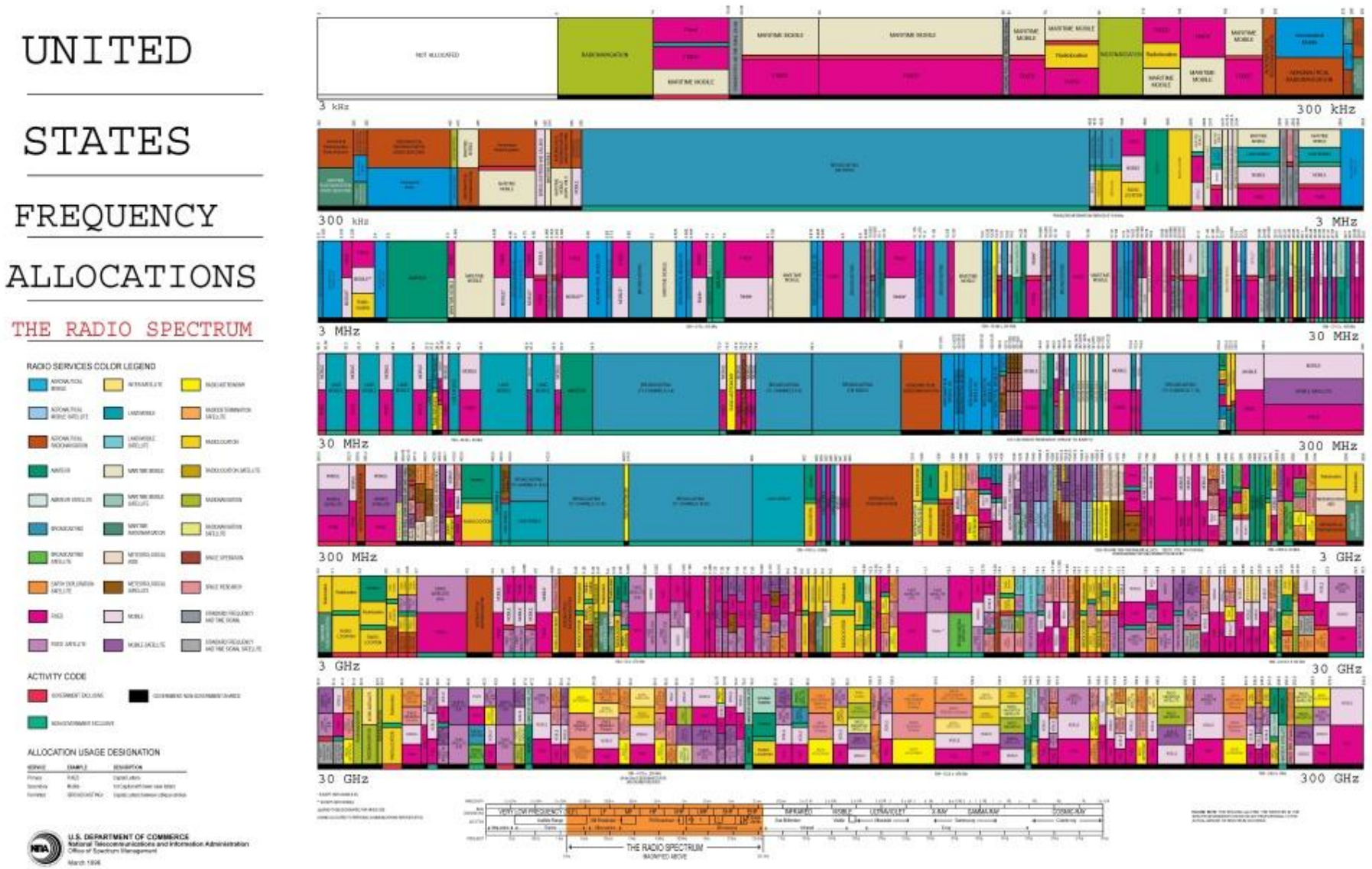
Baseband

- All nodes share access to network media on an equal basis
- Data uses entire bandwidth of media

Broadband

- Data takes segment of media by dividing media into channels (frequency bands)

Broadband: RF broadcasts

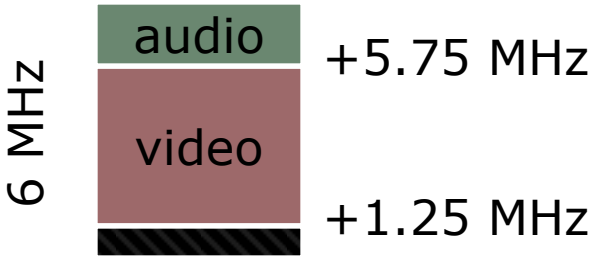


http://www.ntia.doc.gov/osmhome/allochrt.pdf

Broadband/Baseband: Cable TV

Broadband

55-552 MHz: analog channels 2-78
553-865 MHz: digital channels 79-136



Baseband within Broadband

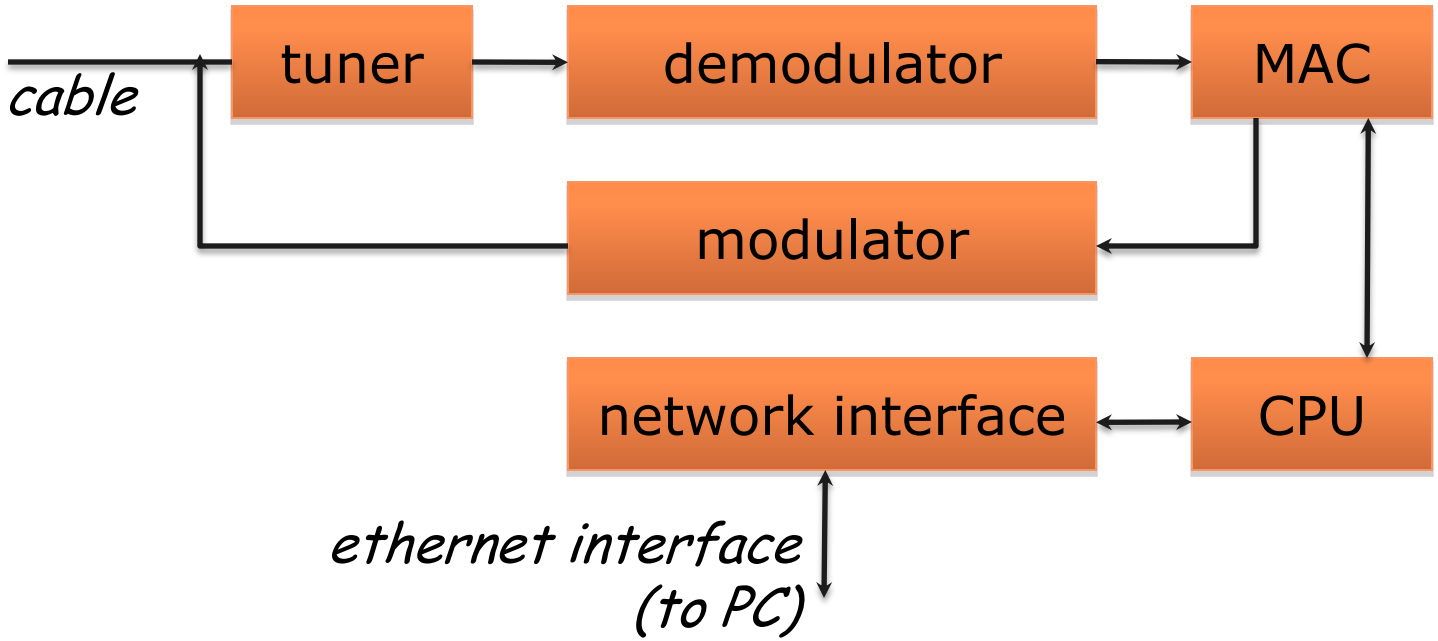
DOCSIS: Data Over Cable Service Interface Specification
(approved by ITU in 1998; DOCSIS 2.0 in 2001)

Downstream: 50-750 MHz range, 6 MHz bandwidth
- up to 38 Mbps
- received by all modems

Upstream: 5-42 MHz range
- 30.72 Mbps (10 Mbps in DOCSIS 1.0, 1.1)
- data delivered in timeslots (TDM)

DOCSIS 3.0 features channel bonding for greater bandwidth

DOCSIS Modem



Restrictions on upload/download rates set by transferring a configuration file to the modem via TFTP when it connects to the provider.

Baseband: Ethernet

Standardized by IEEE as 802.3 standard

Speeds: 100 Mbps - 1 Gbps typical today

- Ethernet: 10 Mbps
- Fast Ethernet: 100 Mbps
- Gigabit Ethernet: 1 Gbps
- 10 Gbps, 100 Gbps

Network access method is **Carrier Sense Multiple Access with Collision Detection (CSMA/CD)**

- Node first listens to network to see if busy
- Send
- Sense if collision occurred
- Retransmit if collision

Ethernet media

- Bus topology (original design)
  - originally thick coax (max 500m): 10Base5
  - then… thin coax (<200m): 10Base2
    - BNC connector
- Star topology (central hub or switch)
  - 8 pit RJ-45 connector, UTP cable, 100 meters range
  - 10BaseT for 10 Mbps
  - 100BaseT for 100 Mbps
  - 1000BaseT for 1 Gbps
  - Cables
    - CAT-5: unshielded twisted pair
    - CAT-5e: designed for 1 Gbps
    - CAT-6: 23 gauge conductor + separator for handling crosstalk better

Wireless Ethernet media

Wireless (star topology)

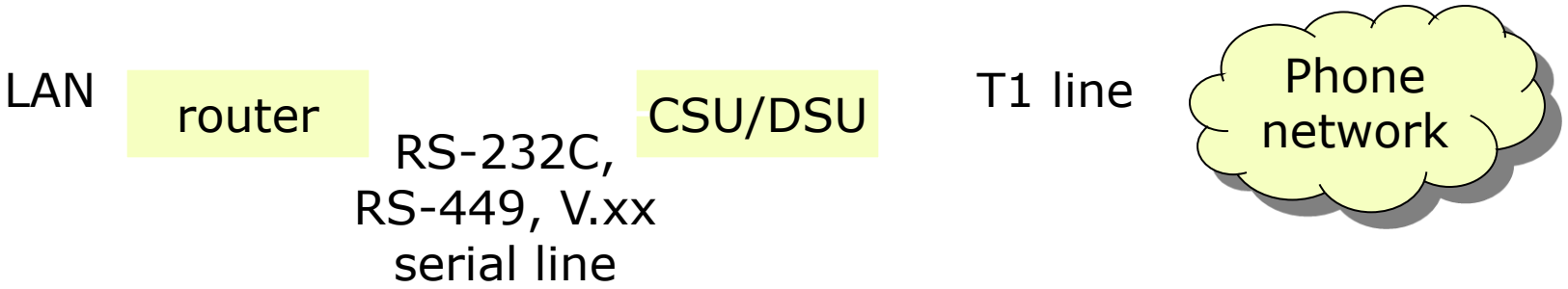
- 802.11 (1-2 Mbps)
- 802.11b (11 Mbps - 4-5 Mbps realized)
- 802.11a (54 Mbps - 22-28 Mbps realized)
- 802.11g (54 Mbps - 32 Mbps realized)
- 802.11n (108 Mbps - 30-47 Mbps realized)

Connecting to the Internet

- DOCSIS modem via cable TV service
- DSL router
  - Ethernet converted to ATM data stream
  - Up to 20 Mbps up to ~ 2 km.
  - POTS limited to 300-3400 Hz
  - DSL operates > 3500 Hz
- Modem
  - Data modulated over voice spectrum (300-3400 Hz)
  - Serial interface to endpoint
  - V.92: 48 kbps downstream, near 56 kbps up
  - Use PPP or SLIP to bridge IP protocol

Connecting to the Internet

- Dedicated T1 or T3 line
  - T1 line: 1.544 Mbps
    (24 PCM TDMA speech lines @ 64 kbps)
  - T3 line: 44.736 Mbps (672 channels)
  - CSU/DSU at router presents serial interface
    - Channel Service Unit / Data Service Unit



Connecting to the Internet

- Fiber to the Home, Fiber to the Curb
  - Ethernet interface
  - E.g., Verizon's FiOS 30 Mbps to the home
- Long Reach Ethernet (LRE)
  - Ethernet performance up to 5,000 feet
- Wireless:
  - WiMax
  - EDGE (70-135 Kbps)
  - GPRS (<32 Kbps)

Clients and Servers

- Send messages to *applications*
  - not just machines
- Client must get data to the desired *process*
  - server process must get data back to client process
- To offer a service, a server must get a **transport address** for a particular service
  - well-defined location

Questions