Chapter 1: Introduction

Lecturer: Lam Nhut Khang

9/2020

Slides are adapted from

[1] Computer Networks – An Open Source Approach. Ying-dar Lin, Ren-hung Hwang, Fred Baker

[2]Computer Networking: A Top-Down Approach. 8th Edition. Jim Kurose, Keith Ross, Pearson, 2020

[3] Sami Rollins, Computer network's slides, University of San Francisco, www.cs.usfca.edu

[4]Ajit Pal, CSE IIT, Kharagpur https://nptel.ac.in/course.html

The Internet: a "nuts and bolts" view

Billions of connected computing *devices*:

- *hosts* = *end systems*
- running *network apps* at Internet's "edge"

Packet switches: forward packets (chunks of data)

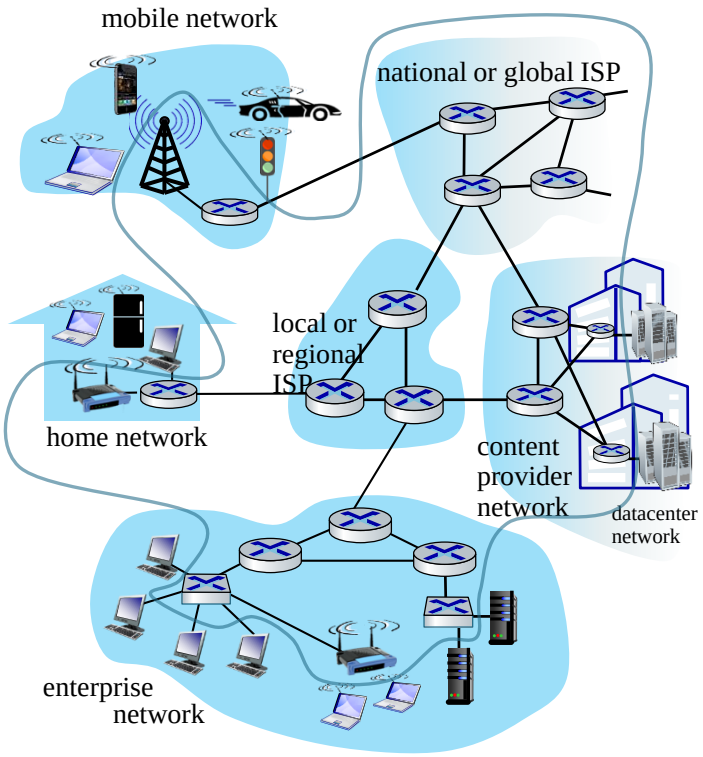
- *routers*, *switches*

Communication links

- fiber, copper, radio, satellite
- transmission rate: *bandwidth*

Networks

- collection of devices, routers, links: managed by an organization



“Fun” Internet-connected devices

Amazon Echo

Internet refrigerator

IP picture frame

Pacemaker & Monitor

Tweet-a-watt: monitor energy use

Web-enabled toaster + weather forecaster

Security Camera

Slingbox: remote control cable TV

AR devices

Internet phones

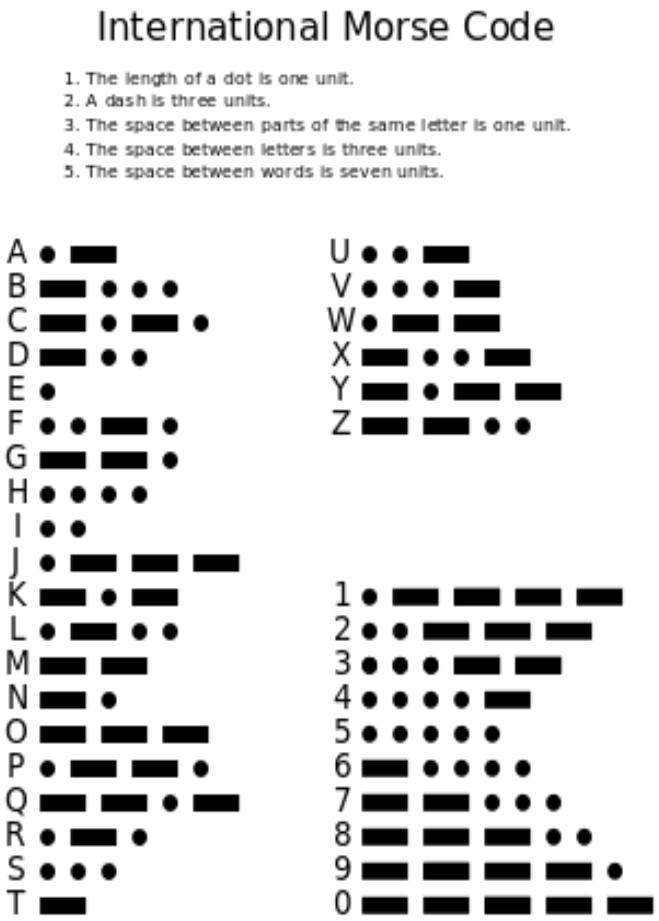
sensorized, bed mattress

Fitbit

Others?

Methods to transmit data

Morse code is a method used in telecommunication to encode text characters as standardized sequences of two different signal durations, called *dots* and *dashes* or *dits* and *dahs*



"International Morse code Recommendation ITU-R M.1677-1". itu.int. International Telecommunication Union. October 2009. Archived from the original on 6 November 2012. Retrieved 23 December 2011.

F. S. Beechey, Electro-Telegraphy, London: E. & F. N. Spon, 1876, p. 71

Methods to transmit data

Telephone network

- *Circuit switching* or *connection oriented network* consists of the simple process of establishing a physical circuit (the so-called dedicated communication path) between two devices.

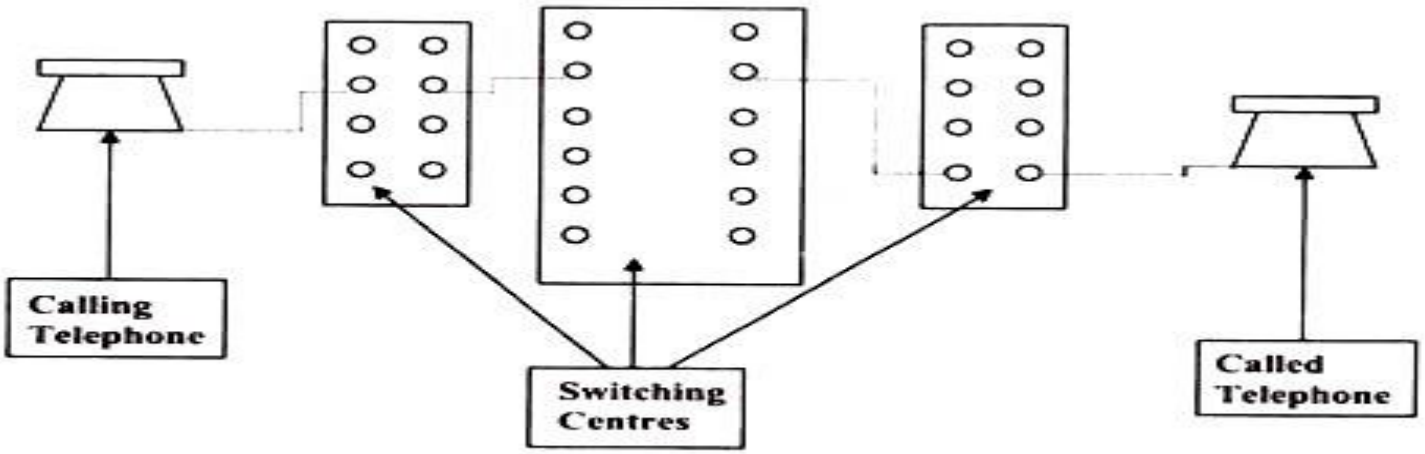


Fig. 6.4 Circuit-Switched Telephone Network

https://www.engineeringenotes.com/networking/methods-used-for-switching-in-telephone-systems-networking/14836

Computer network

Definition of a computer network:

- A *shared* platform through which a *large* number of users and applications *communicate* with each other.

Connectivity: *who and how to connect?*

Scalability: *how many to connect?*

Resource sharing: *how to utilize the connectivity?*

- Packet switching in datacom
- Circuit switching in telecom

Connectivity: Node, Link, Path

Another definition of a computer network (connectivity version):

- A *connected* platform constructed from a set of *nodes* and *links*, where any two nodes can reach each other through a *path* consisting of a sequence of nodes and links.

Node: host or gateway

- Host: end-point where users or applications reside
- Gateway: device to interconnect hosts

Link: point-to-point or broadcast

- Point-to-point: two end-points
- Broadcast: many attach-points

Path: routed or switched

- Routed: *stateless* concatenation of links
- Switched: *stateful* concatenation of links

Node: Host or Intermediary

Host

- Mainframe, workstation, desktop, hand-held, set-top-box, etc.
- Act as client or server, or both

Intermediary

- Hub, switch, router, gateway, etc.
- Wire-speed processing is a goal
- Embedded system with special ICs for speedup or cost reduction

Link: Point-to-Point or Broadcast

Access type

- Point-to-Point
  - Simplex, half-duplex, full-duplex
  - Usually WANs
- Broadcast
  - Multiple access: contend to transmit
  - Usually LANs (exception: satellite-based ALOHA)

Media type

- Wired
  - Twisted pair, coaxial cable, fiber optics
- Wireless
  - Radio(10^4~10^8 Hz), microwave (10^8~10^{11} Hz), infrared (10^{11}~10^{14} Hz)

Computer network structure

Network edge:

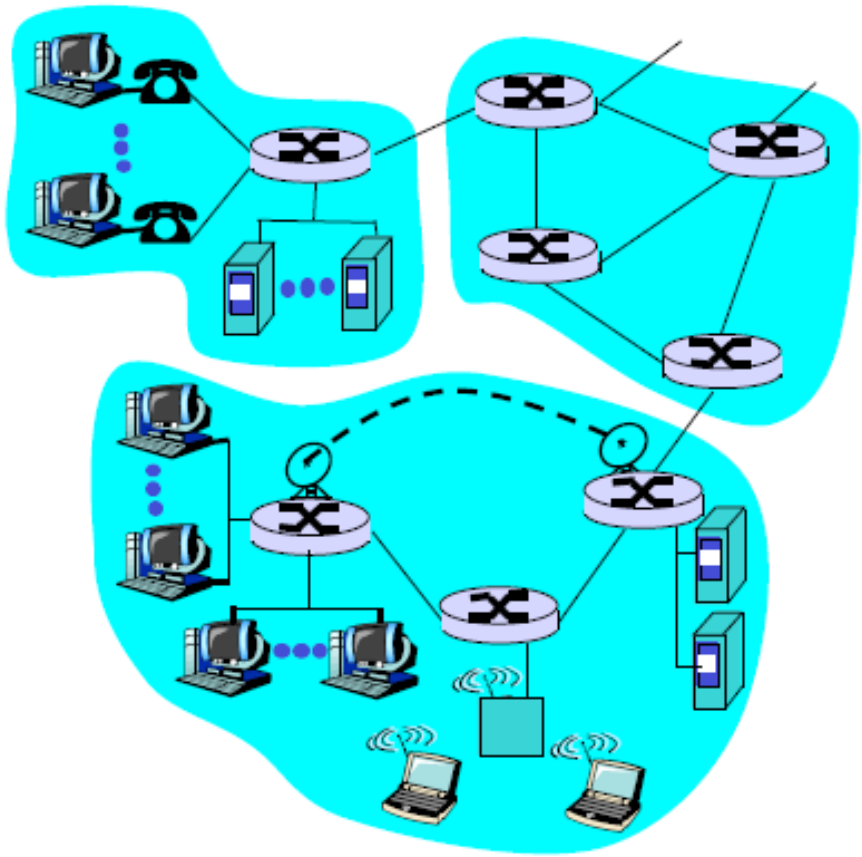
- applications and hosts

Network core:

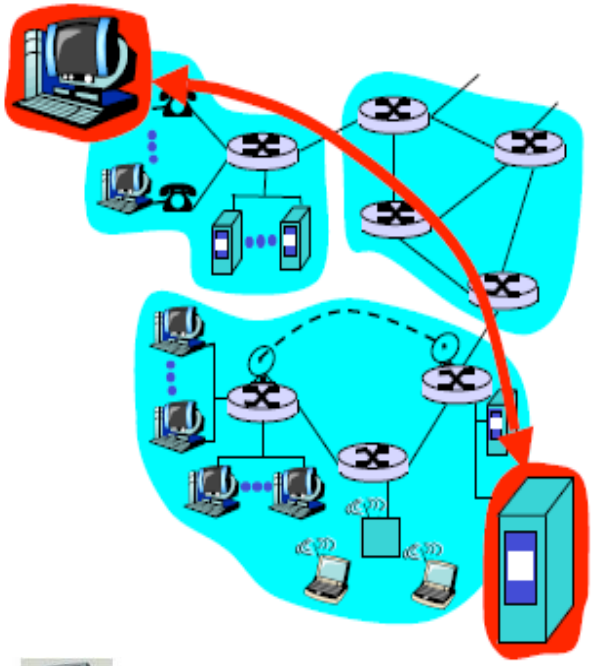
- Routers
- Network of networks

Access networks, physical media:

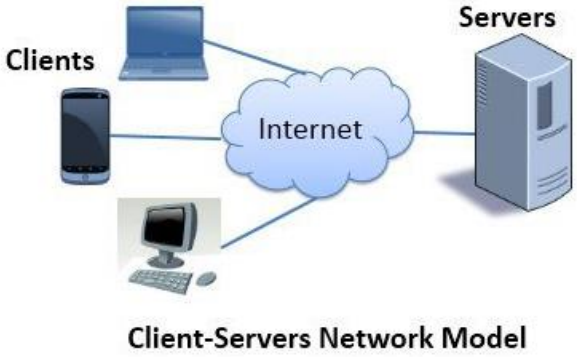
- Communication links



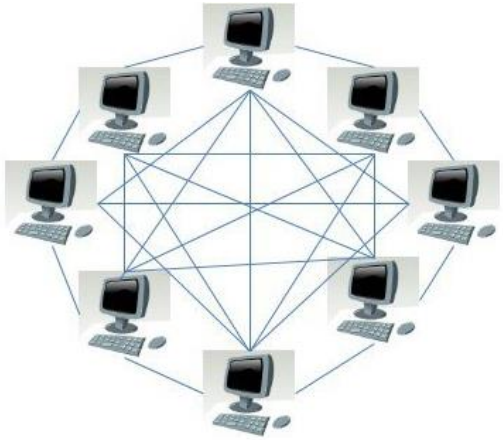
The network edge



- End systems (hosts)
  - Run application programs
  - e.g., web, email
- Client/Server model
- Peer-peer model



Client-Servers Network Model



Peer-to-Peer Network Model

https://techdifferences.com/difference-between-client-server-and-peer-to-peer-network.html

Internet services models

Connection-oriented service

- Data transfer between end systems
- TCP – Transmission Control Protocol
  - Reliable, byte-stream data transfer. If loss→ acknowledgements and retransmissions
  - Flow control: sender won't overwhelm receiver
  - HTTP, FTP, SMTP, Telnet

Connectionless service

- Data transfer between end systems
- UDP – User Datagram Protocol
  - Connectionless
  - Unreliable data transfer
  - No flow control
  - No congestion control
  - Streaming media, teleconferencing, DNS, Internet telephony

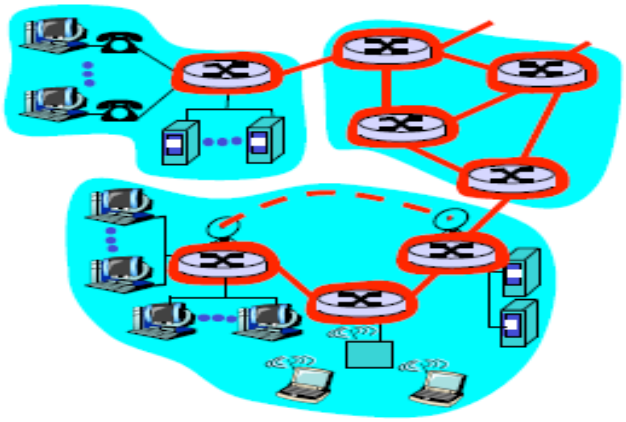
The network core

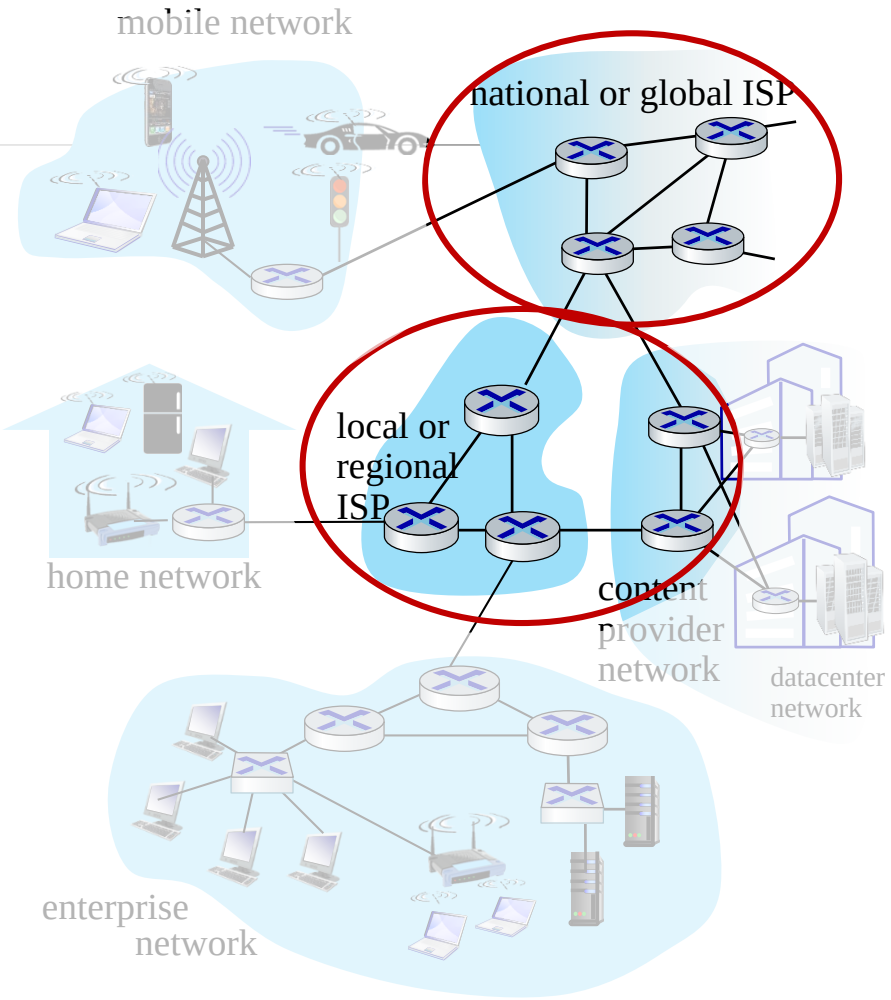
Mesh of interconnected routers

The fundamental question:

How is data transferred through net?

- Circuit switching: dedicated circuit per call (telephone net)
- Packet-switching: data sent through net in discrete "chunks"

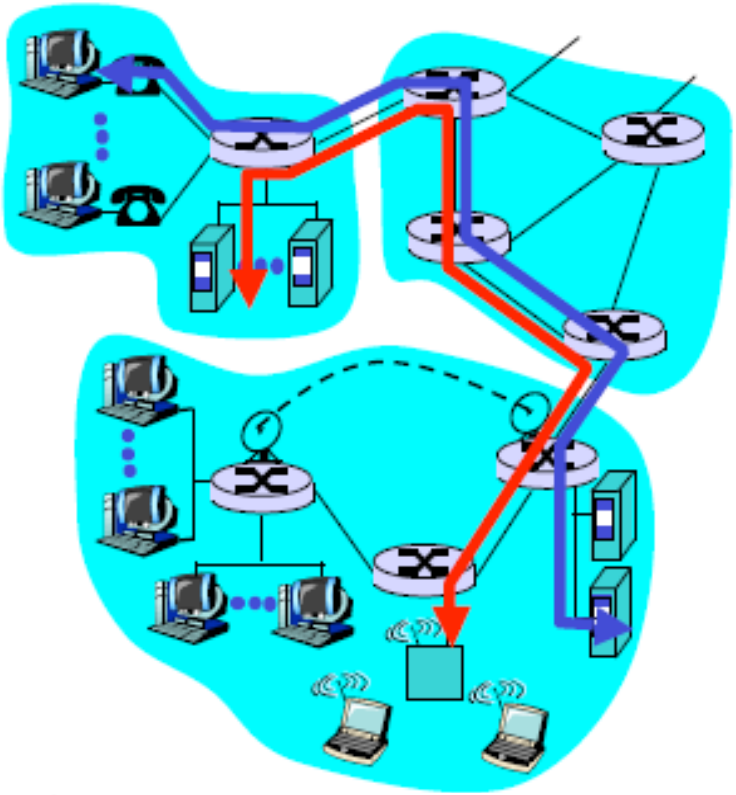


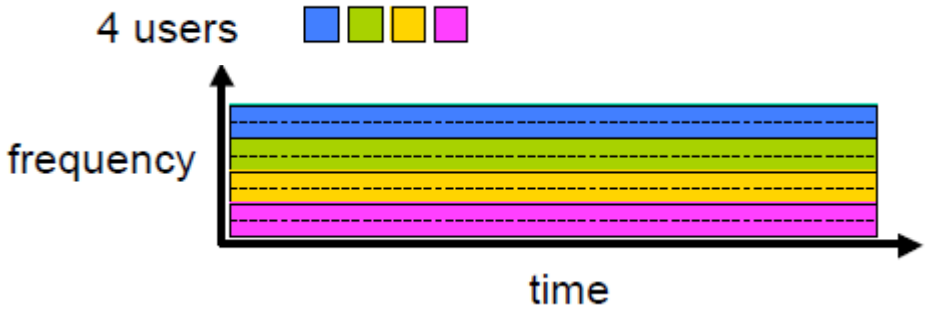


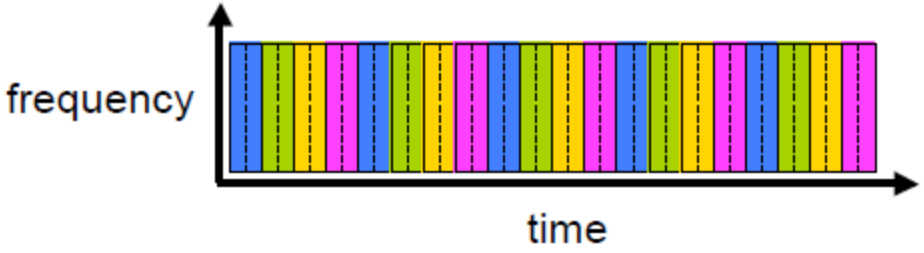
The network core: circuit switching

End-to-end resources reserved for "call"

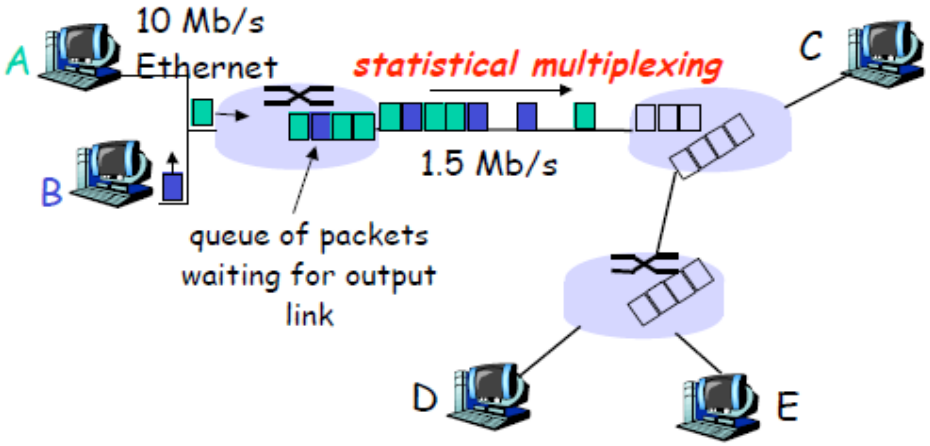
- Dedicated resources: no sharing
- Circuit-like (guaranteed) performance
- Call setup required
- Must divide link between into pieces
- E.g., Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA)







The network core: packet switching



Each end-end data stream divided into packets

- User A, B packets share network resources
- Each packet uses full link bandwidth
- Resources used as needed

Resource contention

- Aggregate resource demand can exceed amount available
- Congestion: packets queue, wait for link use
- Store and forward

Datagram network

- Destination address in packet determines next hop
- Routes may change during session
- Analogy: driving, asking directions
- Datagram network is NOT either connection-oriented or connectionless

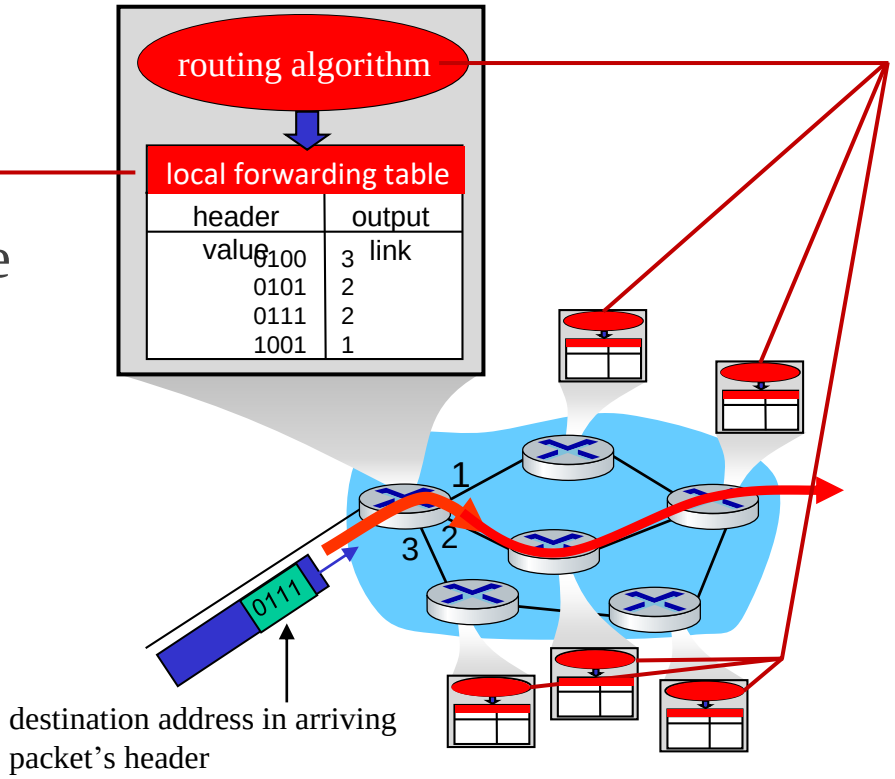
Virtual circuit network

- Each packet carries tag (virtual circuit ID), tag determines next hop
- Fixed path determined at call setup time
- Routes maintain per-call state

Two key network-core functions

Forwarding:

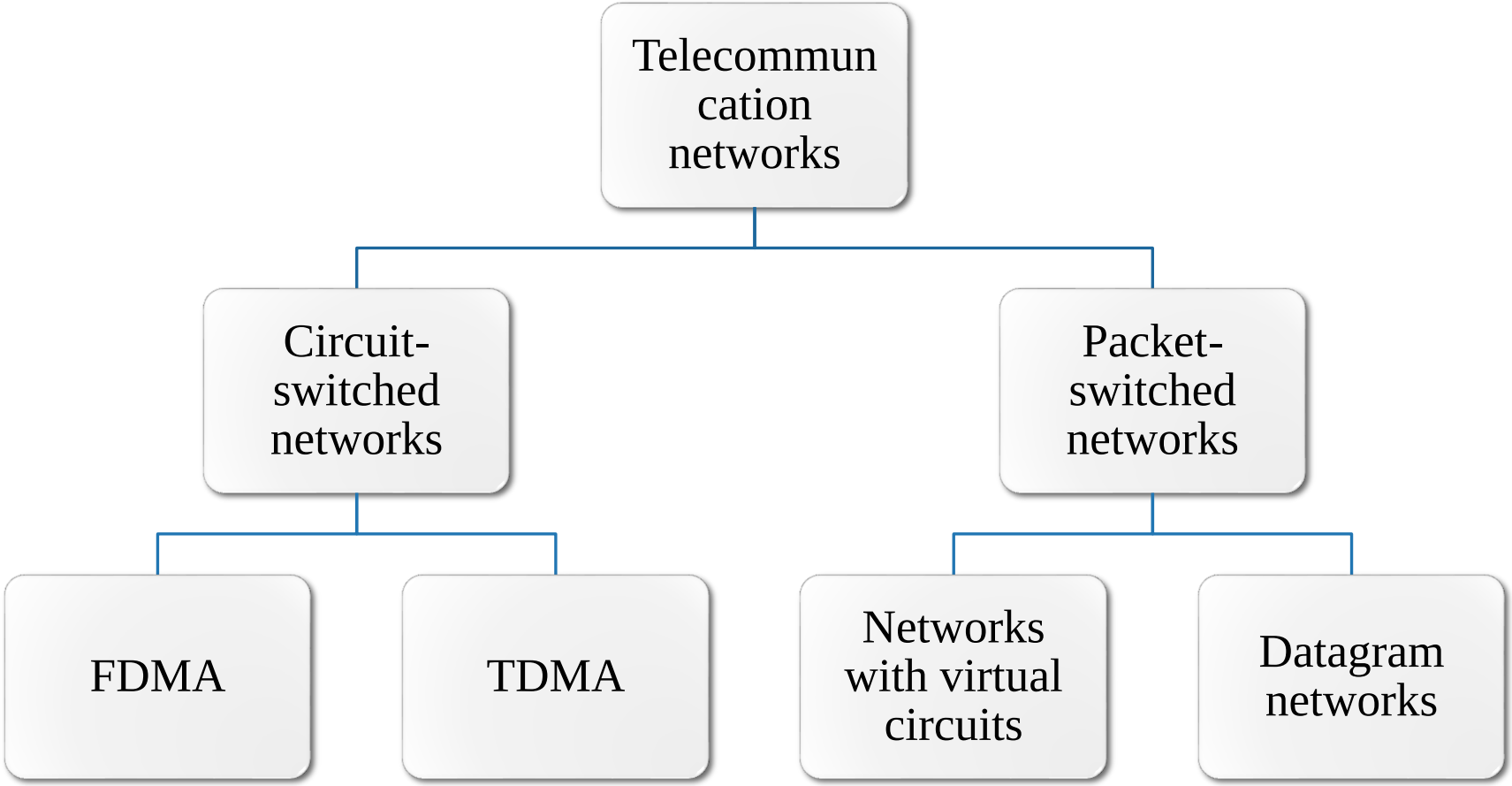
local action: move arriving packets from router's input link to appropriate router output link



Routing:

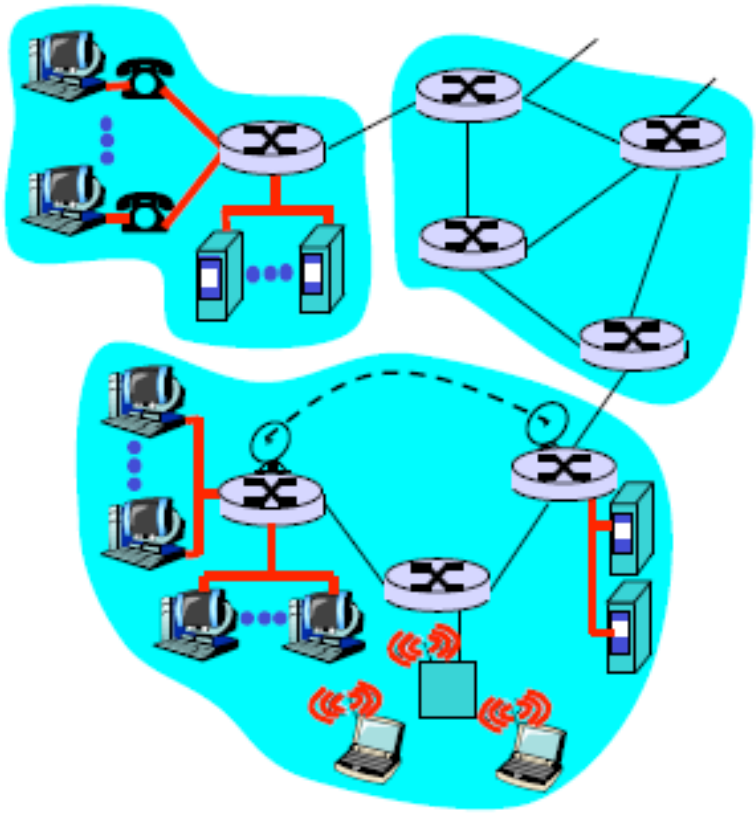
- *global* action: determine source-destination paths taken by packets
- routing algorithms

Network taxonomy



Access networks

- Connect end systems to edge router

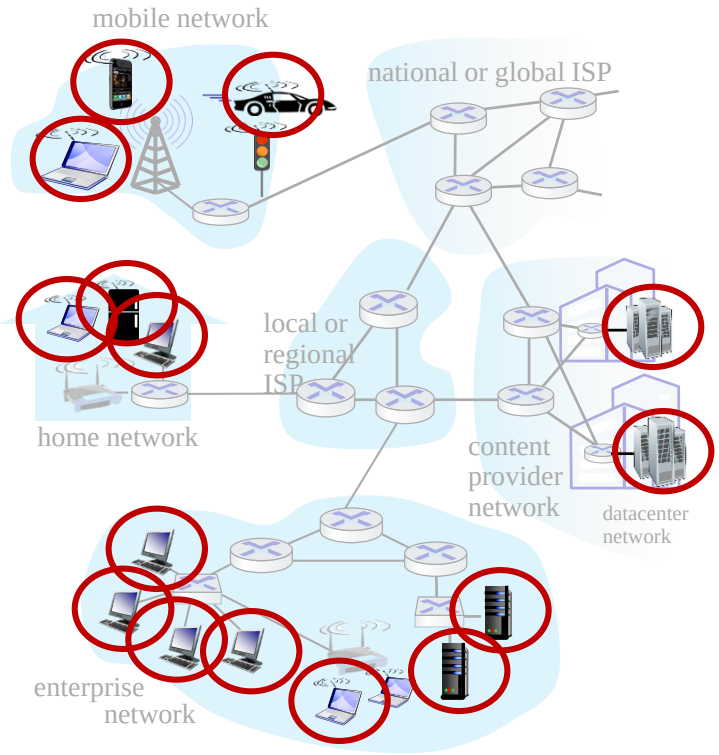


A closer look at Internet structure

Network edge:

hosts: clients and servers

servers often in data centers



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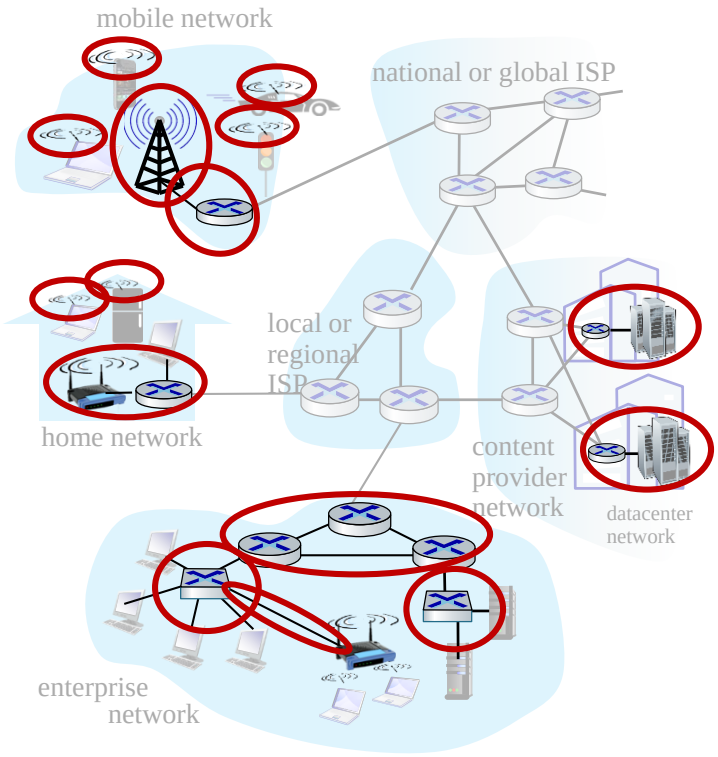
Access networks, physical media:

- wired, wireless communication links



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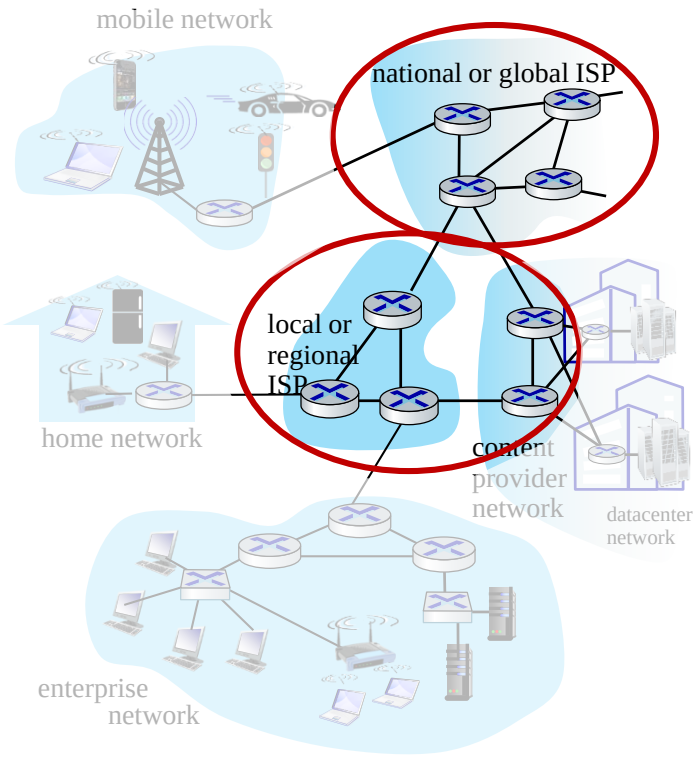


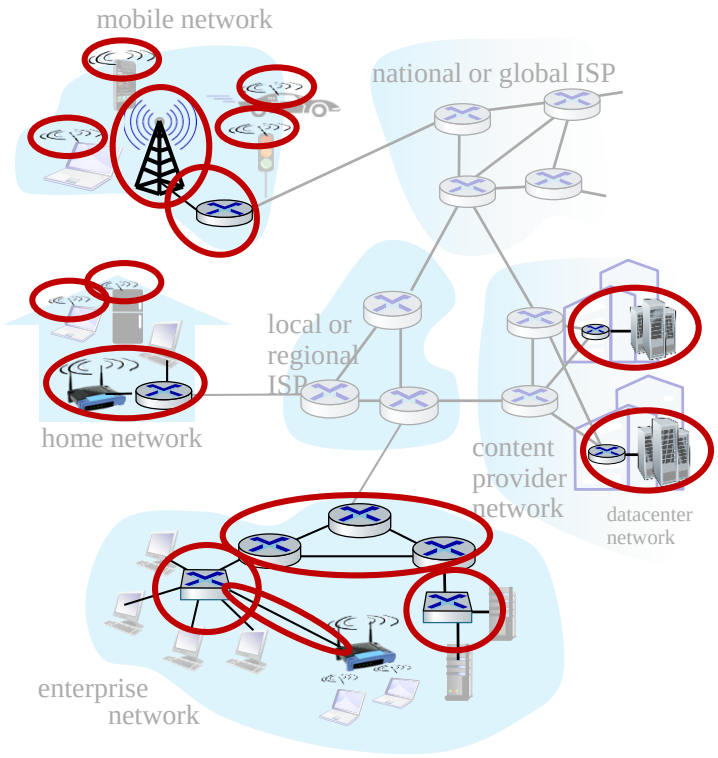
Access networks and physical media

Q: How to connect end systems to edge router?

residential access nets

institutional access networks (school, company)

mobile access networks (WiFi, 4G/5G)



What to look for:

- transmission rate (bits per second) of access network?
- shared or dedicated access among users?

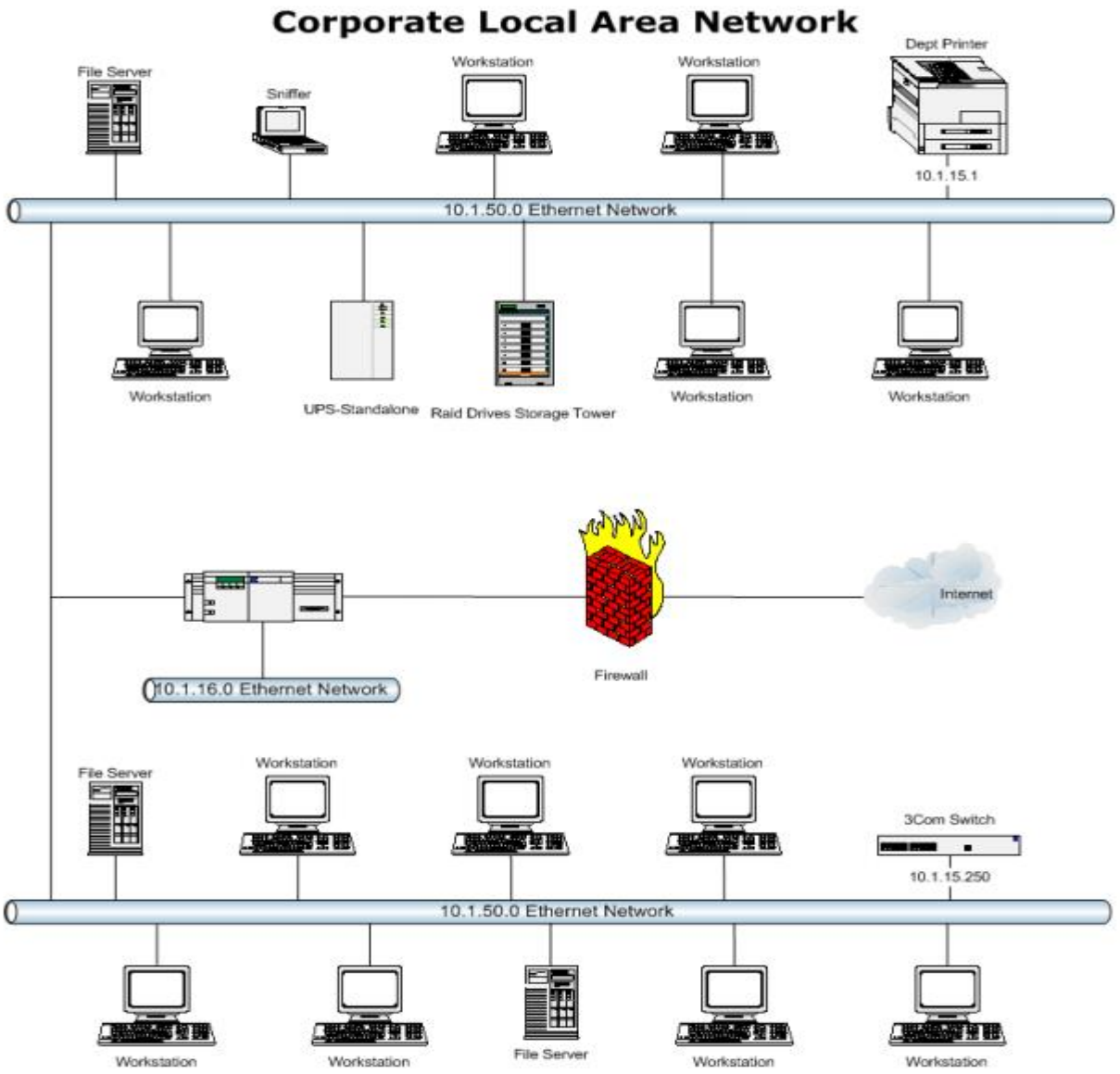
Types of networks

The two most common types of network infrastructures are:

- Local Area Network (LAN)
- Wide Area Network (WAN)

Other types of networks include:

- Metropolitan Area Network (MAN)
- Wireless LAN (WLAN)
- Storage Area Network (SAN)



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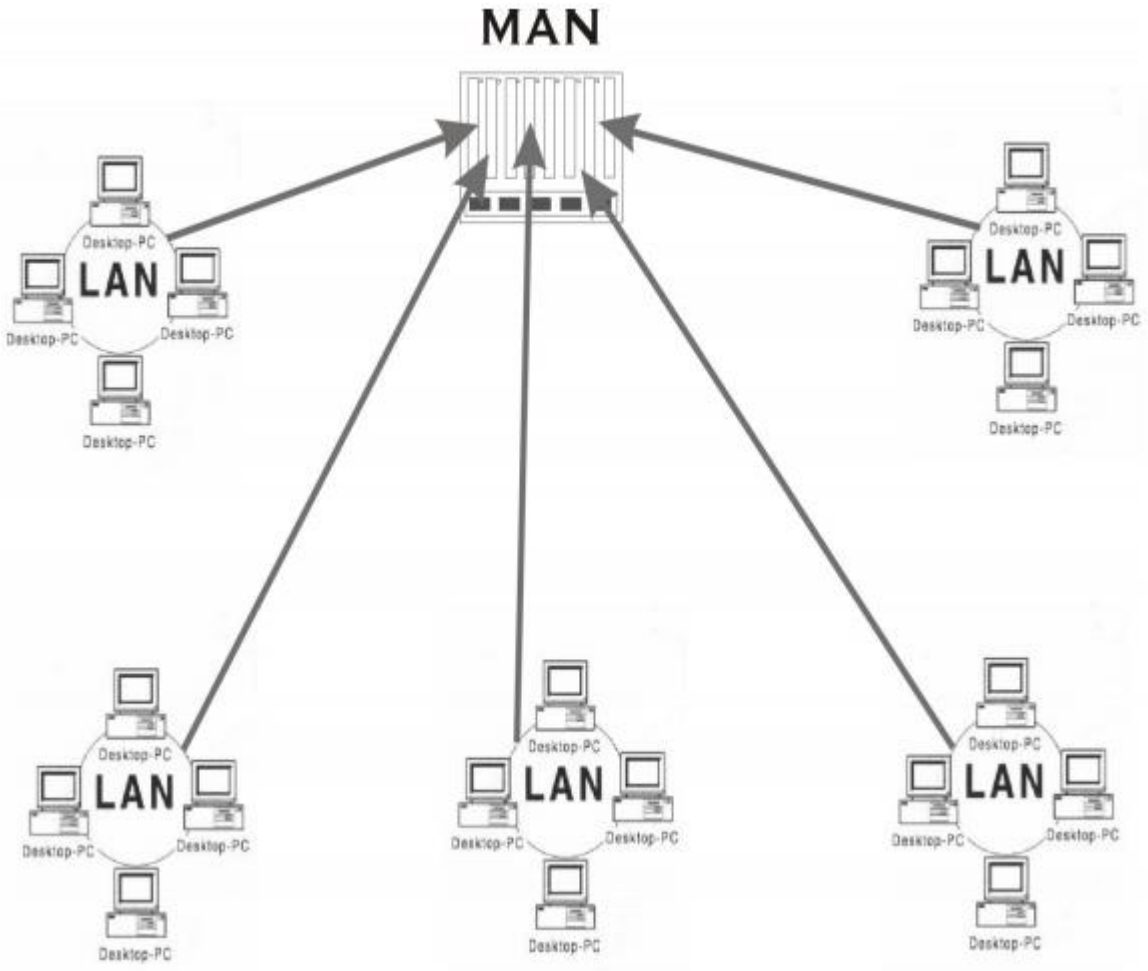
https://nptel.ac.in/course.html



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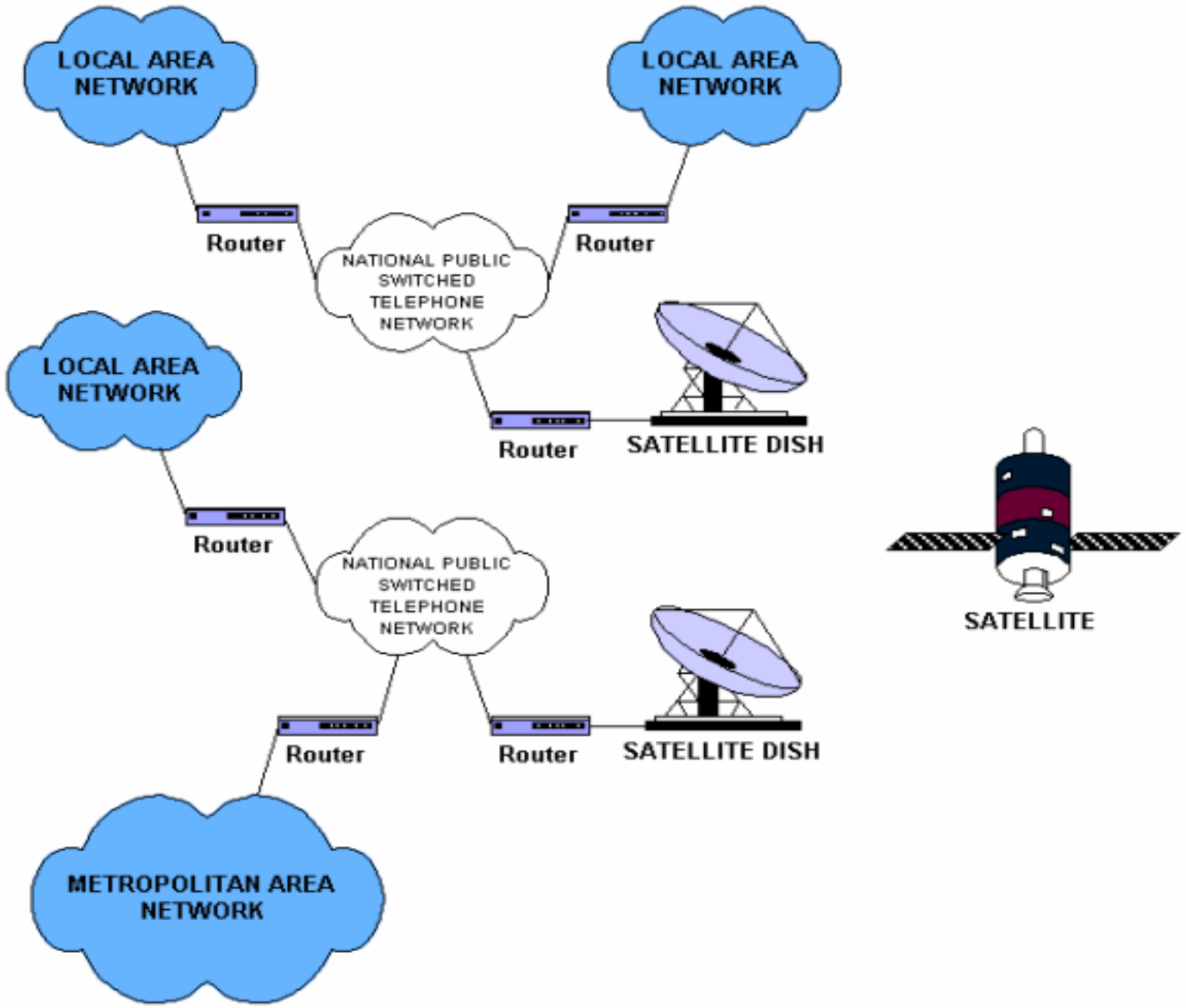

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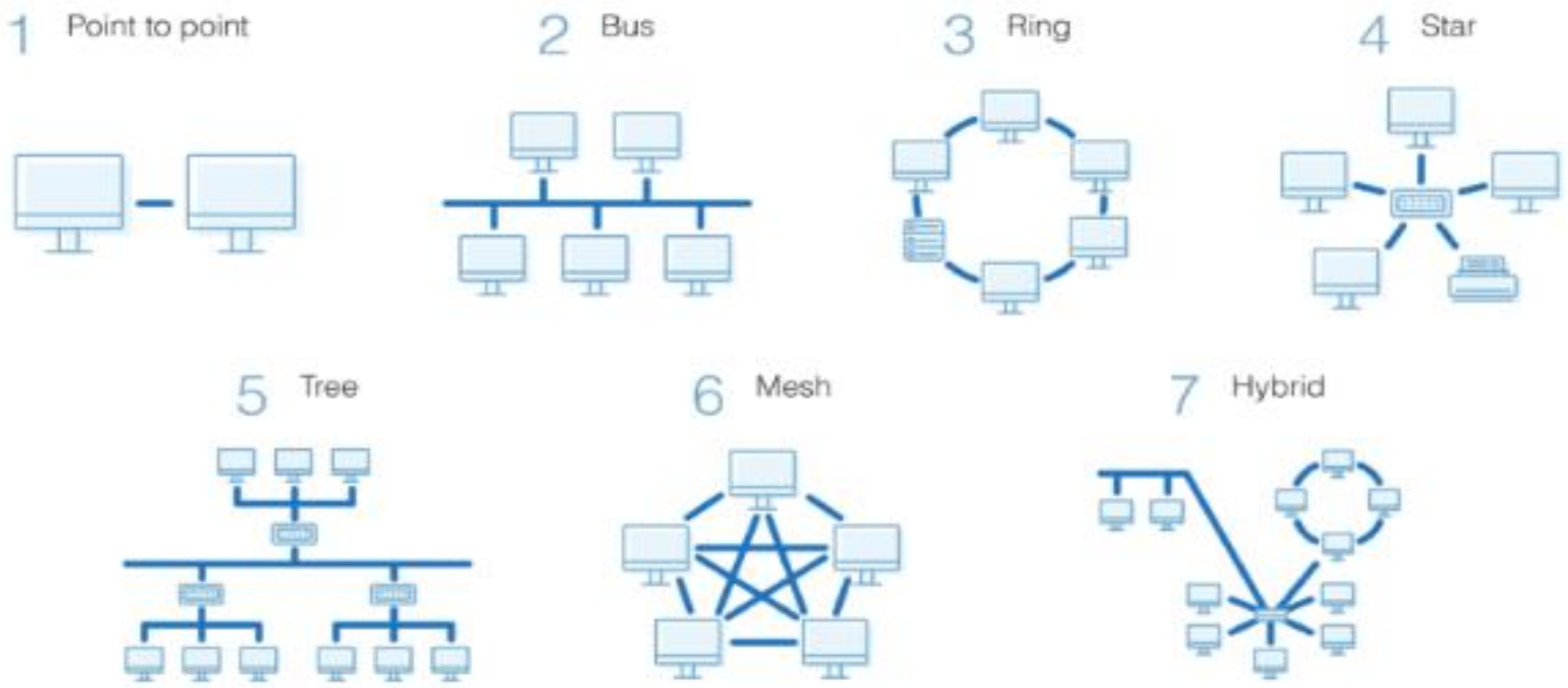
Network topology



https://www.dnsstuff.com/what-is-network-topology

What's a protocol?

human protocols:

"what's the time?"

"I have a question"

introductions

network protocols:

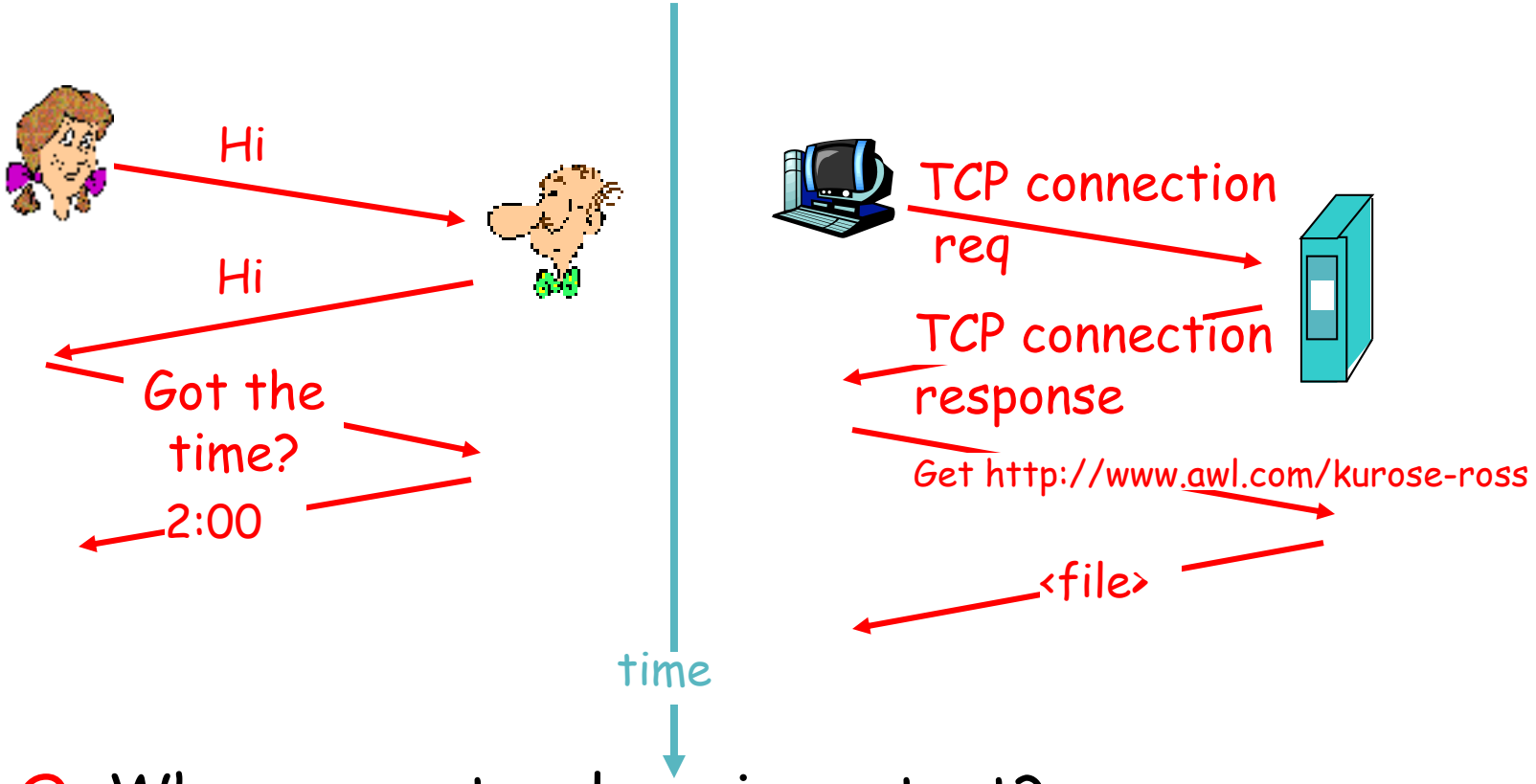
machines rather than humans

all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:

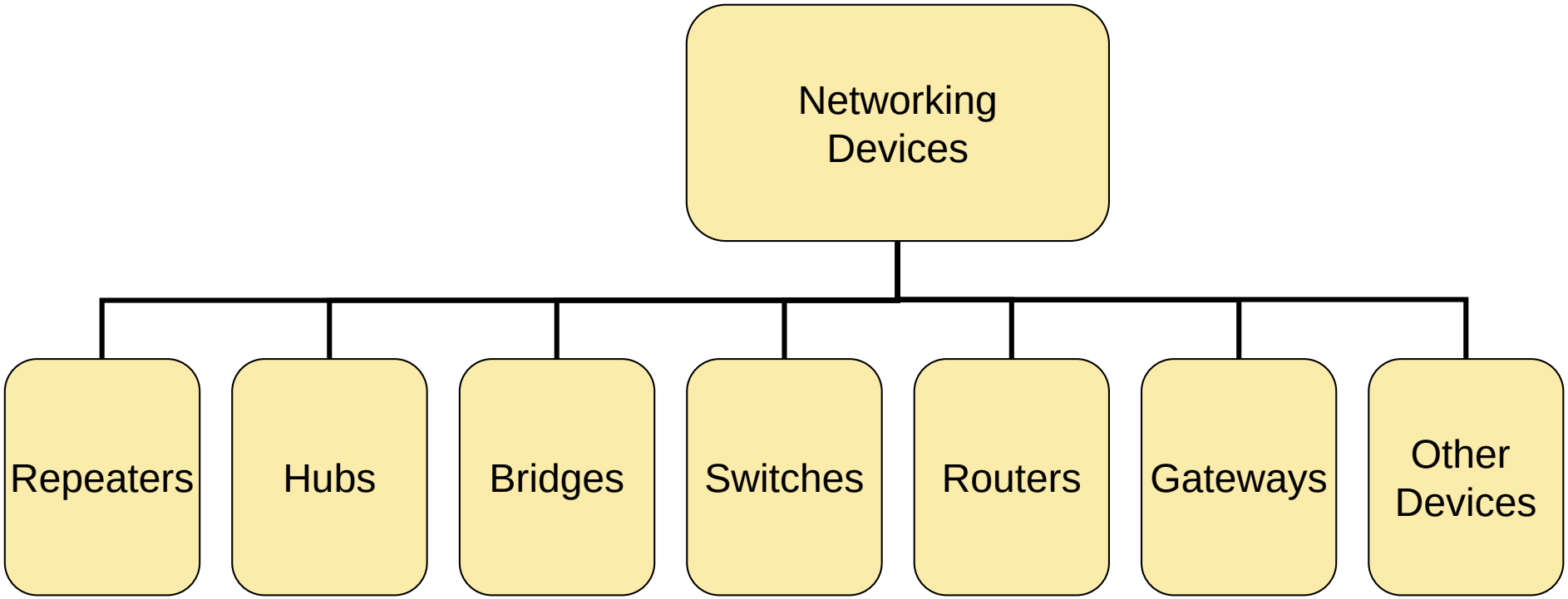


Q: Why are protocols so important?

Network protocols

- Rules of Communication
- Network Protocols and Standards
- Moving Data in the Network

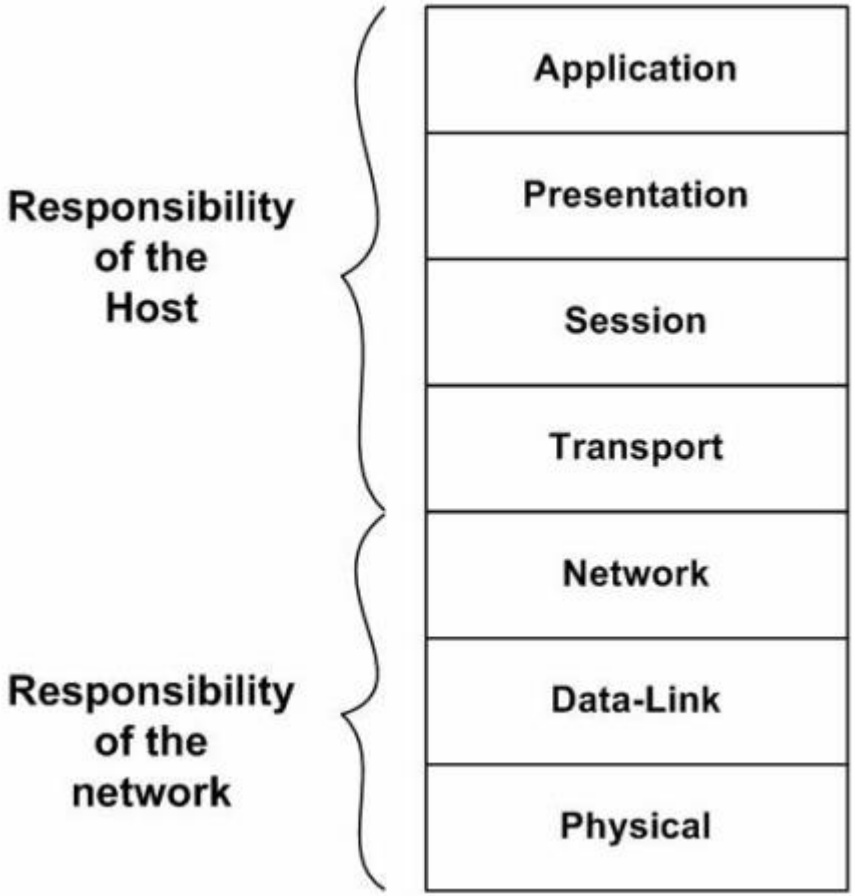
Networking devices



OSI model

OPEN SYSTEMS INTERCONNECTION MODEL

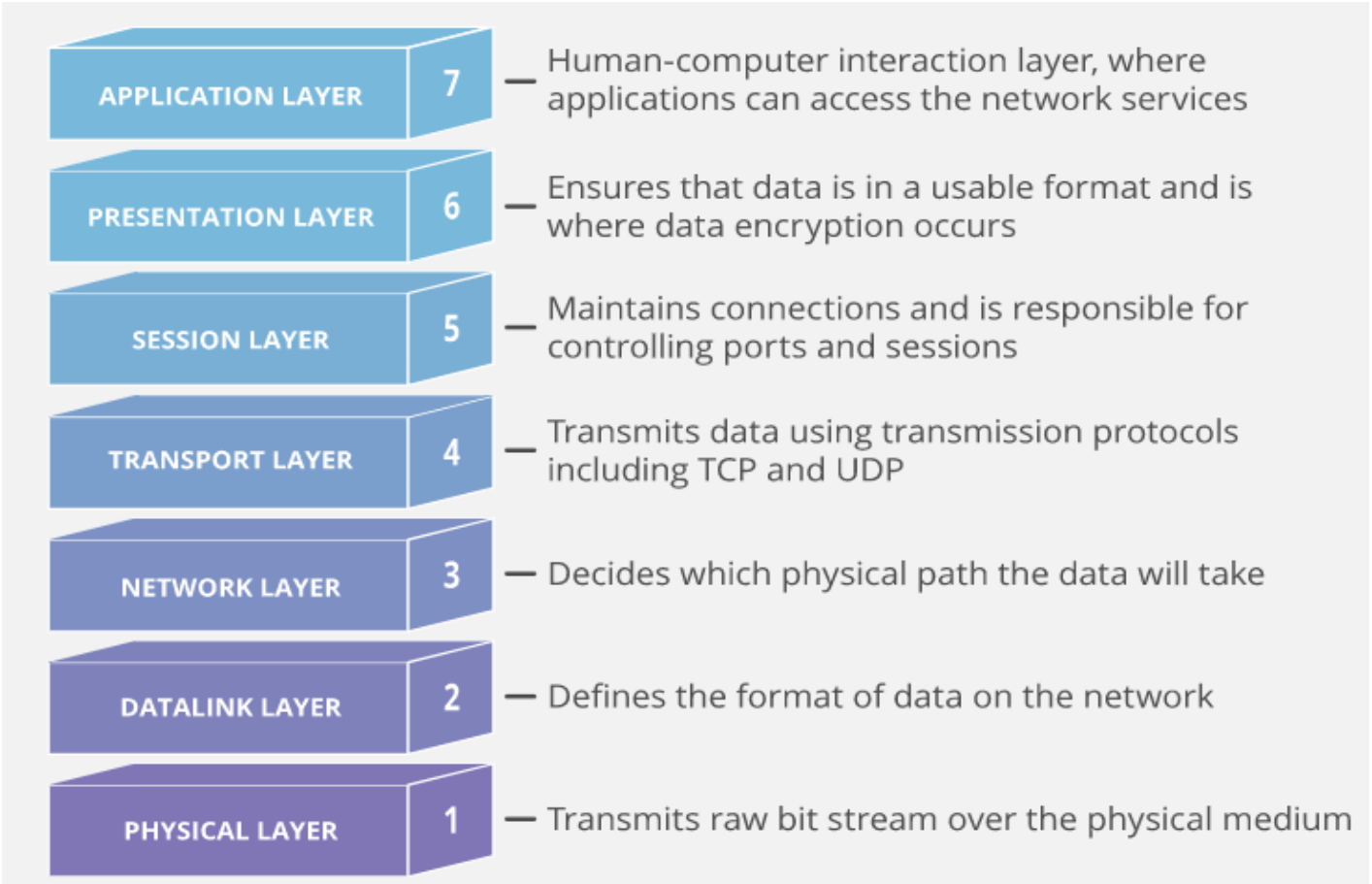
OSI model

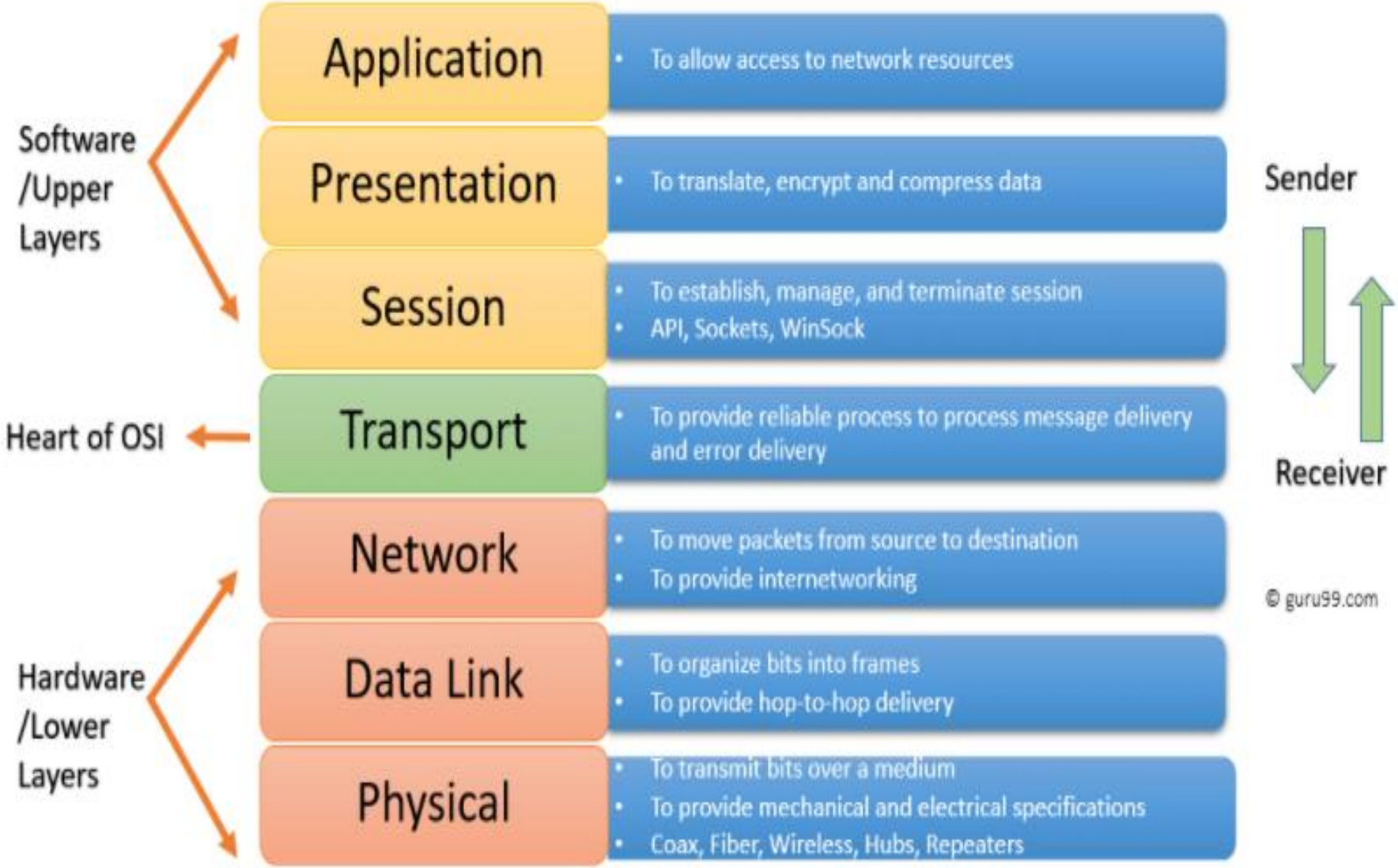


- Developed by the ISO
- Describe flow of information from one computer to others
- Consist of 7 layers

OSI model

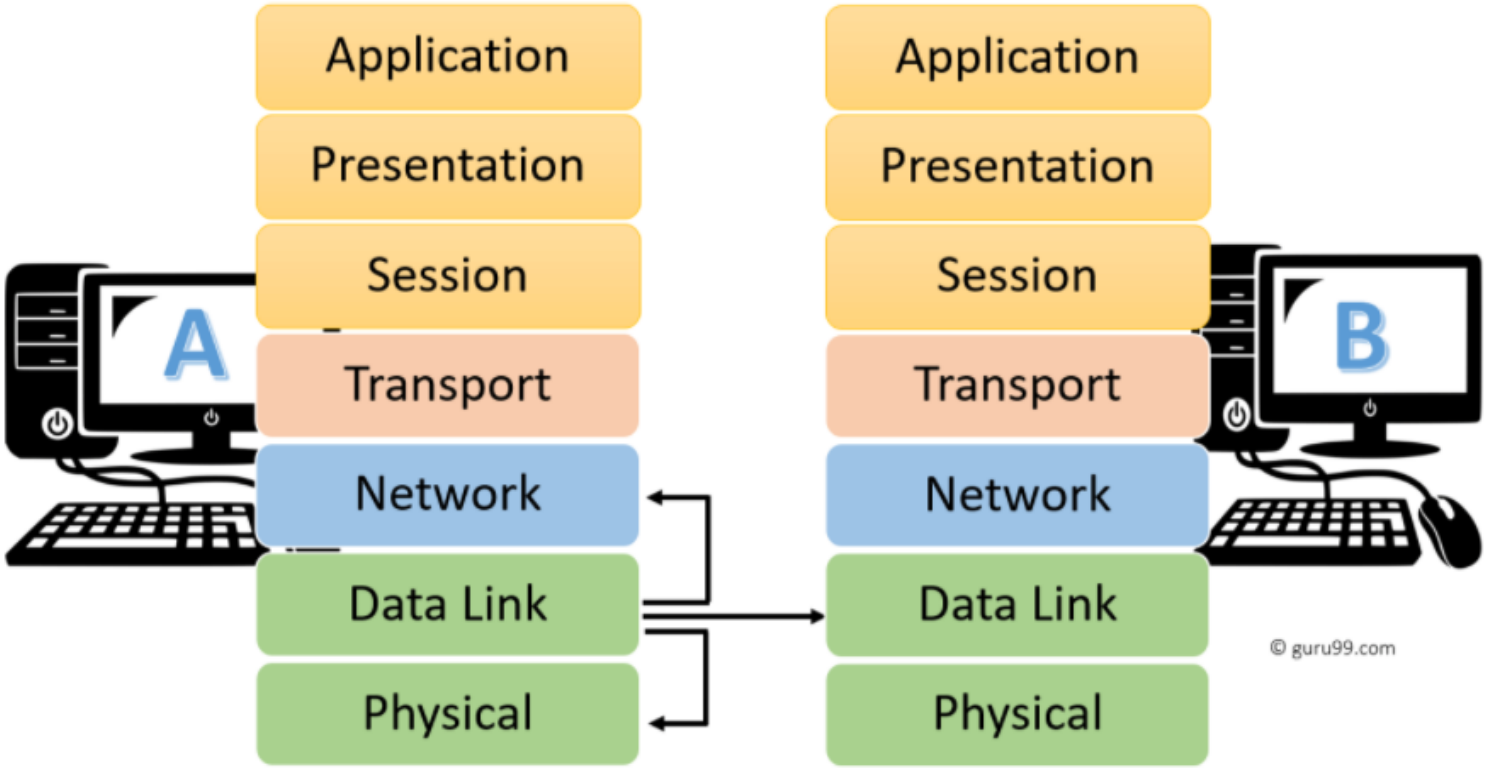
https://www.cloudflare.com/learning/ddos/glossary/open-systems-interconnection-model-osi/





https://www.guru99.com/layers-of-osi-model.html

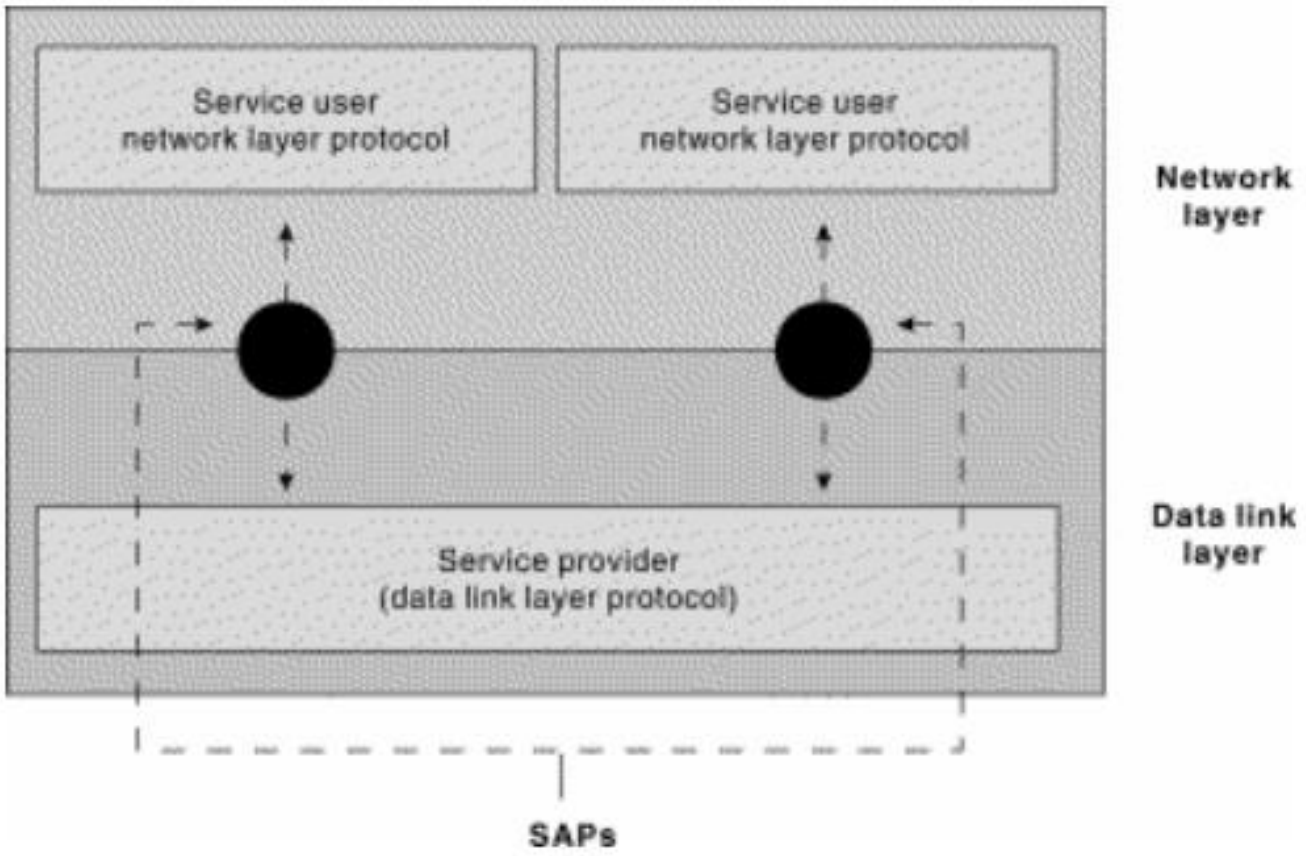
Interaction between OSI Model Layers



https://www.guru99.com/layers-of-osi-model.html

Services and service access points

Service Users, Providers, and SAPs interact at the Network and Data Link



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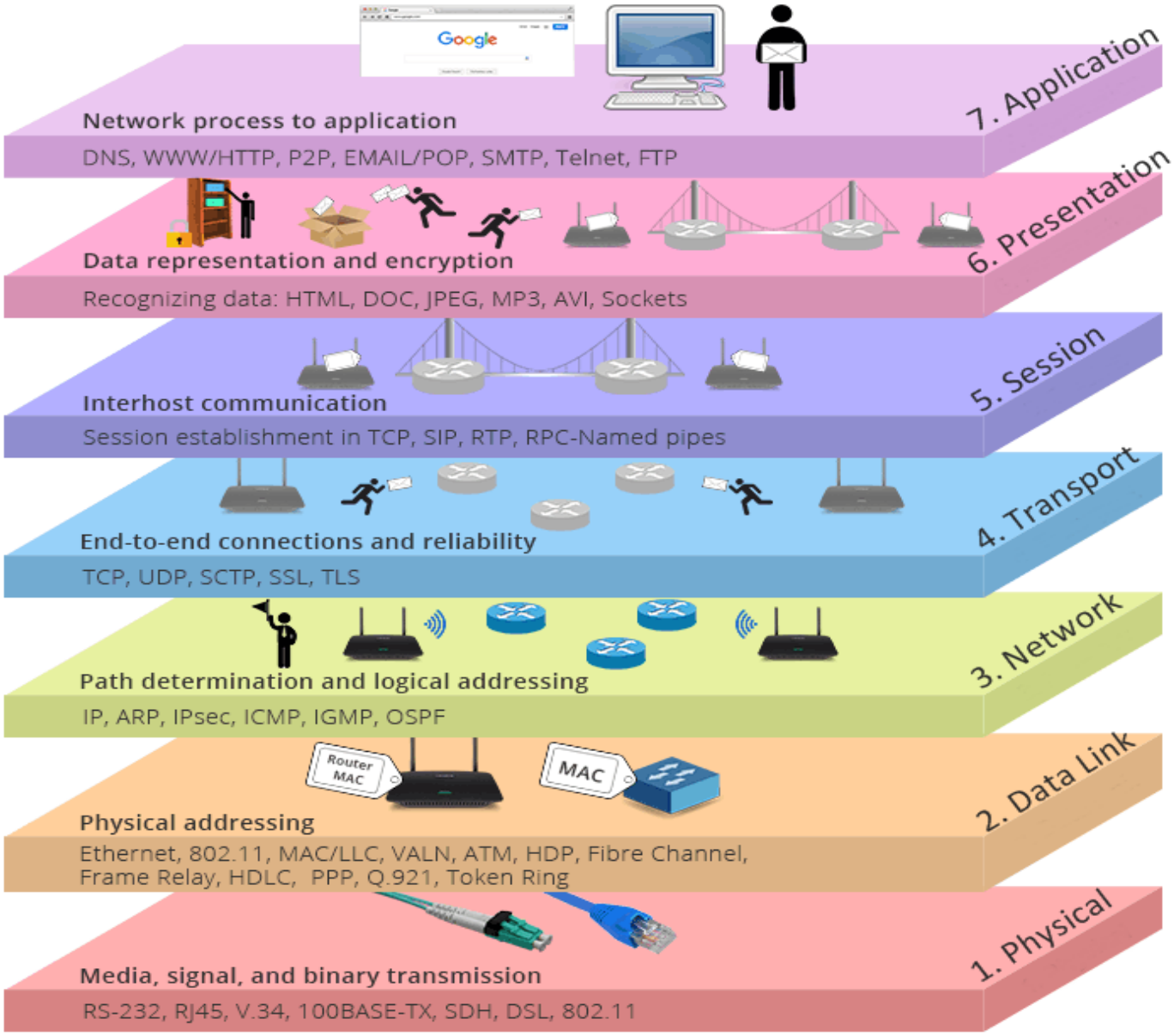
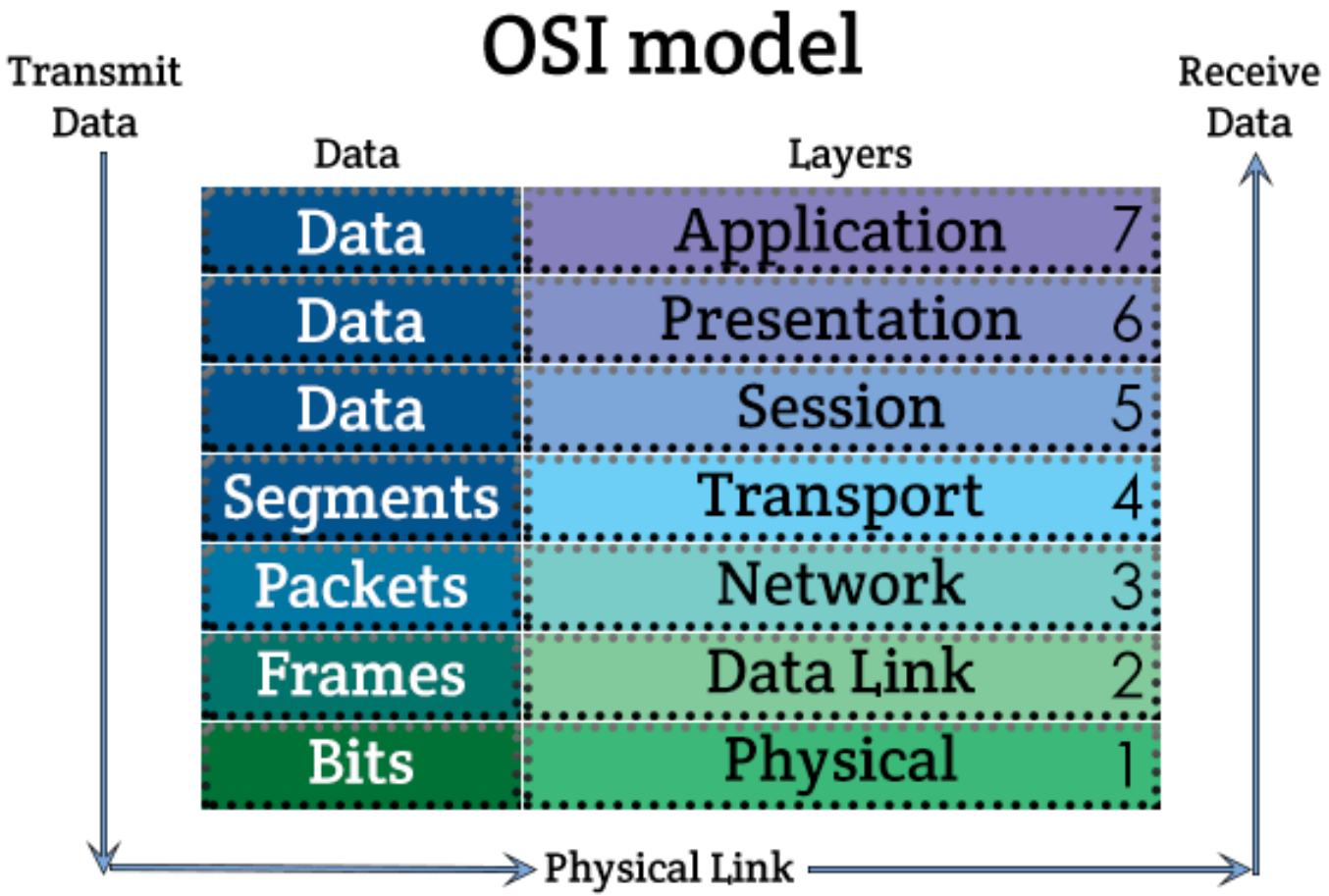
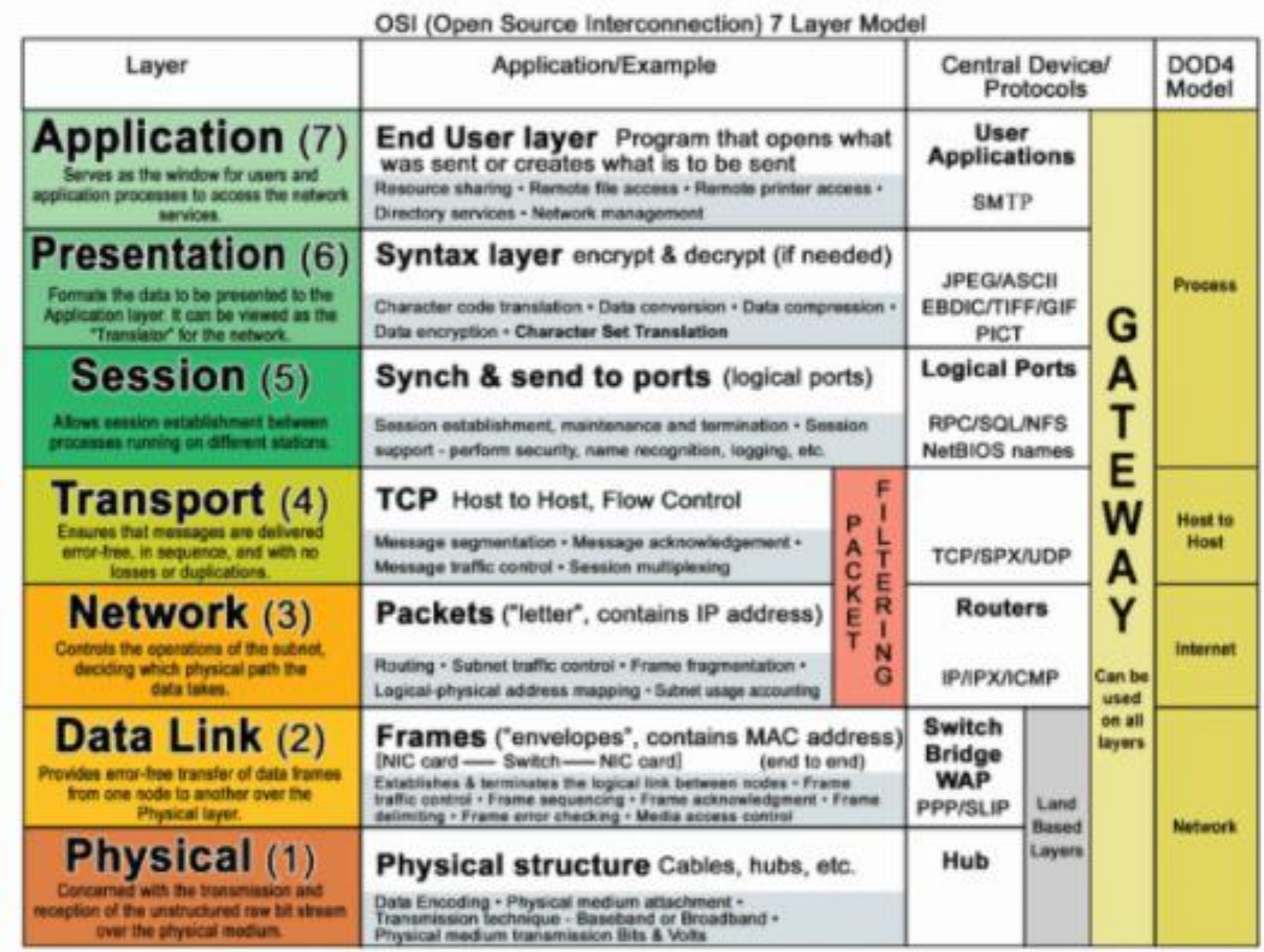
https://community.fs.com/blog/tcpip-vs-osi-whats-the-difference-between-the-two-models.html

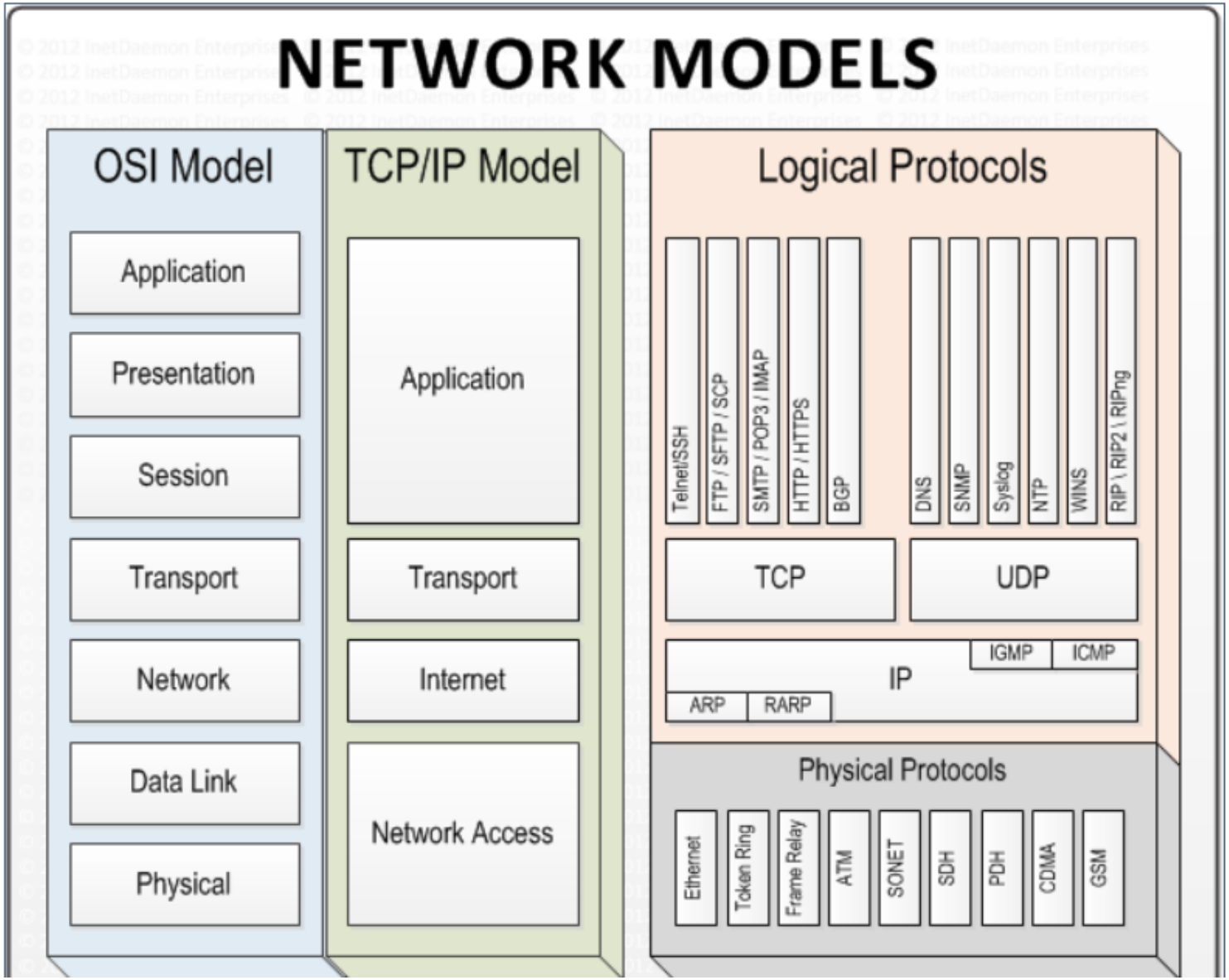




https://open4tech.com/osi-model-overview/

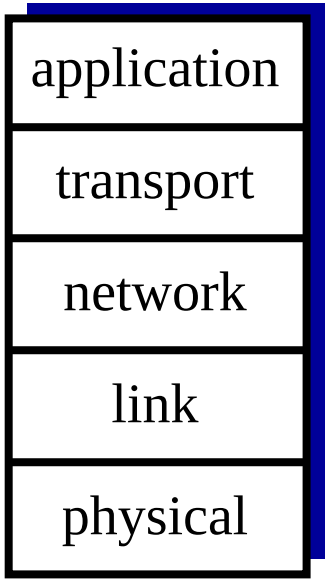


https://blogs.cisco.com/cloud/an-osi-model-for-cloud

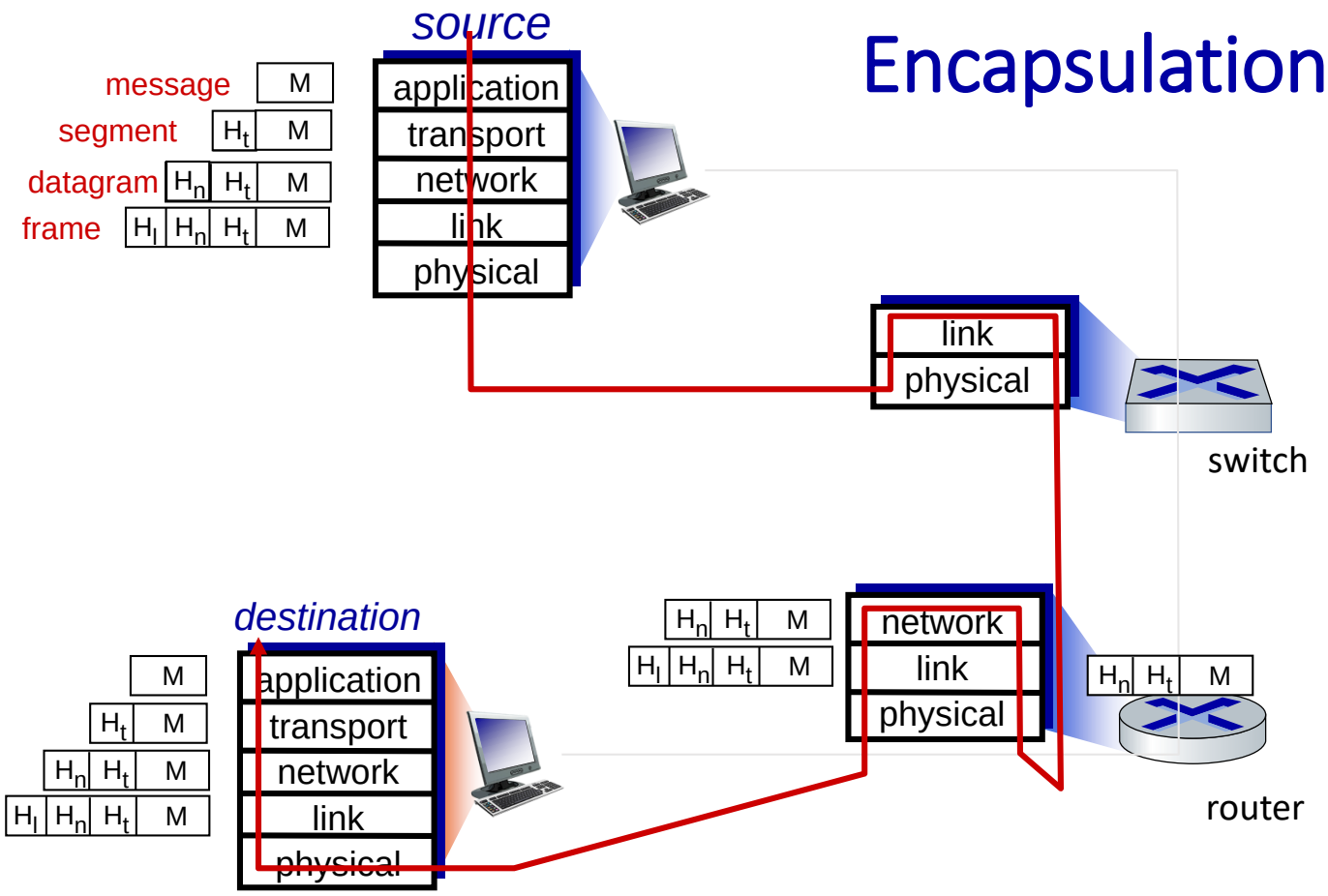

NETWORK MODELS
OSI Model
Application
Presentation
Session
Transport
Network
Data Link
Physical
TCP/IP Model
Application
Transport
Internet
Network Access
Logical Protocols
Telnet/SSH
FTP / SFTP / SCP
SMTP / POP3 / IMAP
HTTP / HTTPS
BGP
DNS
SNMP
Syslog
NTP
WINS
RIP \ RIP2 \ RIPng
TCP
UDP
IGMP
ICMP
IP
ARP
RARP
Physical Protocols
Ethernet
Token Ring
Frame Relay
ATM
SONET
SDH
PDH
CDMA
GSM

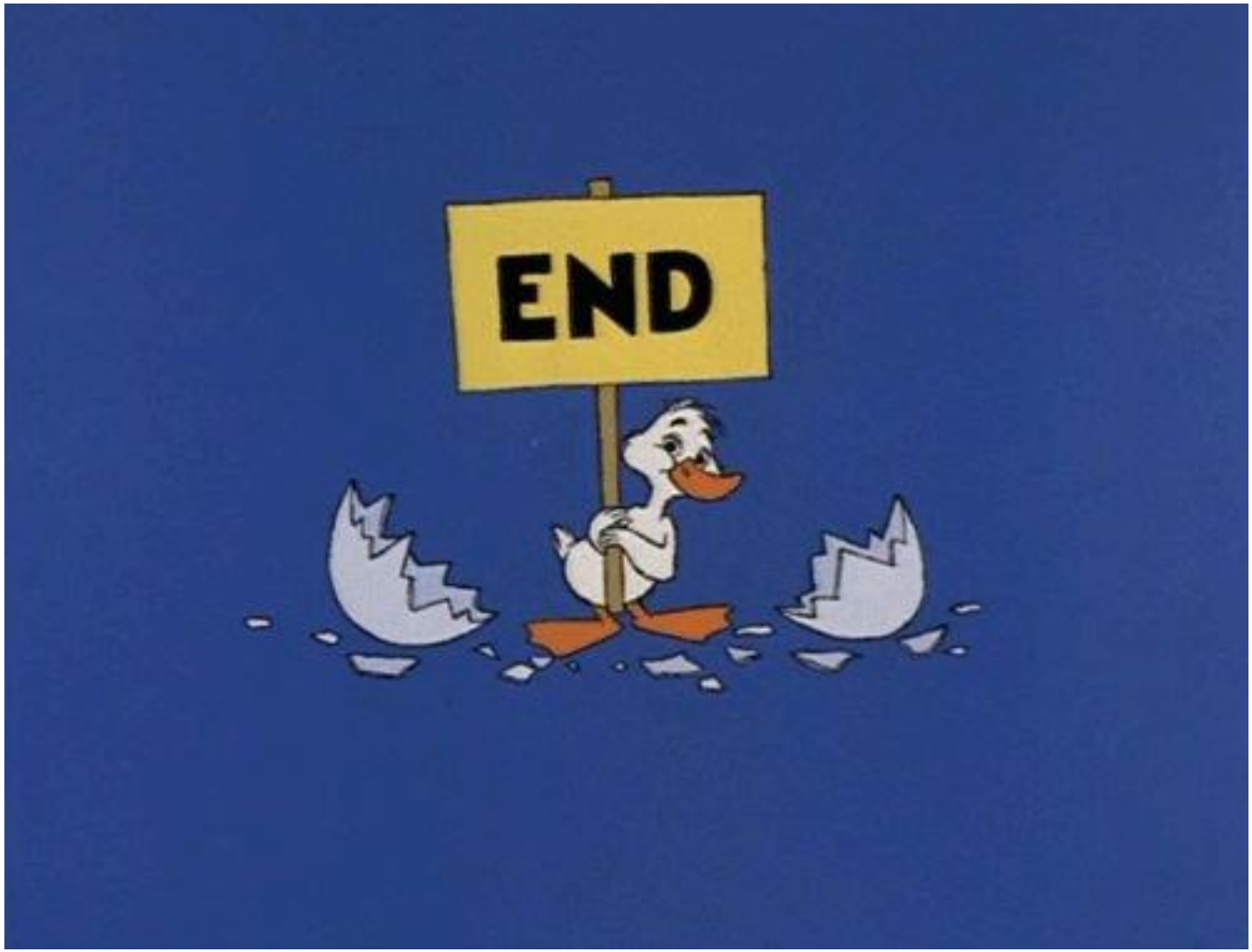
Internet protocol Stack

- *application:* supporting network applications
  - IMAP, SMTP, HTTP
- *transport:* process-process data transfer
  - TCP, UDP
- *network:* routing of datagrams from source to destination
  - IP, routing protocols
- *link:* data transfer between neighboring network elements
  - Ethernet, 802.11 (WiFi), PPP
- *physical:* bits “on the wire”



Encapsulation




END