



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*

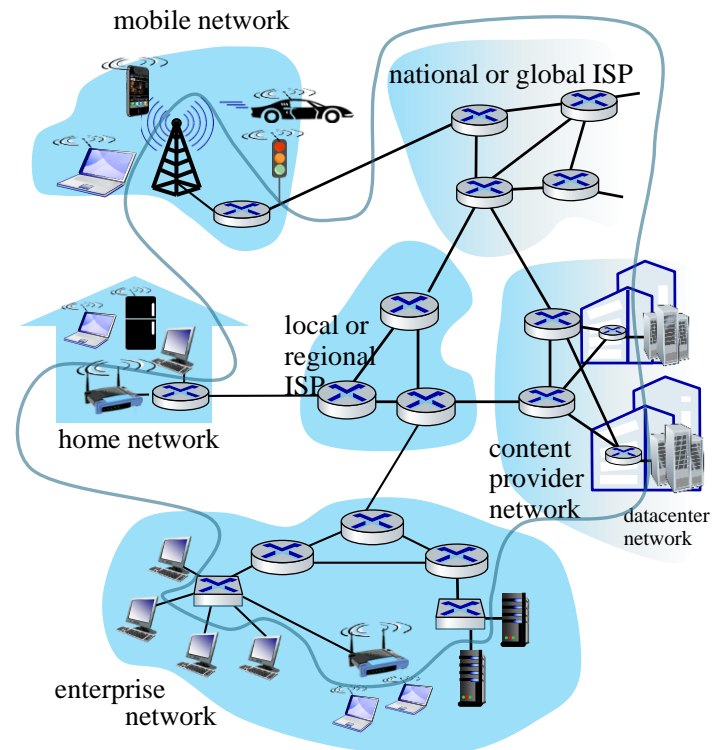


Communication links

- 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



Security Camera



Slingbox: remote
control cable TV



Web-enabled toaster +
weather forecaster



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

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

A	• —	U	• • —
B	— • • •	V	• • • —
C	— • — •	W	• — —
D	— • •	X	— • • —
E	•	Y	— • — —
F	• • — •	Z	— — • •
G	— — •		
H	• • • •		
I	• •		
J	• — — —		
K	— • —		
L	• — • •		
M	— —		
N	— •		
O	— — —		
P	• — — •		
Q	— — • —		
R	• — •		
S	• • •		
T	—		
		1	• — — — —
		2	• • — — —
		3	• • • — —
		4	• • • • —
		5	• • • • •
		6	— • • • •
		7	— — • • •
		8	— — — • •
		9	— — — — •
		0	— — — — —

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.

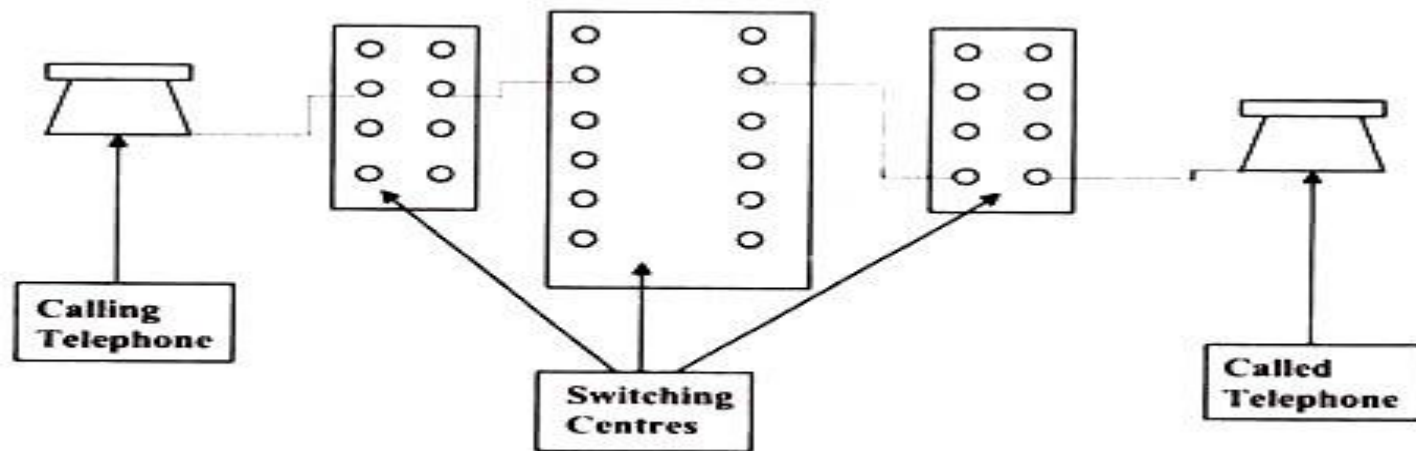


Fig. 6.4 Circuit-Switched Telephone Network

<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($10^4 \sim 10^8$ Hz), microwave ($10^8 \sim 10^{11}$ Hz), infrared ($10^{11} \sim 10^{14}$ Hz)

Computer network structure

Network edge:

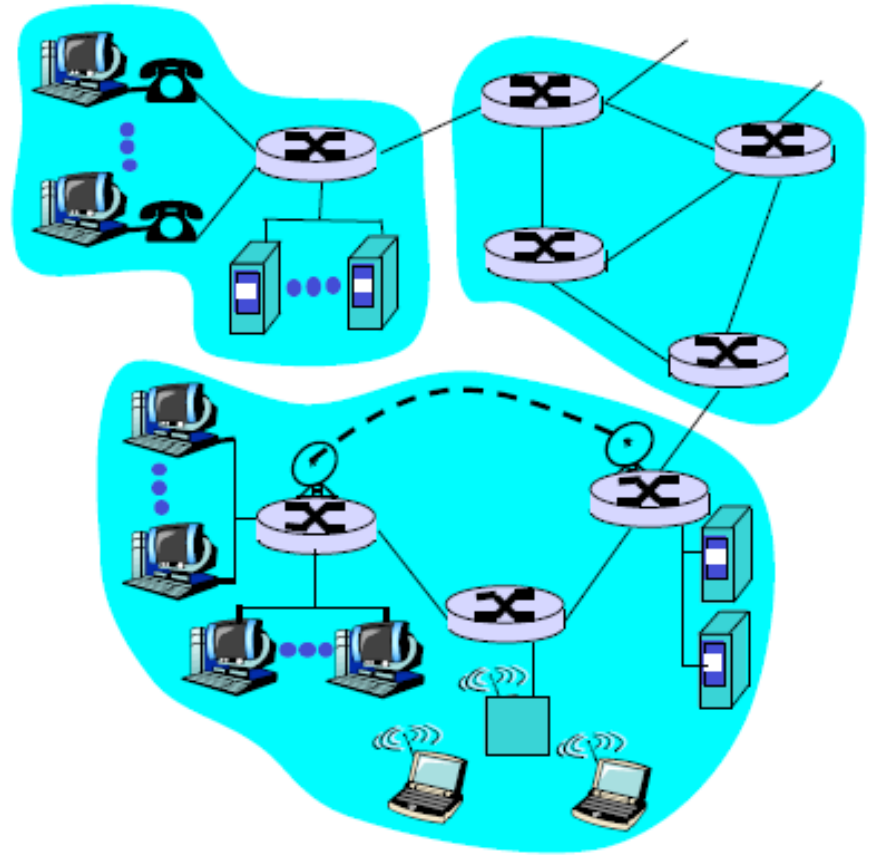
- applications and hosts

Network core:

- Routers
- Network of networks

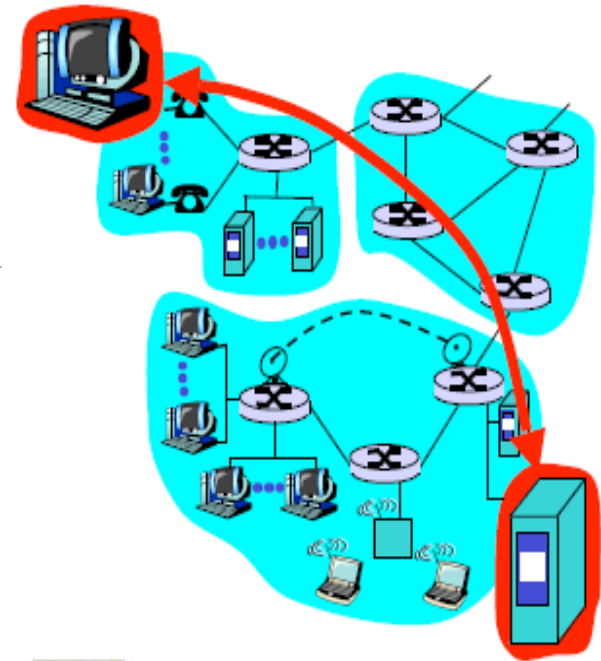
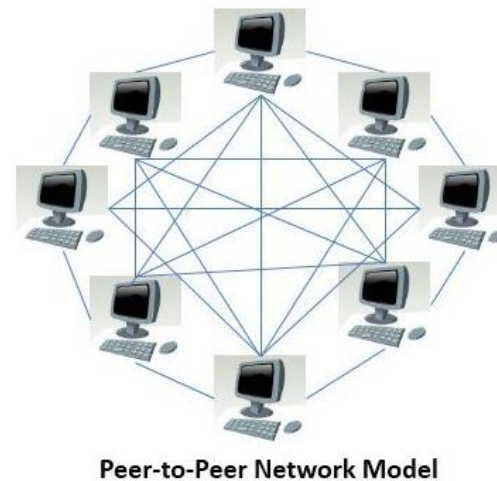
Access networks, physical media:

- Communication links



The network edge

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



<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

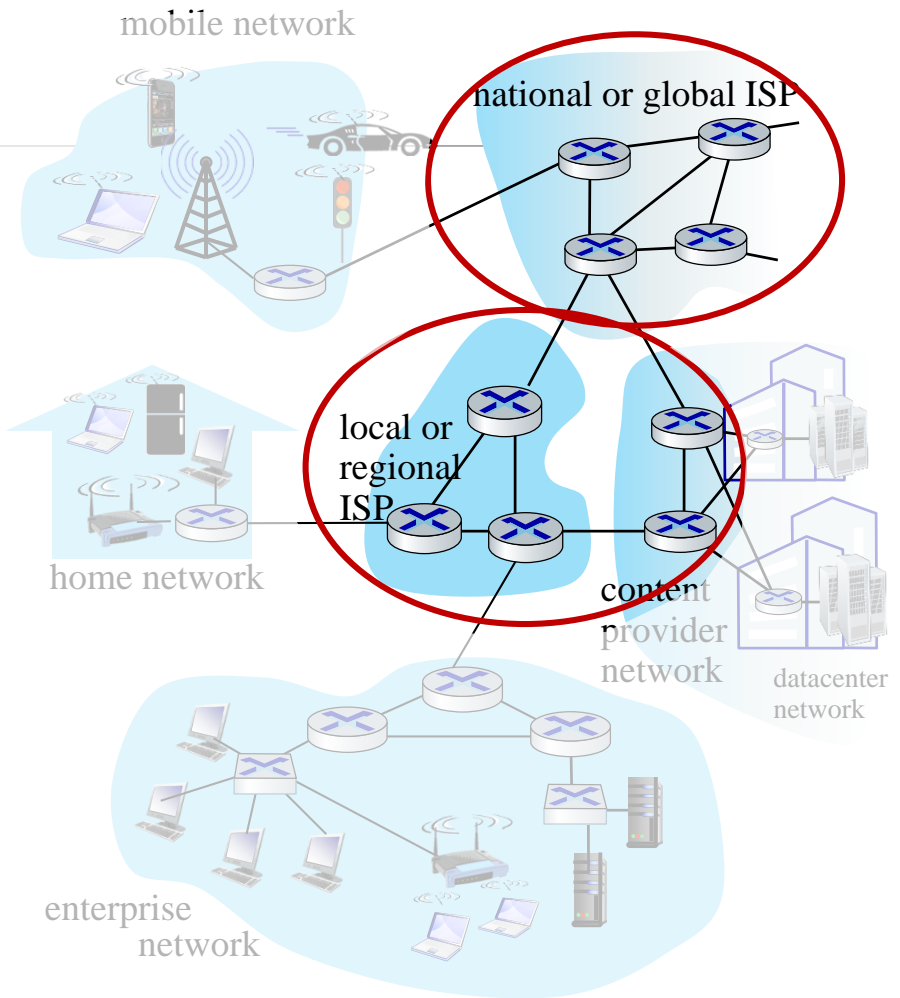
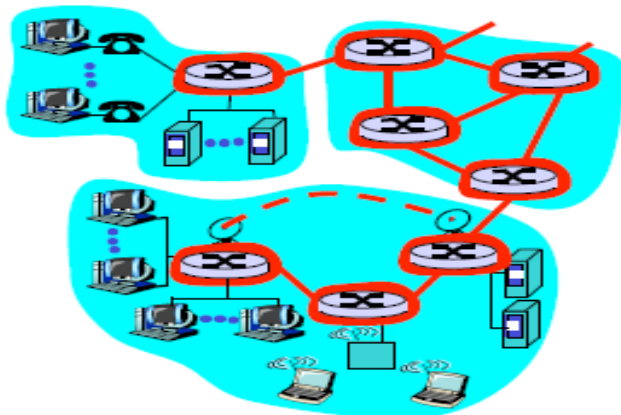
The network core

Mesh of interconnected routers

The fundamental question:

How is data transferred through net?

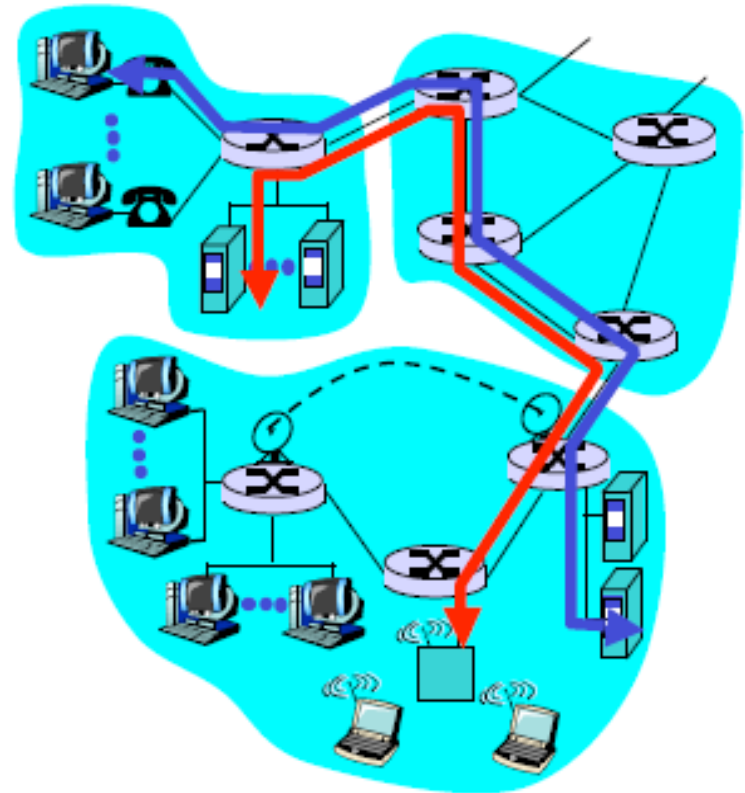
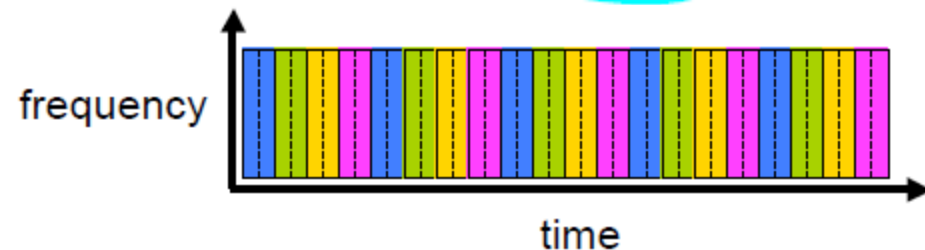
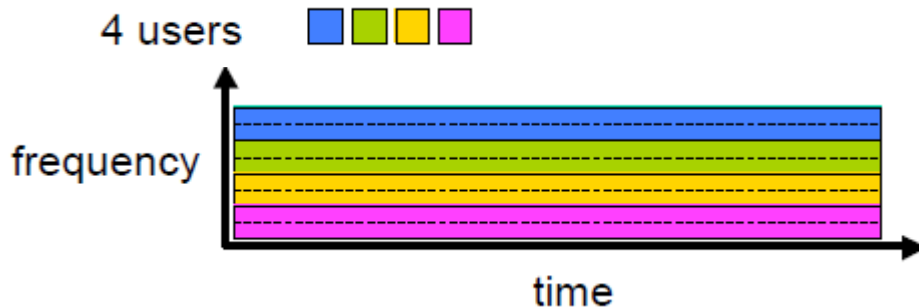
- Circuit switching: dedicated circuit per call (telephone net)
- Packet-switching: data sent through net in discrete “chunks”



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)



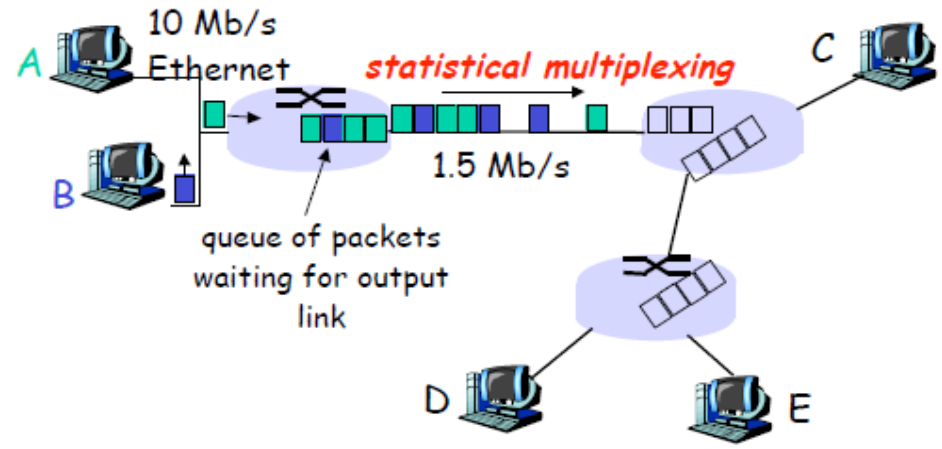
The network core: packet switching

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

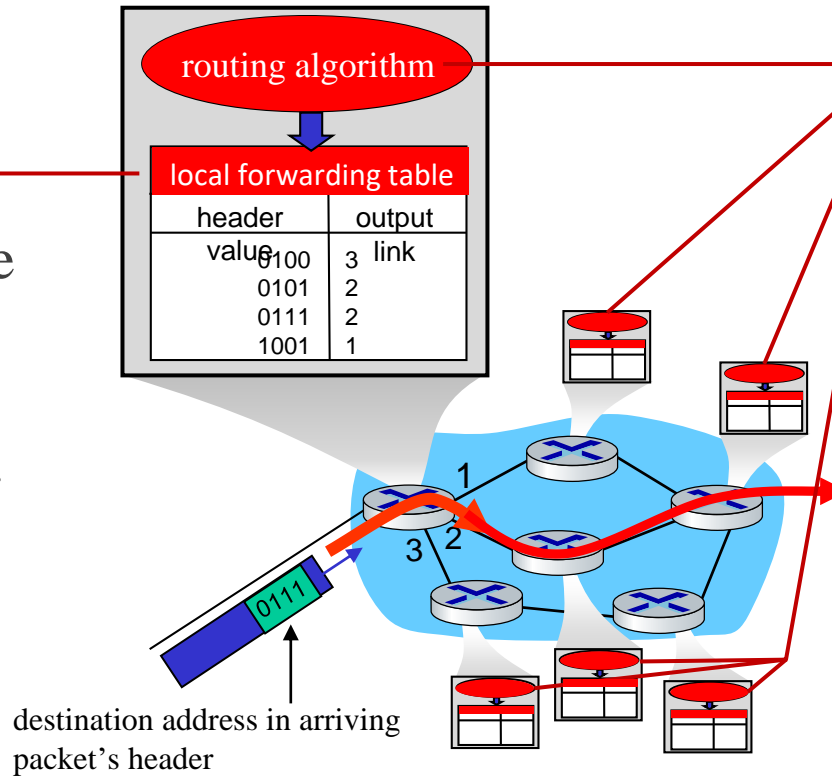
Virtual circuit network

- 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:

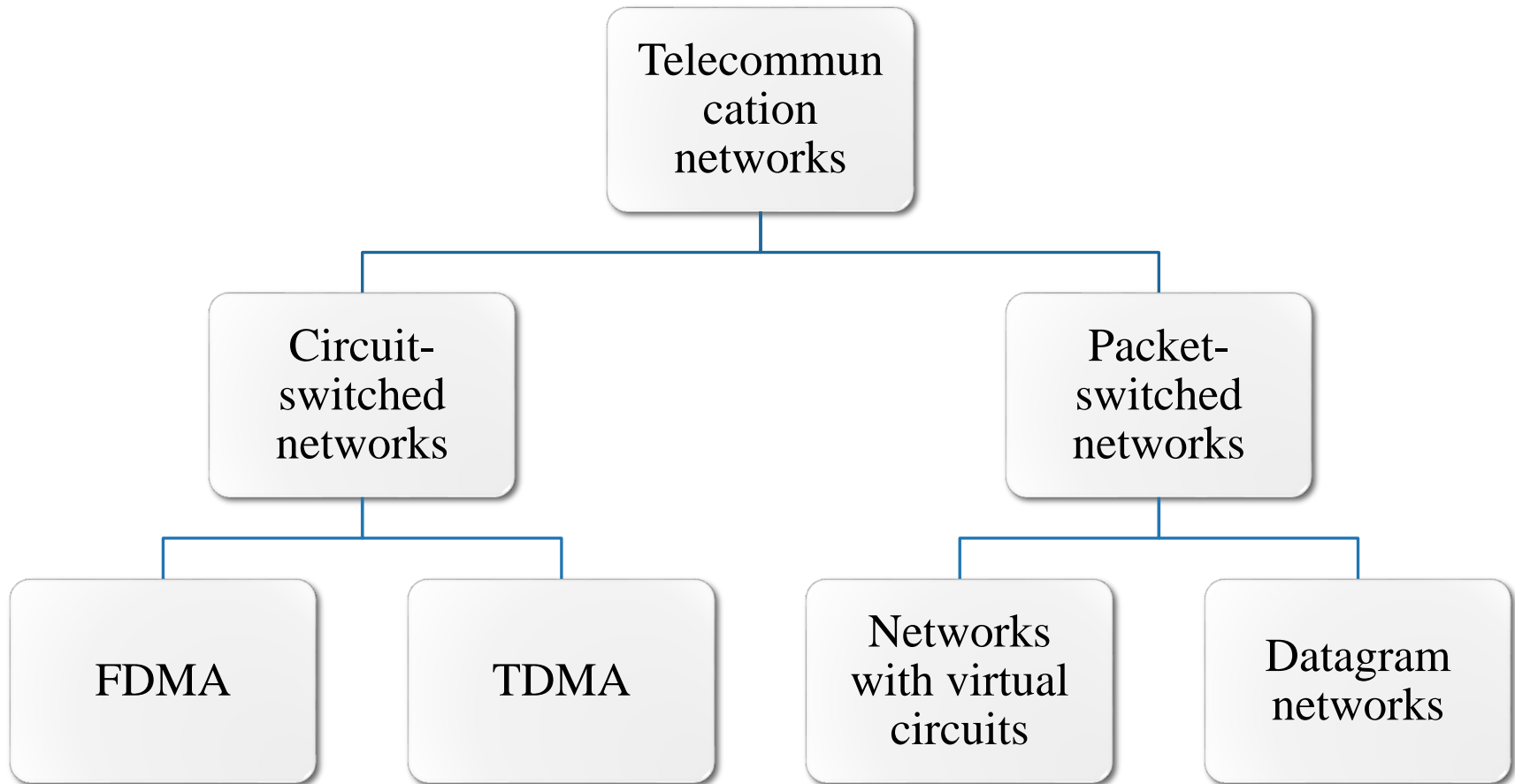
local action: move arriving packets from router's input link to appropriate router output link



Routing:

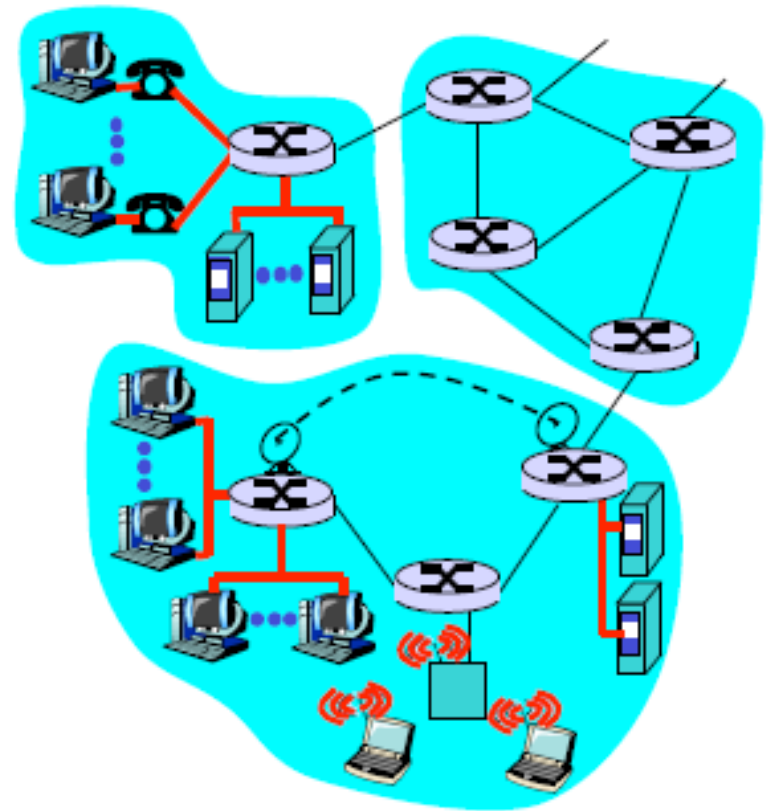
- *global* action: determine source-destination paths taken by packets
- routing algorithms

Network taxonomy



Access networks

- Connect end systems to edge router

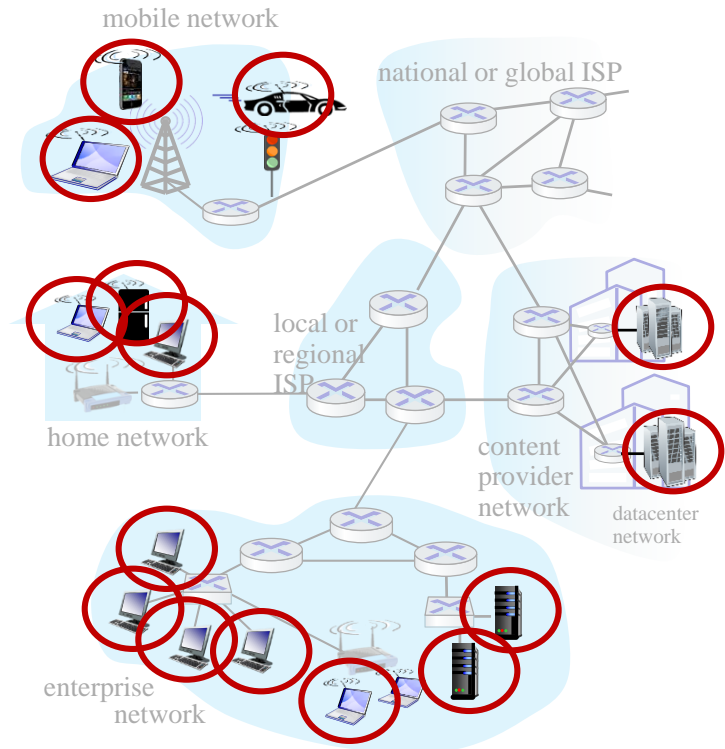


A closer look at Internet structure

Network edge:

hosts: clients and servers

servers often in data centers



A closer look at Internet structure

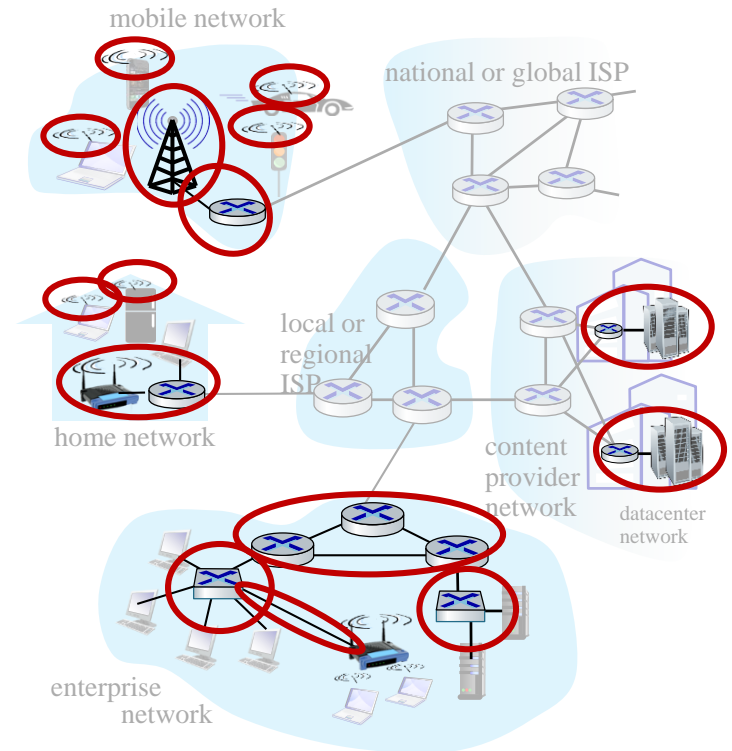
Network edge:

hosts: clients and servers

servers often in data centers

Access networks, physical media:

wired, wireless communication links



A closer look at Internet structure

Network edge:

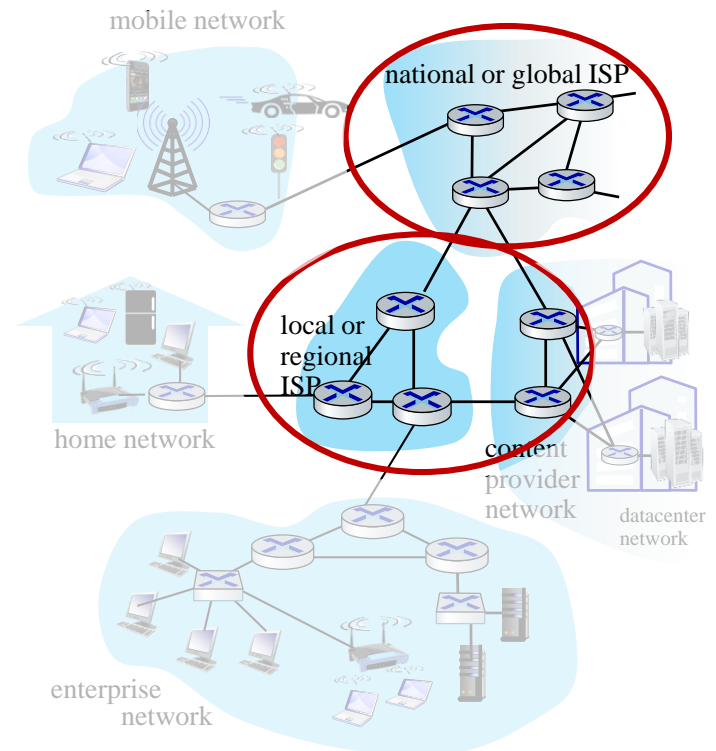
hosts: clients and servers
servers often in data centers

Access networks, physical media:

wired, wireless communication
links

Network core:

- interconnected routers
- network of networks



Access networks and physical media

Q: How to connect end systems to edge router?

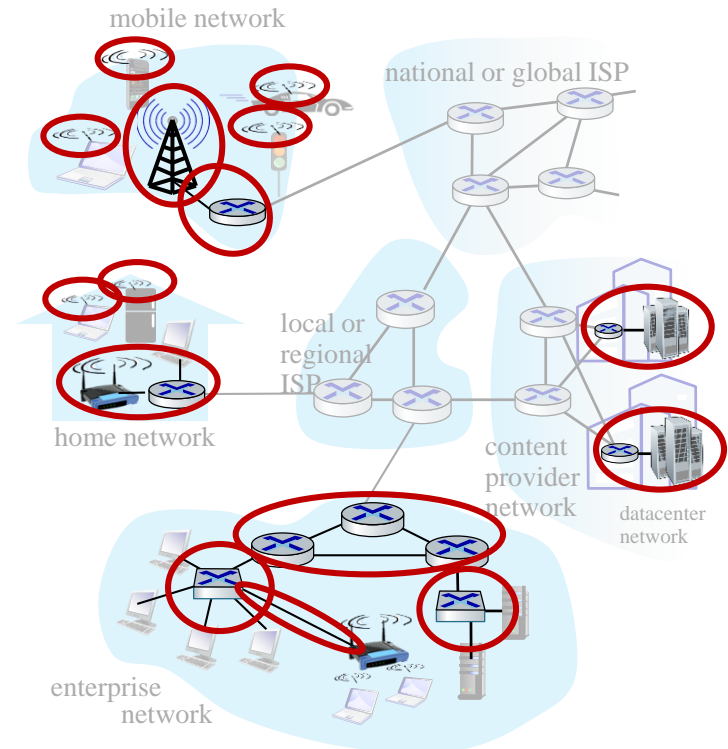
residential access nets

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

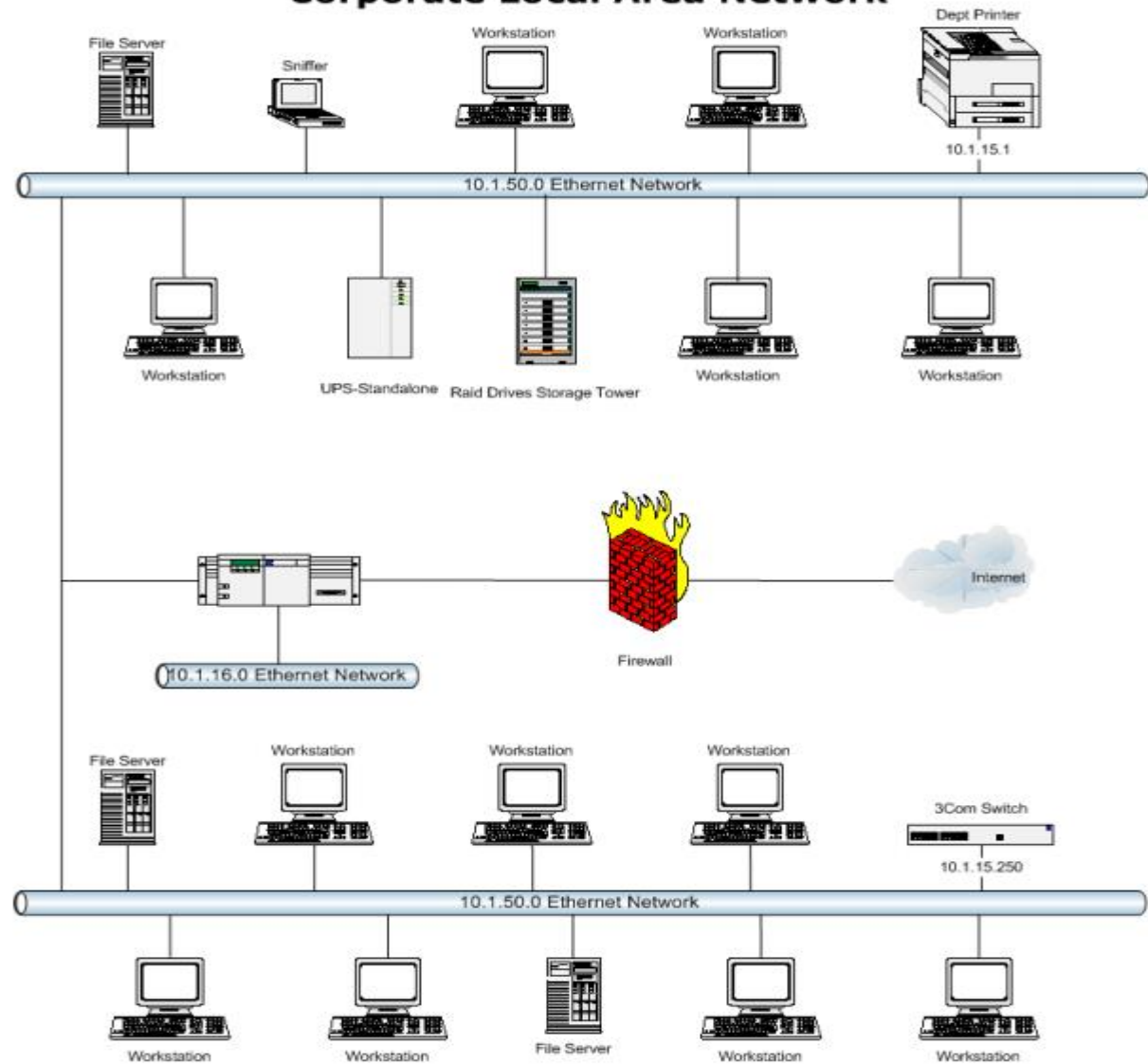
The two most common types of network infrastructures are:

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

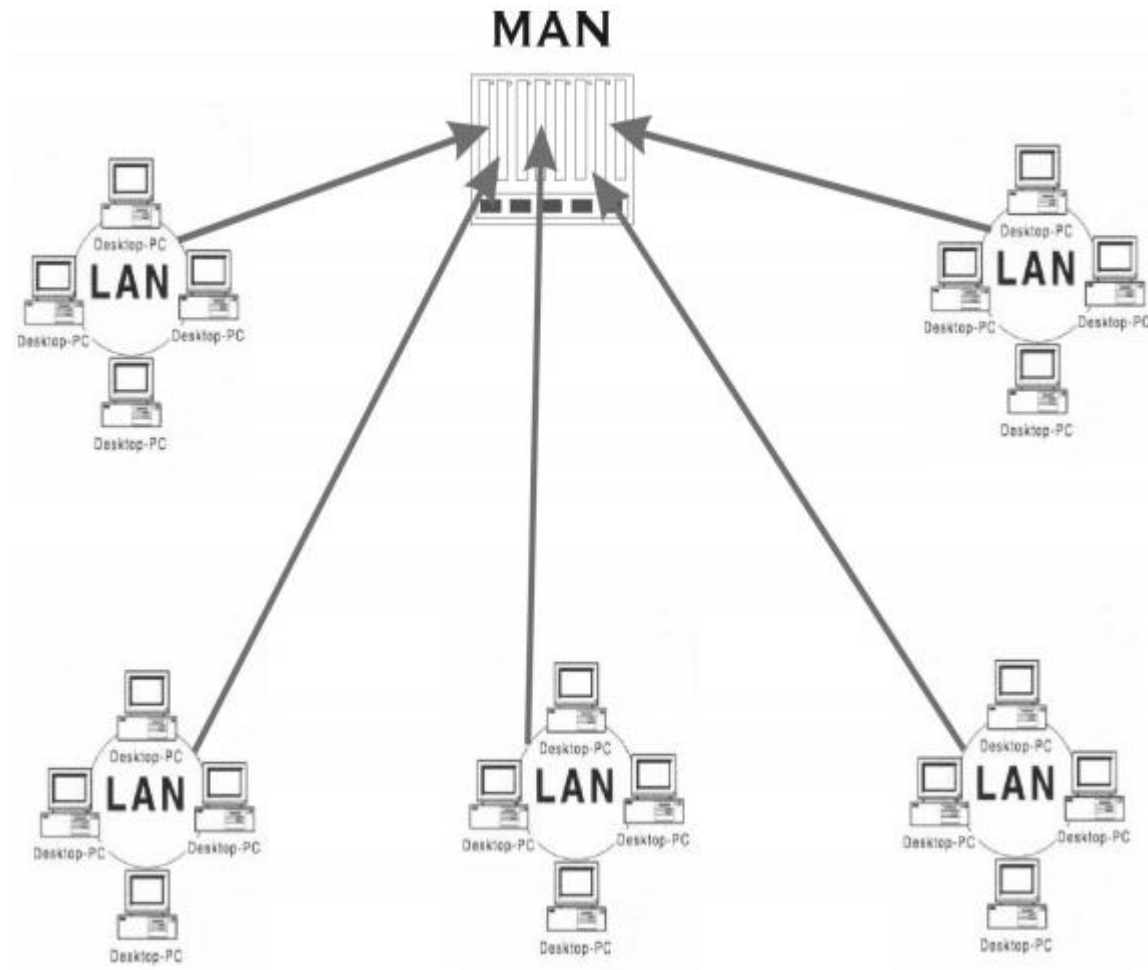
Other types of networks include:

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

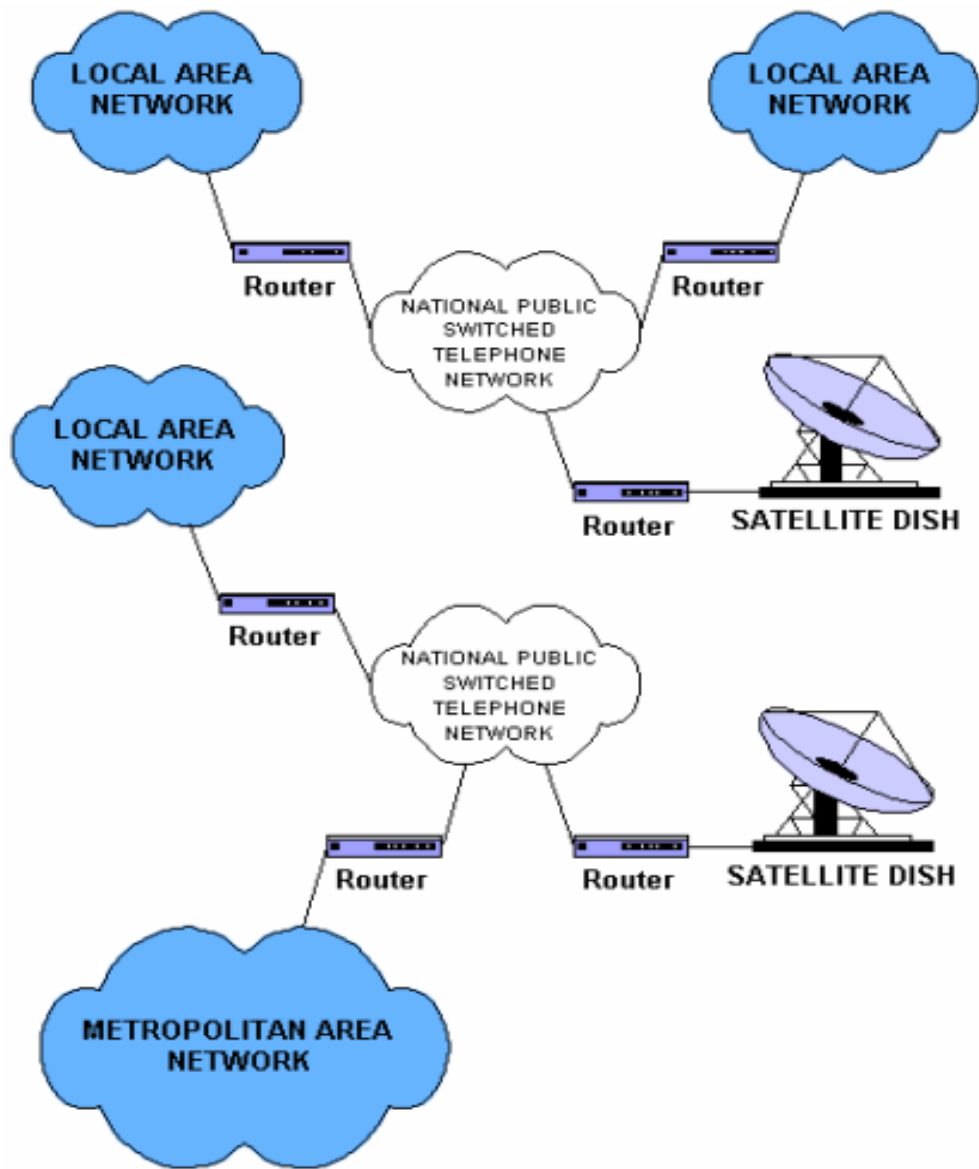
Corporate Local Area Network



Ajit Pal, CSE
IIT, Kharagpur
<https://nptel.ac.in/course.html>



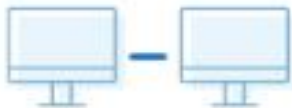
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/course.html](https://nptel.ac.in/course.html)



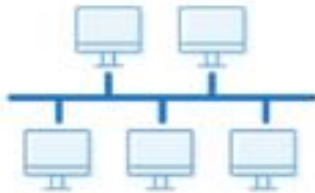
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Network topology

1 Point to point



2 Bus



3 Ring



4 Star



5 Tree



6 Mesh



7 Hybrid



<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:

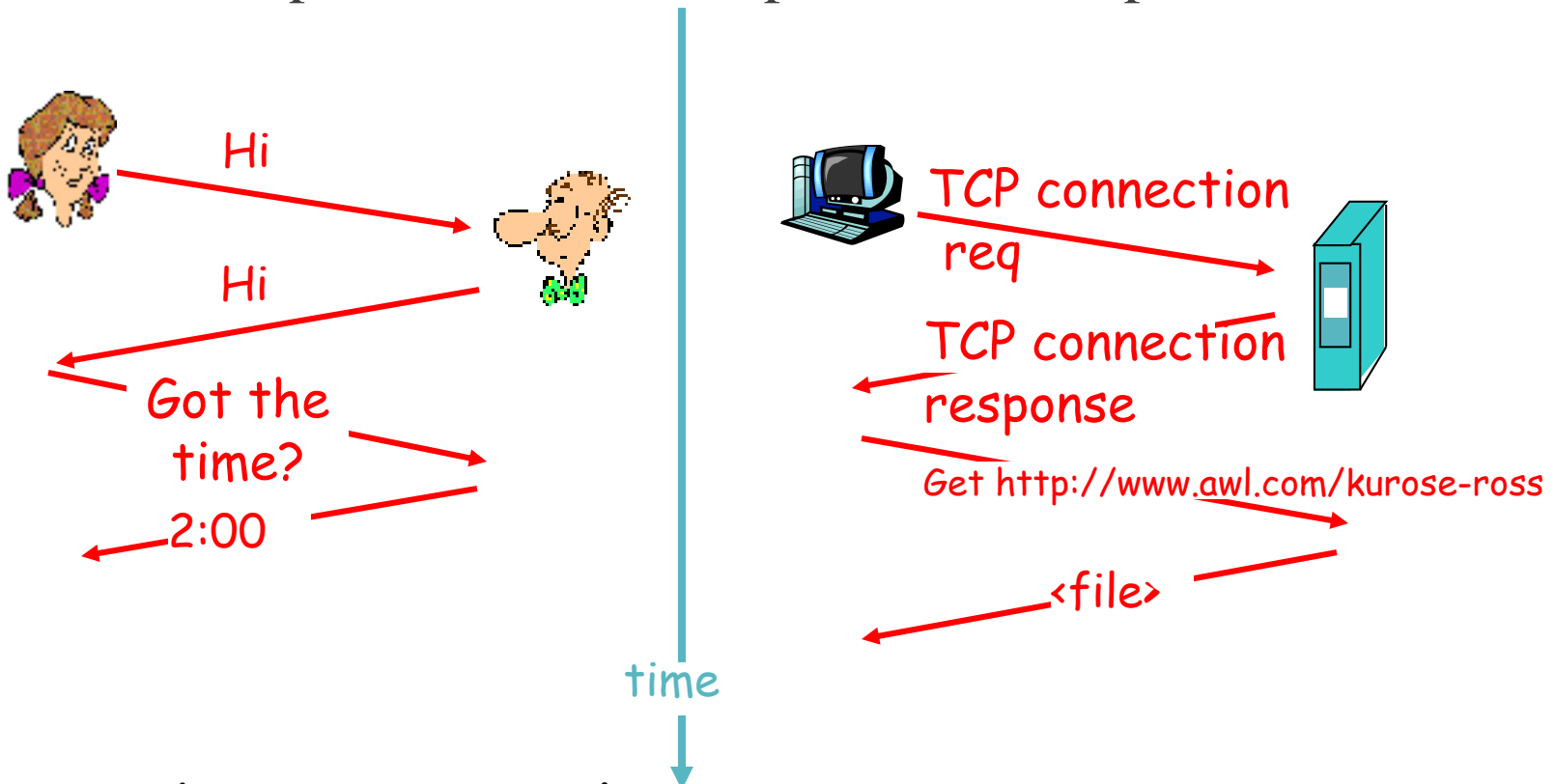
machines rather than humans

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:

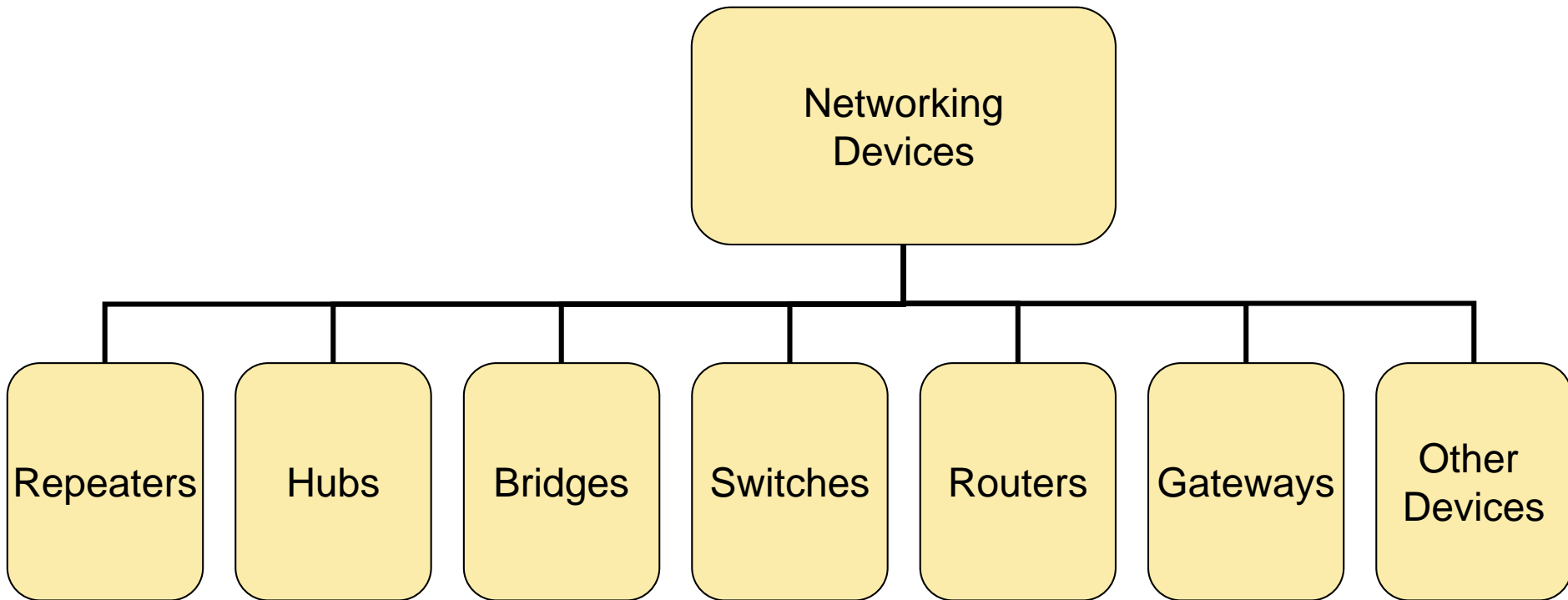


Q: Why are protocols so important?

Network protocols

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

Networking devices

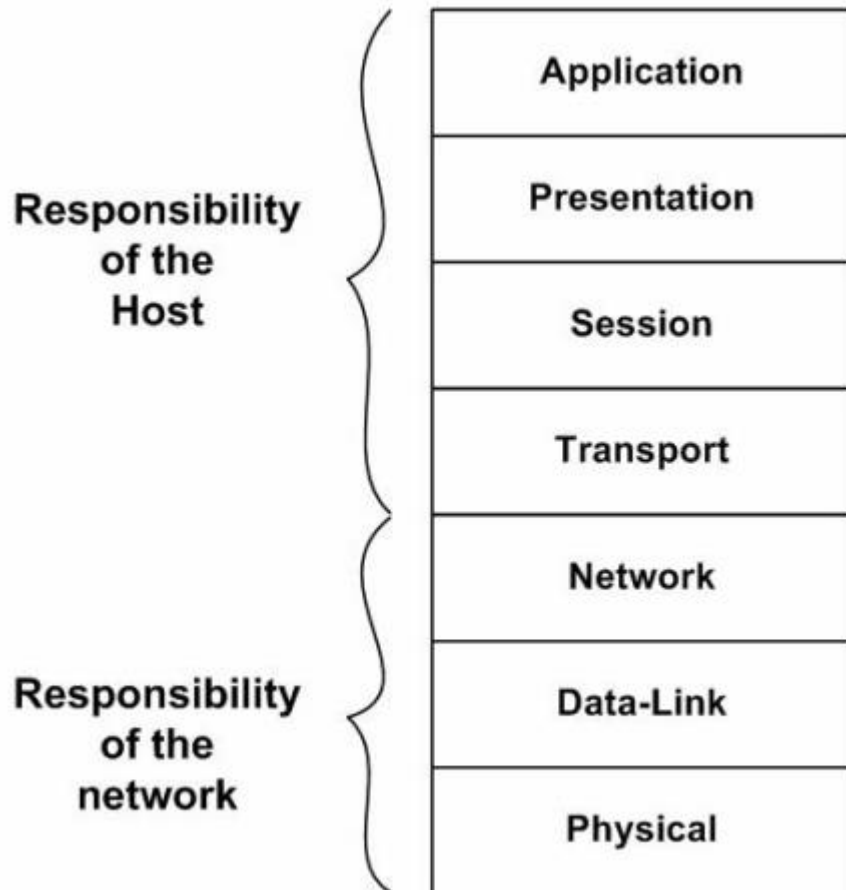




OSI model

OPEN SYSTEMS INTERCONNECTION MODEL

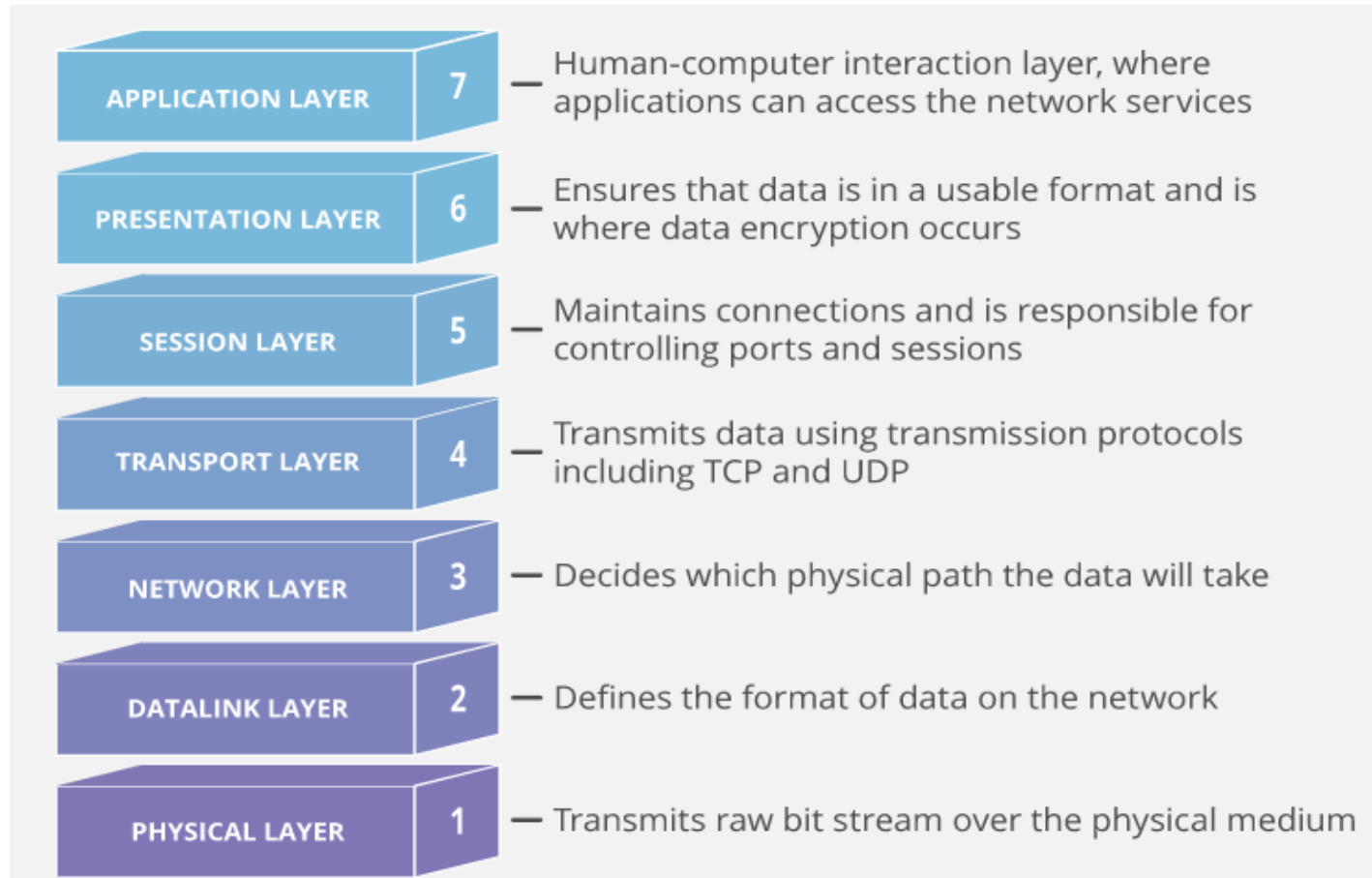
OSI model

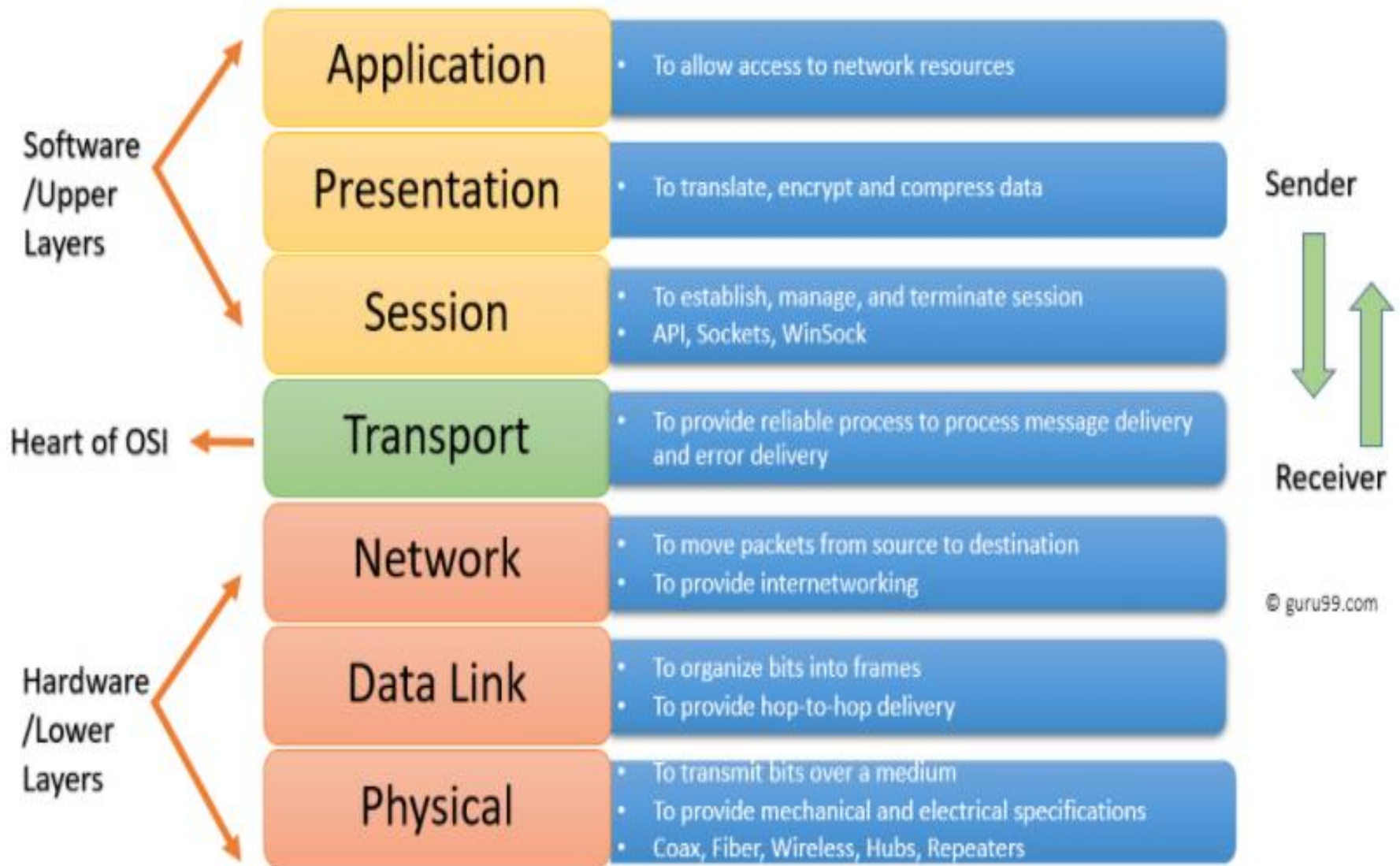


- Developed by the ISO
- Describe flow of information from one computer to others
- Consist of 7 layers

OSI model

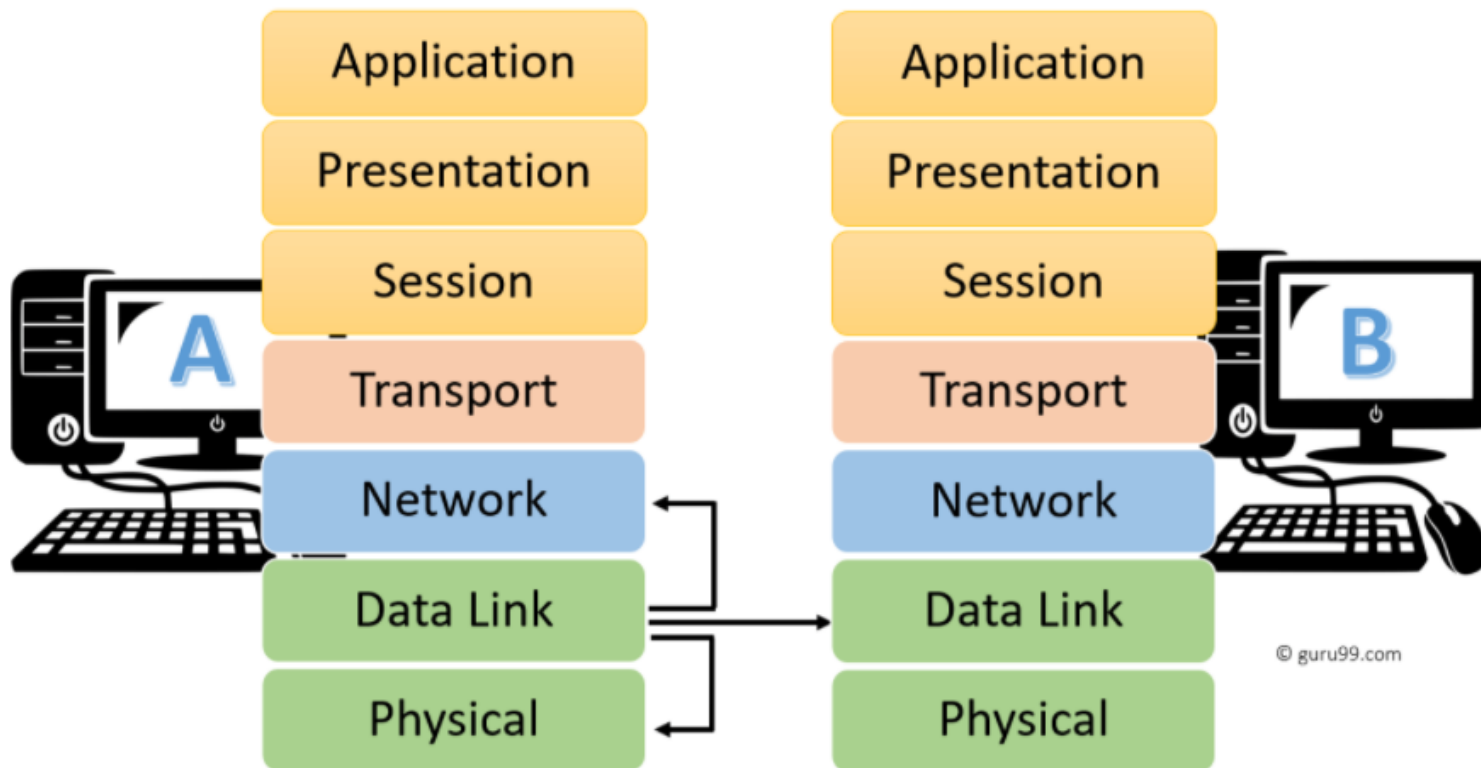
<https://www.cloudflare.com/learning/ddos/glossary/open-systems-interconnection-model-osi/>





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

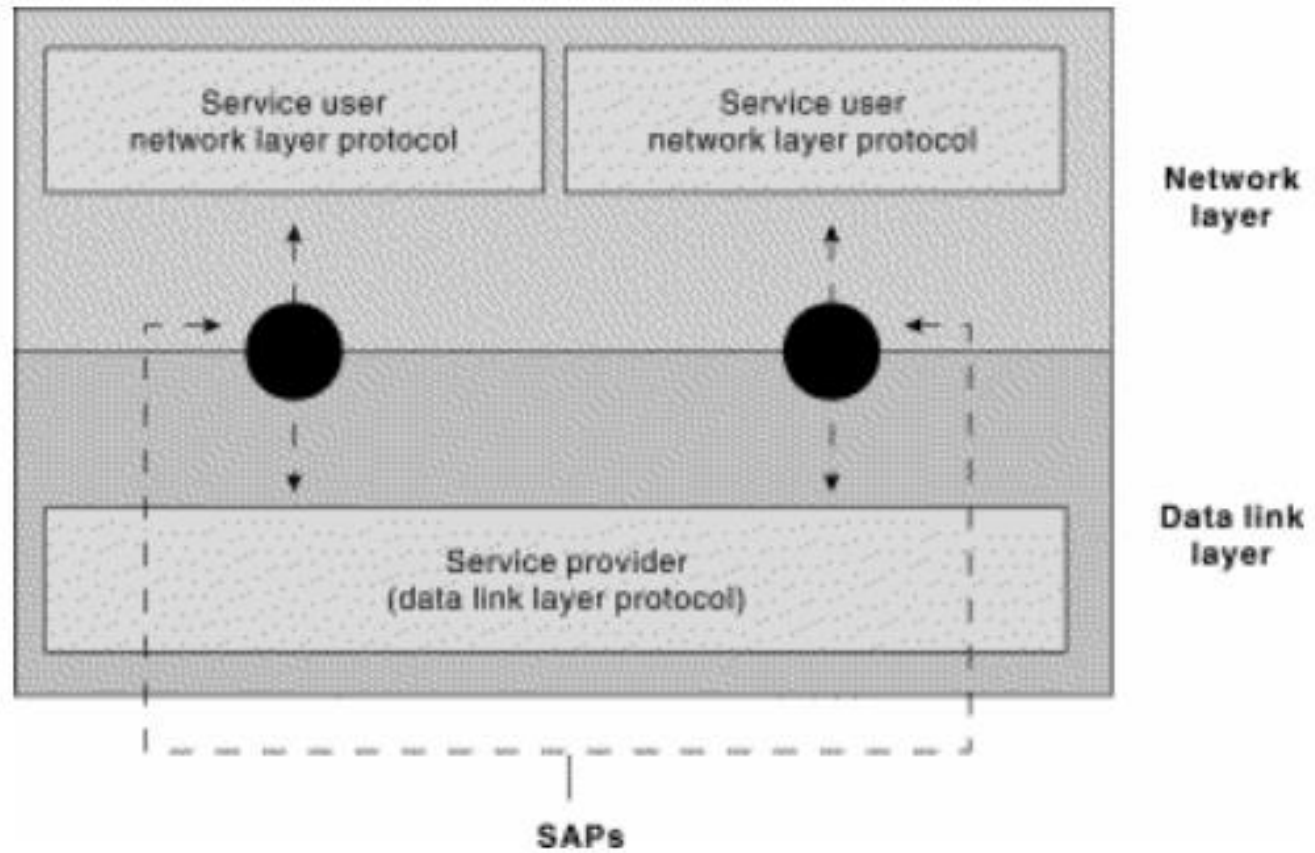
Interaction between OSI Model Layers



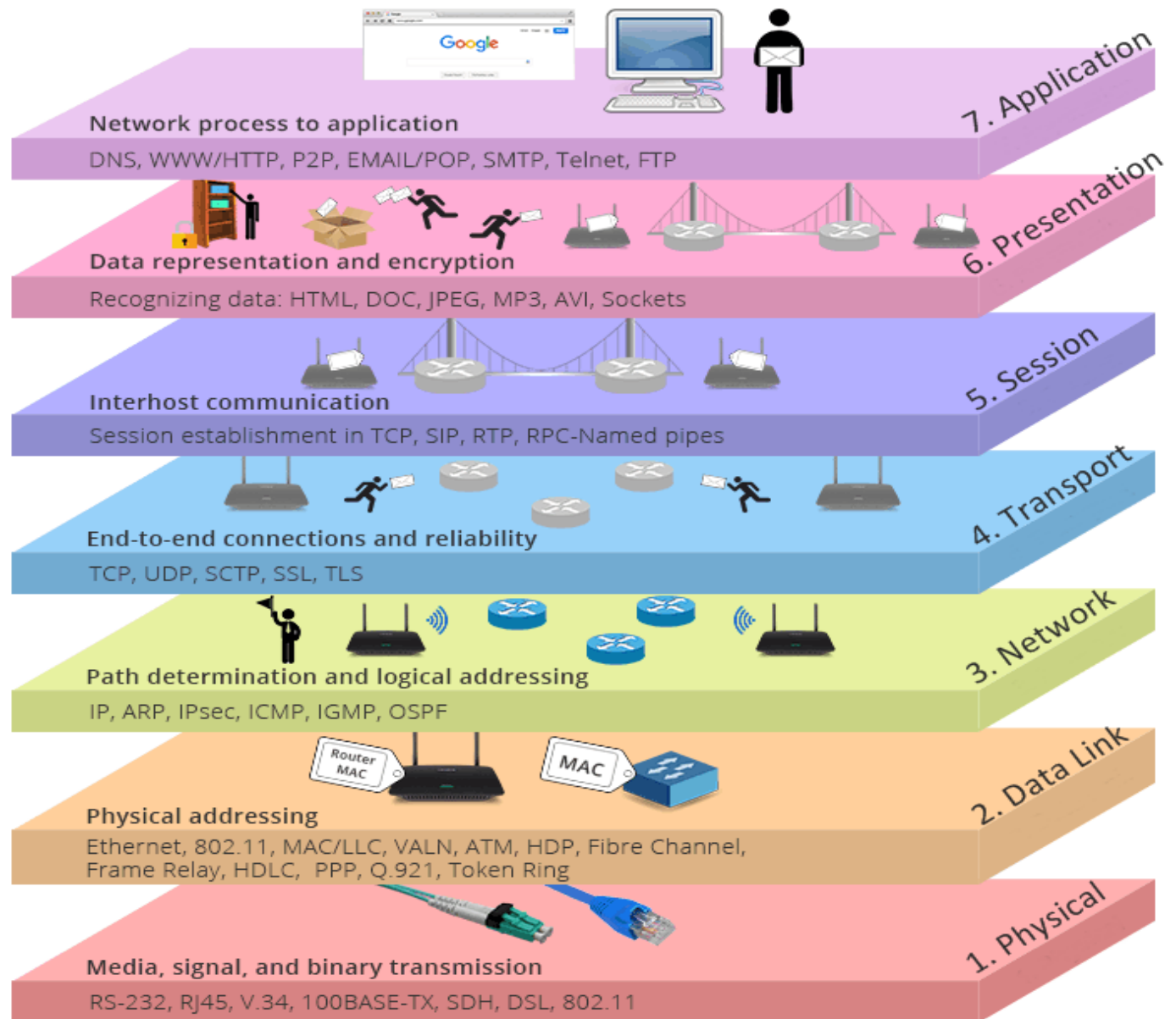
<https://www.guru99.com/layers-of-osi-model.html>

Services and service access points

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

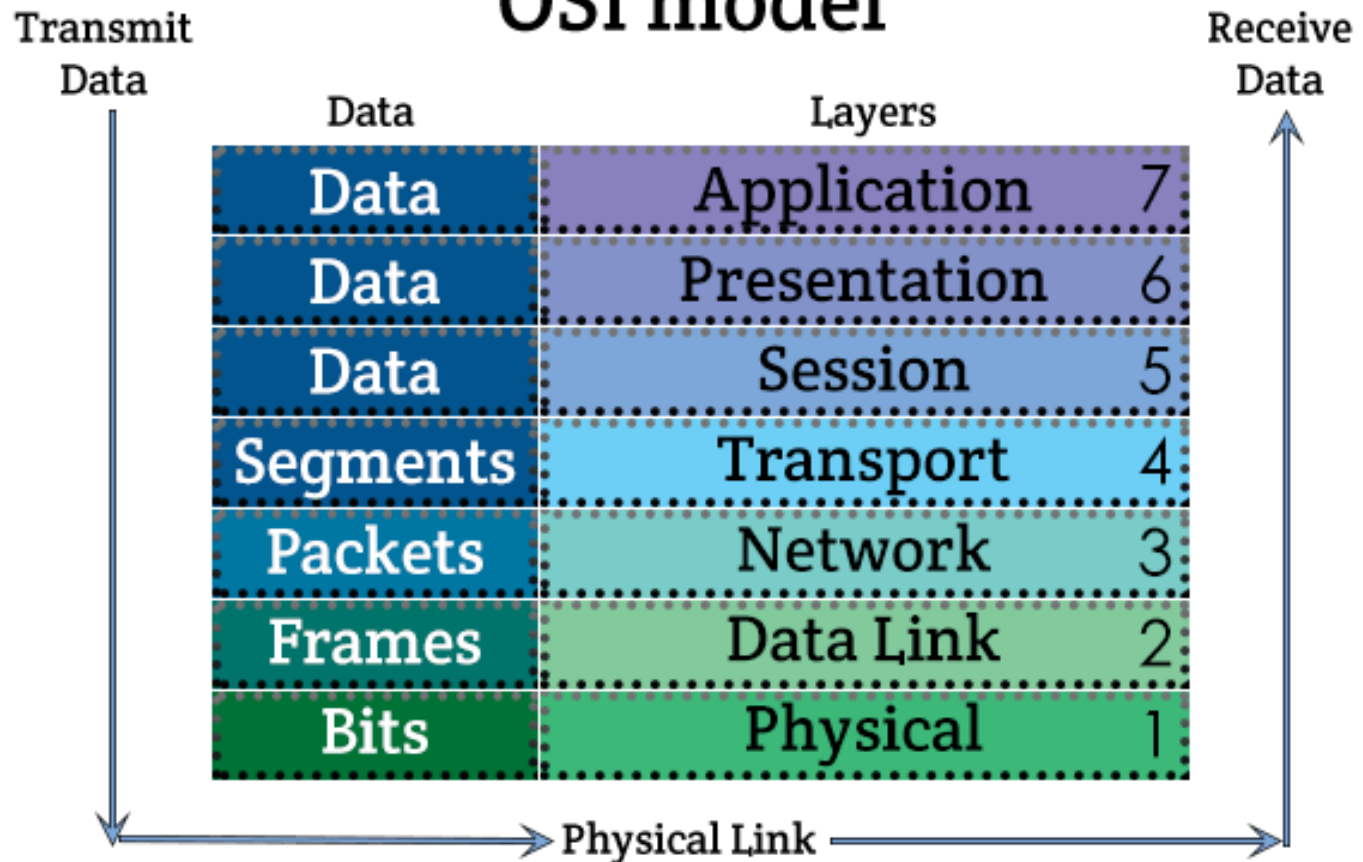


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[https://community.f
s.com/blog/tcpip-
vs-osi-whats-the-
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models.html](https://community.fs.com/blog/tcpip-vs-osi-whats-the-difference-between-the-two-models.html)

OSI model



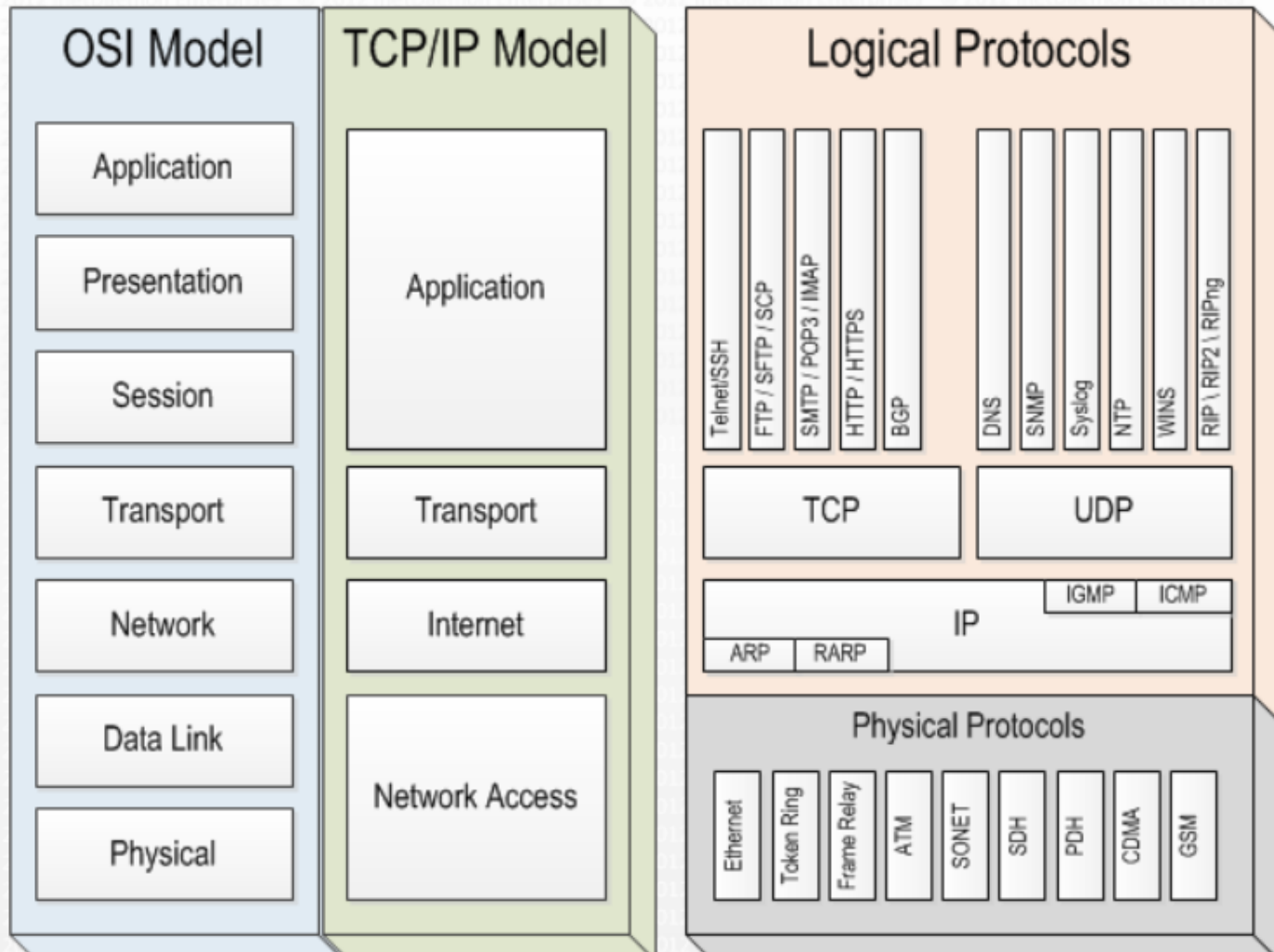
<https://open4tech.com/osi-model-overview/>

OSI (Open Source Interconnection) 7 Layer Model

Layer	Application/Example	Central Device/ Protocols		DOD4 Model
Application (7) Serves as the window for users and application processes to access the network services.	End User layer Program that opens what was sent or creates what is to be sent Resource sharing • Remote file access • Remote printer access • Directory services • Network management	User Applications SMTP	G A T E W A Y	Process
Presentation (6) Formats the data to be presented to the Application layer. It can be viewed as the "Translator" for the network.	Syntax layer encrypt & decrypt (if needed) Character code translation • Data conversion • Data compression • Data encryption • Character Set Translation	JPEG/ASCII EBDIC/TIFF/GIF PICT		
Session (5) Allows session establishment between processes running on different stations.	Synch & send to ports (logical ports) Session establishment, maintenance and termination • Session support - perform security, name recognition, logging, etc.	Logical Ports RPC/SQL/NFS NetBIOS names		
Transport (4) Ensures that messages are delivered error-free, in sequence, and with no losses or duplications.	TCP Host to Host, Flow Control Message segmentation • Message acknowledgement • Message traffic control • Session multiplexing	F I L T E R I N G P A C K E T	TCP/SPX/UDP	Host to Host
Network (3) Controls the operations of the subnet, deciding which physical path the data takes.	Packets ("letter", contains IP address) Routing • Subnet traffic control • Frame fragmentation • Logical-physical address mapping • Subnet usage accounting		Routers IP/IPX/ICMP	Internet
Data Link (2) Provides error-free transfer of data frames from one node to another over the Physical layer.	Frames ("envelopes", contains MAC address) [NIC card — Switch — NIC card] (end to end) Establishes & terminates the logical link between nodes • Frame traffic control • Frame sequencing • Frame acknowledgment • Frame delimiting • Frame error checking • Media access control	Switch Bridge WAP PPP/SLIP	Land Based Layers	Network
Physical (1) Concerned with the transmission and reception of the unstructured raw bit stream over the physical medium.	Physical structure Cables, hubs, etc. Data Encoding • Physical medium attachment • Transmission technique - Baseband or Broadband • Physical medium transmission Bits & Volts	Hub		

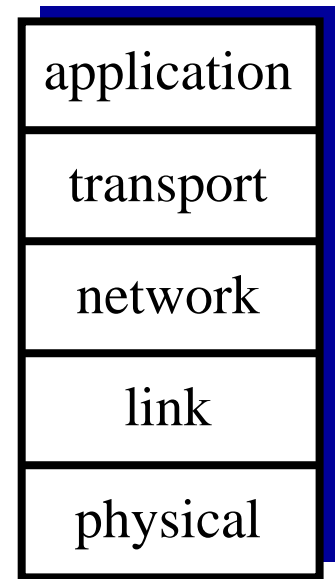
<https://blogs.cisco.com/cloud/an-osi-model-for-cloud>

NETWORK MODELS



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

