Introduction to Data Communication and Networking

Information and Communication Technology (ICT)

Data and Signal Transmission

The Internet and Protocols

The Role of the Router

Information and Communication Technology (ICT)

Brief history of ICT:

- In 19th century, information took days or weeks to be transmitted at long distances. **Tony Express:** the earliest mail service.
  http://www.youtube.com/watch?v=y1R-GeEd95c

- In the early 20th century, information took **minutes** or **hours** for long distance transmission.

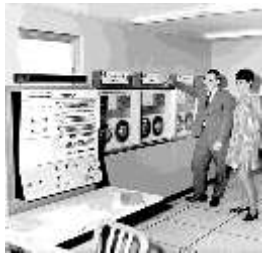
Alexander Graham Bell wrote to his father at March 10, 1876: "*the day is coming when telegraph wires will be laid on to houses just like water or gas is, and friends will converse with each other without leaving homes*."

- **Digital telephony** starts from 1960s:
  - evolves from landlines and switchboards to cell phones and cell towers.

The **telephone** network dominated for four generations.

Image source:
https://en.wikipedia.org/?title=Telephone#/media/File:Alexander_Graham_Telephone_in_Newyork.jpg

Progress of Computing



Batch processing mainframes

Online real-time

PC LANs become common

1950 1960 1970 1980 1990 2000

Data communications over phone lines

PC revolution

Networking everywhere

Source: www.inetgiant.com.au/.../3243882

Data and Signal Transmission

Data – some entity that has meaning or conveys information

Signal – a representation of data via a medium

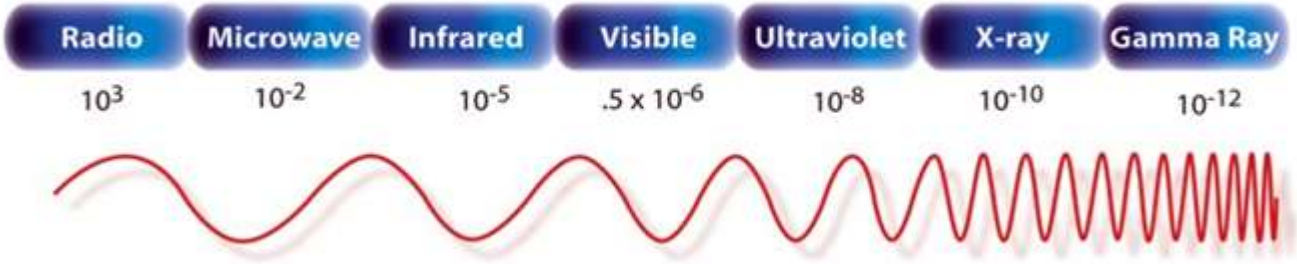
Transmission – moving data from source to destination using signals

Communication channel – any pathway over which data are transmitted

Electromagnetic radiation is the basis for all common forms of data transmission

- Electromagnetic radiation propagates (spreads, disseminates) along different media (copper wire, fiber, etc.) and in free space (air)

The electromagnetic spectrum (Wavelength in meters):



In telephone system, the usable voice frequency band ranges from approximately 300 Hz to 3400 Hz.

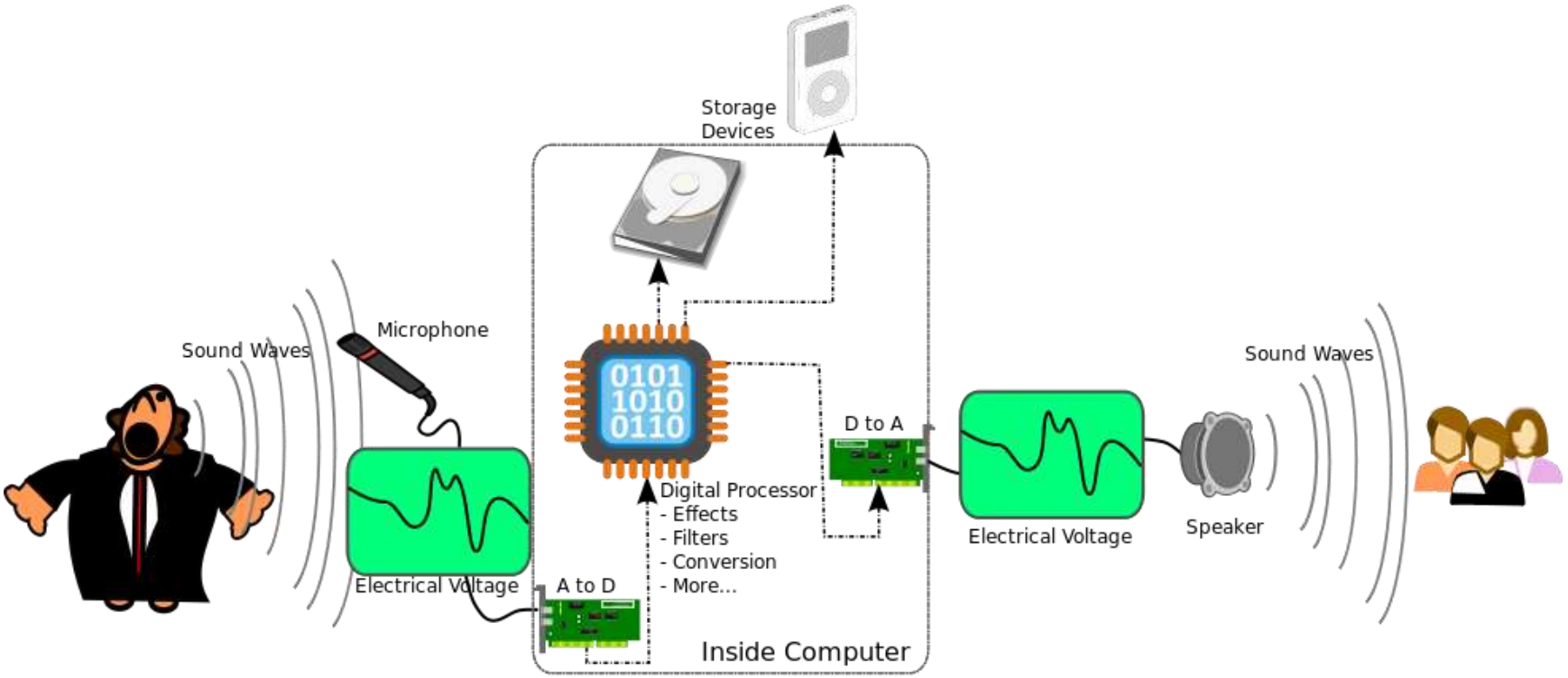
The Physical World is Analog in Nature

A periodic **signal** completes a pattern within a measurable time frame.

- It repeats that pattern over subsequent identical periods.
- The completion of one full pattern is called a cycle.

The sine wave is the most fundamental form of a periodic analog signal.

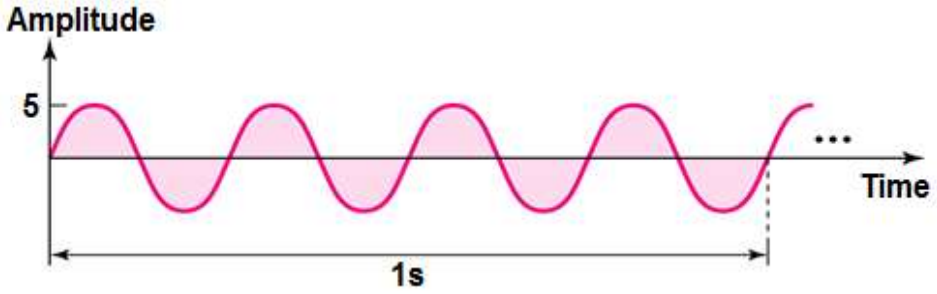
- It changes over the course of a cycle is smooth and continuous.



Sine Waves

Simplify

Signal is a function of time. It can also be described as a function of frequency.

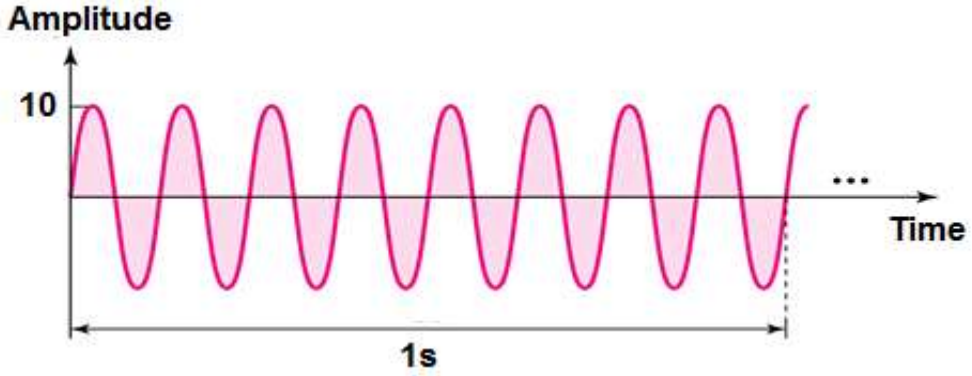


Peak Amplitude (***A***):

- maximum strength of signal

Frequency (*f*) Hertz (Hz)

- rate of change
- cycles per second



Period: time for one repetition (*T*)

$T = 1/f$,

Radio Broadcasting

Radio is a wireless transmission of electromagnetic waves.

Original (**baseband**) voice signals have low frequencies.

For efficient transmission of the voice signals, *carrier wave* has a frequency that is selected from an appropriate band in the radio spectrum.

Radio broadcasting in **Victoria**:

- **Amplitude Modulation (AM)** radio: frequencies range of 621 – 1701 **k**Hz;
- **Frequency Modulation (FM)** radio: frequencies range of 87.6 – 107.5 **M**Hz

FM has better sound quality due to **higher bandwidth**.

Units conversion:

- **k** – 10^3
- **M** – 10^6
- **G** – 10^9
- **T** -- 10^12

Audio receiver; https://youtu.be/uakGke5TN9Q

Examples

- What is the period of an AM radio signal 774KHz?
  - 774KHz = 774 000 Hz
  - 1/774 000 = 1.29 micro seconds
  - (1s = 1,000,0000 microseconds)

- What is the period of a mobile phone carrier operating at 1800MHz ?
  - 1MHz = 10^6 Hz, so 1800Mhz = 1.8 GHz = 1.8 x 10^9
  - 1/1.8 x 10^9 = 0.55 ns (nano seconds)

Wavelength

- In air, the signals travel at approximately the speed of light – 3×10^8 m/s
- So we can calculate the wavelength by multiplying the period by the speed:

- $\lambda = 1/f * v = v/f$ λ (lambda) is the usual symbol for wavelength, v is speed of waves

- Eg

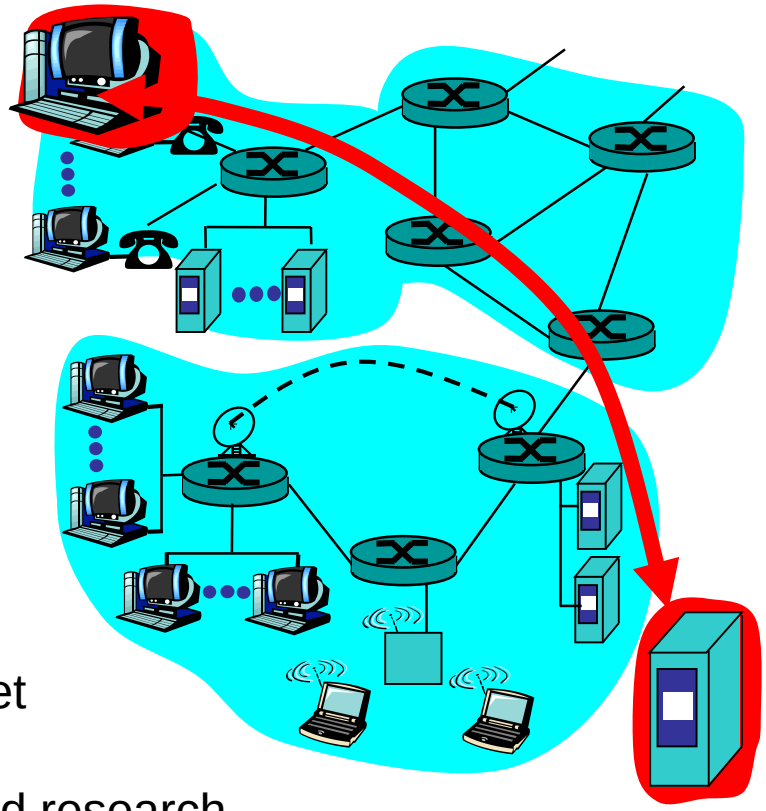
774Khz: $1.29 \times 10^{-6} \times 3 \times 10^8 = 3.87 \times 10^2$ m = 367 m

101.1 MHz: $0.0098 \times 10^{-6} \times 3 \times 10^8 = 0.0297 \times 10^2$ m = 2.9 m

1800Mhz: $0.55 \times 10^{-9} \times 3 \times 10^8 = 1.65 \times 10^{-1}$ m = 16.5 cm

The Internet and Protocols

Originally called ARPANET, began in 1969, a project of DoD in the US (with 4 nodes).



Goals.

- To solve the problem of internetworking.
- To distribute the load over the network – no central node

First packet-switching network based on 5 layers for different network environment

- Computer
- Radio
- satellite

Result in Transmission Control Protocol/ Internet Protocol (TCP/IP) suite.

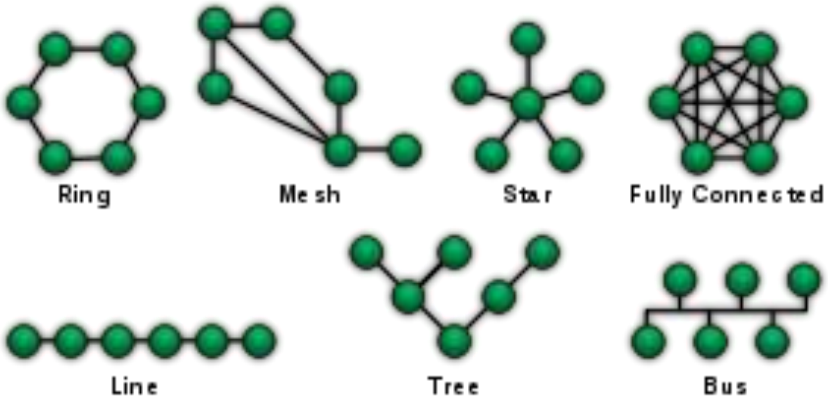
1983: Internet used for academic, education and research.

1986 NSFNet created US Internet backbone.

Since then Internet has become a global network.

Connecting Computers on a Network

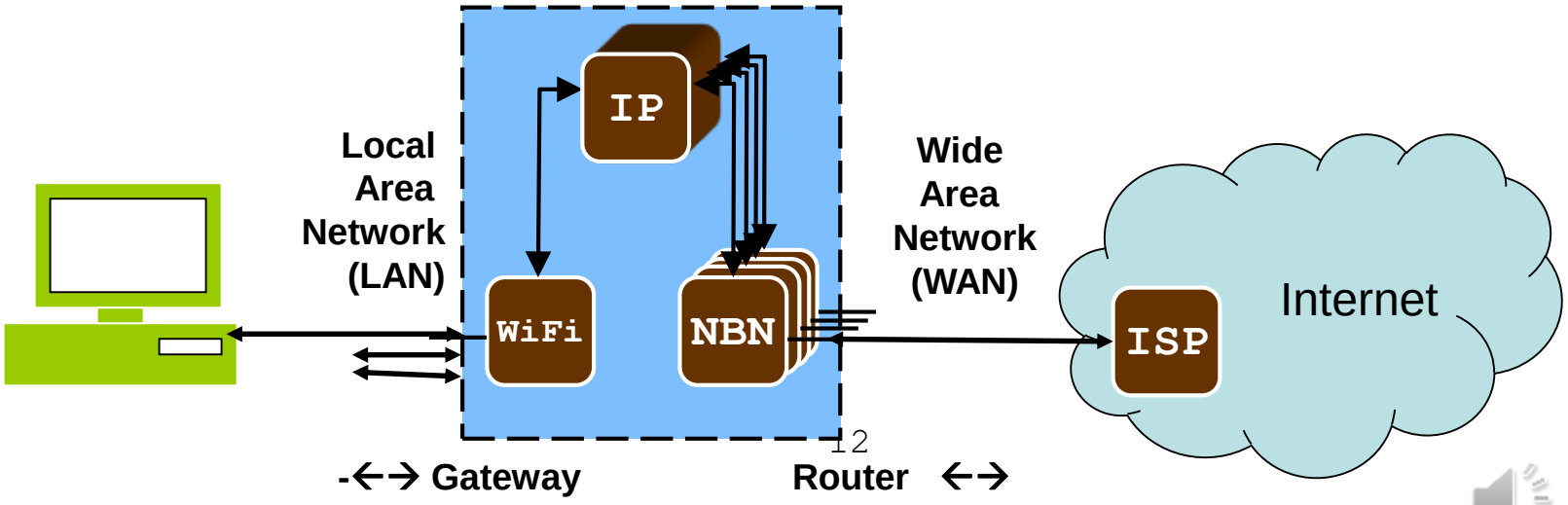
- So what is a network?
  - A network is the inter-connection of more than one computer to allow an exchange of information. Necessary for a network are computers (sometimes referred to as hosts, or nodes), cables, network hardware (eg. routers, switches or hubs) and the implementation of communications protocols.



- Network Topology
  - The way that nodes within a network are connected tis called its ***topology***
  - Such connections are described in computer science as a graph, and the domain is called ***Graph Theory***
  - Also sometimes called ***Network Architecture***

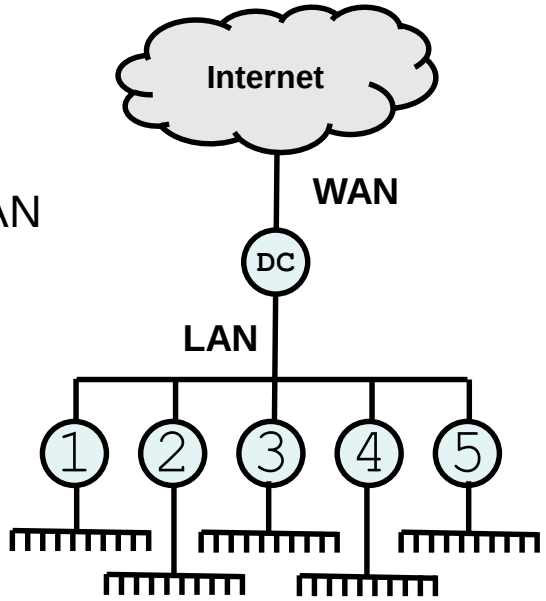
The Role of the Router

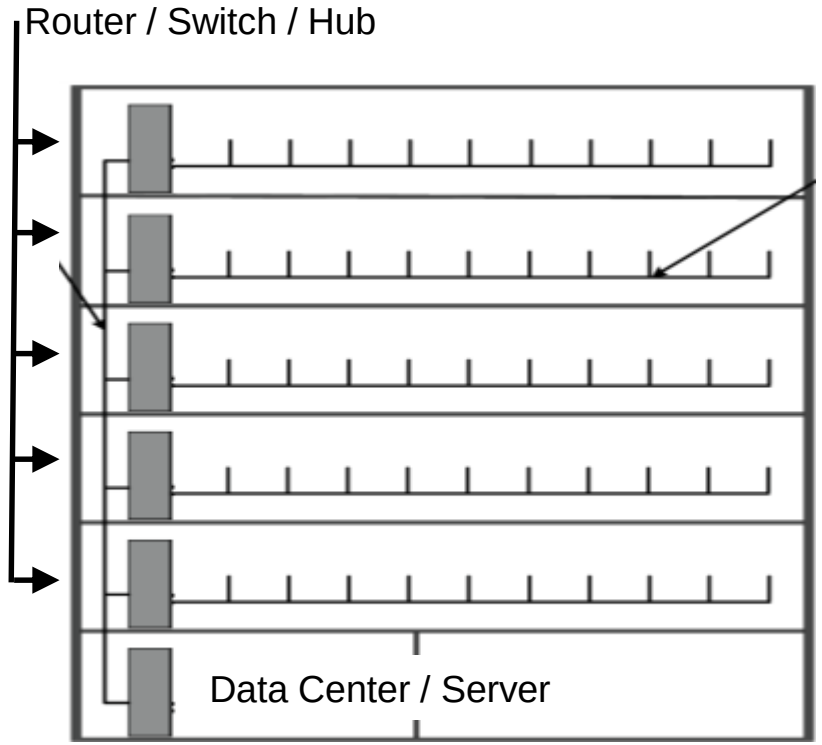
- A simple canonical model of the network is below. This simple model is replicated in a tree structure.
- So the internet is a ***network of networks*** that use the same protocol suite between networks. The networks are inter-connected using routers.
- A router has at least two network interface layers (link layers), since it connects two networks and forwards datagrams between the two networks.



A Simple 2-level Network

- An extension to 2 levels, with one layer for the building and one layer for each floor.
- These can be subnets as shown here, or simply patch panel connections,
- These are typically located in patch closets on each floor.
- In this case, the DC connects the WAN to the LAN





Typical Building Layout

WAN = Wide Area Network
LAN = Local Area Network

Routers, Switches or Hubs?

These terms are often confused, but are very different devices.

- A Hub
  - Physically connects two or more LANs or machines
  - Any packet on one port is copied to all others
  - Hence all ports share the bandwidth → poorer net performance
- A Switch
  - Connects two or more LANs or machines
  - it relays packets from source to target port, others don't see them
  - Hence each port has full bandwidth (not shared) → Better performance

- A Router:
  - Much smarter than hub or switch
  - Connects two WANs, or a WAN with a LAN
  - Can also use wireless access points
  - Packet relays are controlled by router tables
  - Uses specialised protocols to direct packet traffic
  - Can be controlled remotely

Local Area Networks (LANs)

LANs cover a smaller scope: Building or small campus.

- Usually owned by same organization as attached devices;
- Data rates much higher.

LAN configurations

- Switched Ethernet: single or multiple switches
- Wireless: Mobility, ease of installation

LAN that uses the Internet technologies:

Example: www.rmit.edu.au
www.arc.gov.au
www.ebay.com.au
www.cba.com.au

Intranet: Open to those inside the organization

Extranet: Open only to those invited users outside the organization

Metropolitan Area Networks (MANs)

MANs are middle ground between LANs and WANs.

A MAN can be a private or public network, to provide:

- the required capacity at lower costs;
- greater efficiency than obtaining an equivalent service from the local telephone company.

Features:

- Point-to-point and switched network techniques used in WANs may be inadequate for the growing needs of the organizations.
- High speed and cover large areas.

- Not widely used large organizations tends to use LANs with sub nets

Wide Area Networks (WANs)

A WAN consists of a number of interconnected switching.

Data are transmitted from one device, routed through internal nodes to the specified destination.

Alternative technologies

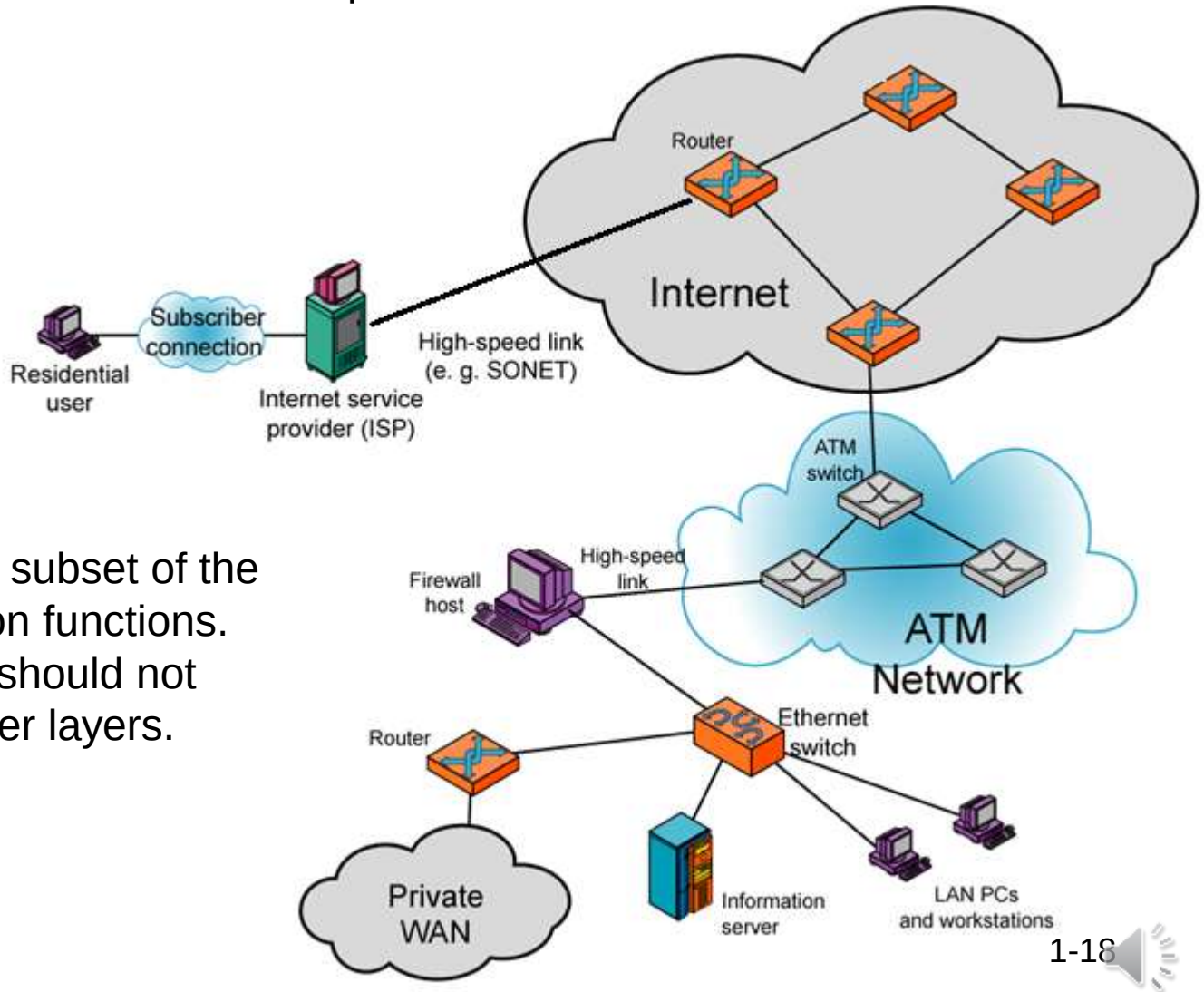
- ***Circuit switching***: Each circuit occupies a fixed capacity, e.g. telephone networks.
  - ✓ Dedicated communications path established for the duration of conversation;
  - ✓ Real-time services, data transmission is rapid, without delay.

- ***Packet switching***: Users share network resources, e.g. computer networks.
  - ✓ Data sent out in a sequence of small chunks (packets) of data at a time;
  - ✓ Packets passed from node to node between source and destination.

- Frame relay
- Asynchronous Transfer Mode (ATM), Evolution of frame relay

OSI Model

Open Systems Interconnection (OSI) Model is created by International Standards Organization (ISO) as a framework for computer network standards in 1984.



Hierarchical layers:

- Each layer performs a subset of the required communication functions.
- Changes in one layer should not require changes in other layers.

7- Layer Model of OSI

Physical Layer
- physical interface between device and transmission medium or network;
- define how individual bits are formatted to be transmitted through the network.

Data Link Layer
- message delineation, error control and network medium access control.

Network Layer: Internet Protocol (IP)
- responsible for making routing decisions.

Transport Layer: Transport Control Protocol (TCP)
- deals with end-to-end issues, e.g. segmenting message for network transport;
- maintaining the logical connections between sender and receiver.

Session Layer
- initiates, maintains and terminates each logical session.

Presentation Layer
- formats data for presentation to the user;
- provides data interfaces, data compression and translation between different data formats.

Application Layer
- set of utilities used by application programs.

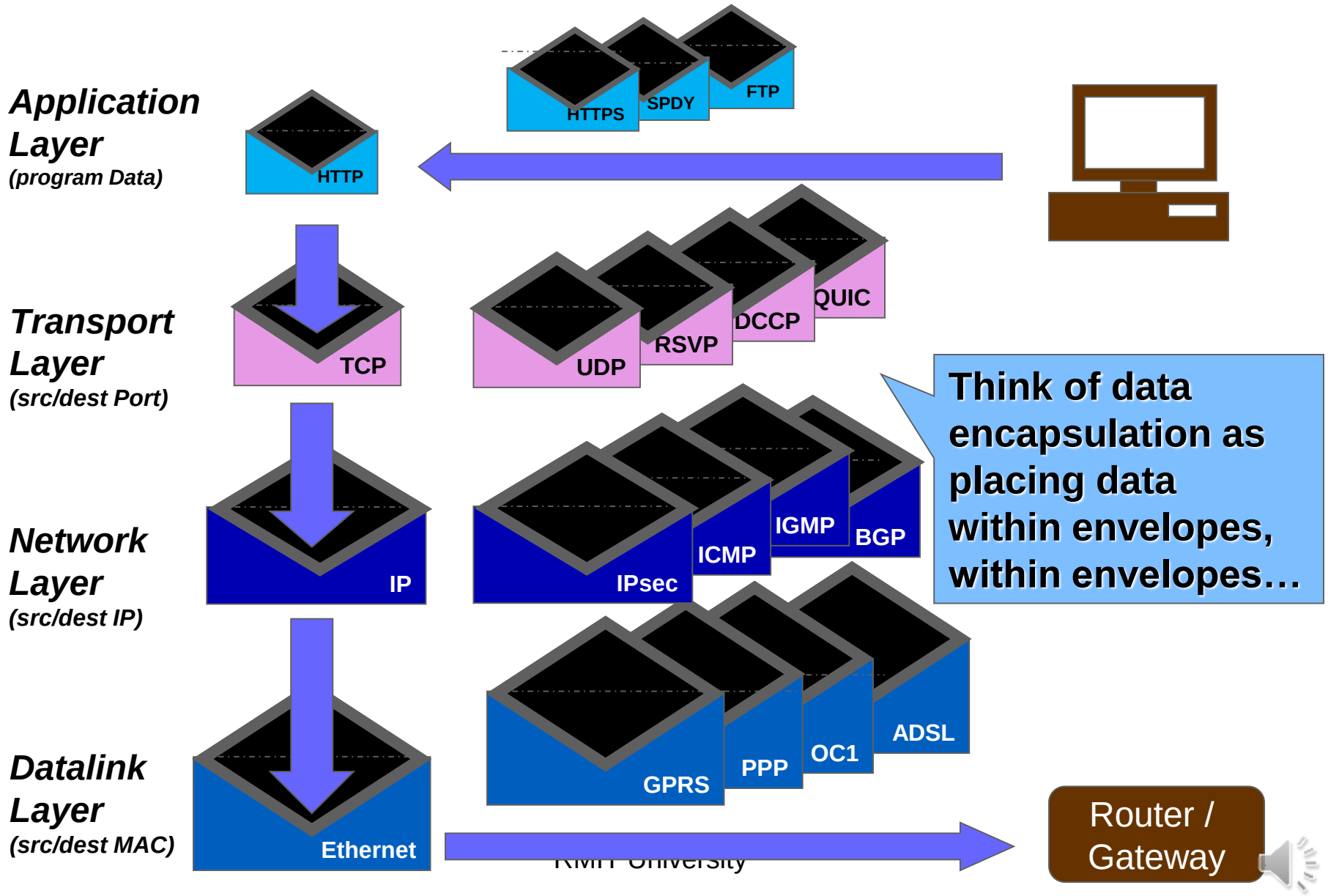
Originally proposed in 1983. Bottom 4 layers well defined, upper one less so

OSI Reference Model (Summary)

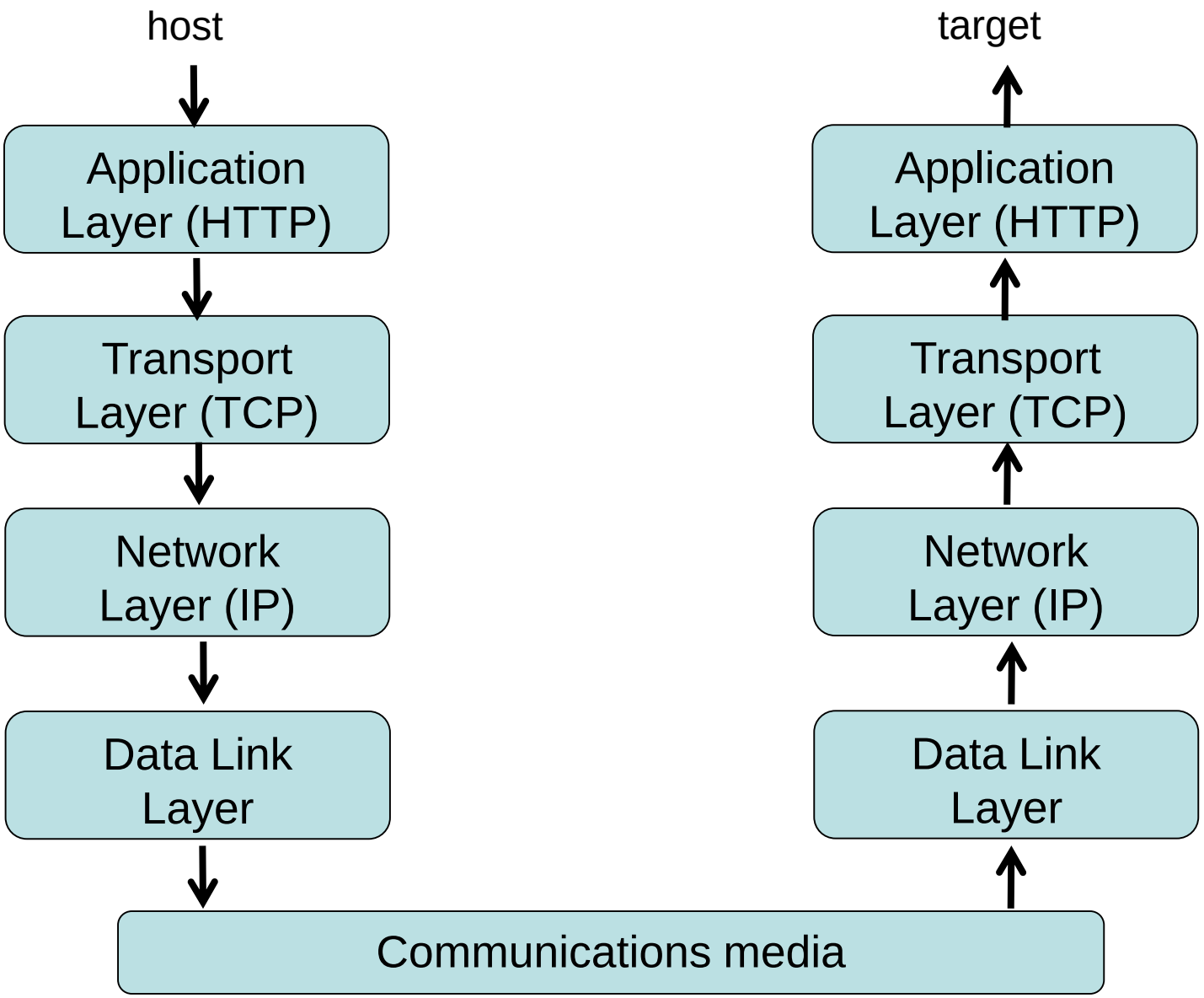
/	Layer	Name	Explanation	Unit	Protocols
Application / Platform	7	Appli-cation	***What*** is being sent	Application dependent	Bootp, DHCP, DNS, NTP, SNMP, SMTP
	6	Presen-tation	***Presenting*** data in different ways to different targets		TLS, SSL,
	5	Session	***Relating*** data items to each other		PP2P, VPN,
Network / Infratructure	4	Transport	***Ways*** to get the data there	Segment / Datagram	TCP, UDP, NAT
	3	Network	***Where*** to send the data	Packet	IPv4, IPv6, IPSec,, ICMP
	2	Datalink	***How*** to send the data	Frame	Ethernet, Wifi
	1	Physical	***Representing*** the data	Bit	Electrical, Fiber

Mnemonic: **A Pizza Served Today Never Delays Progress People Do Need To See Pamela Anderson**

Packets and Data Encapsulation

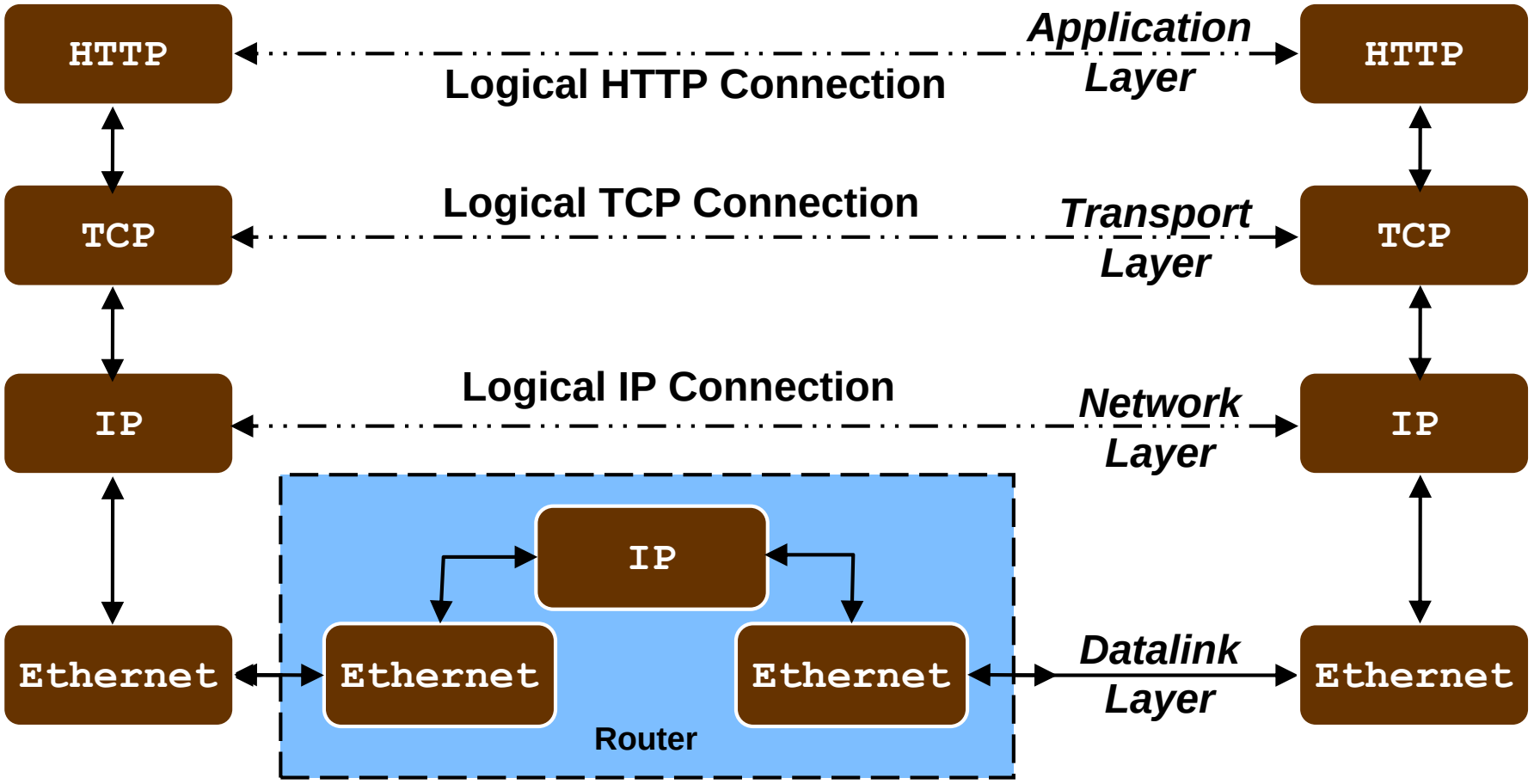


TCP/IP


host
target
Application Layer (HTTP)
Transport Layer (TCP)
Network Layer (IP)
Data Link Layer
Application Layer (HTTP)
Transport Layer (TCP)
Network Layer (IP)
Data Link Layer
Communications media

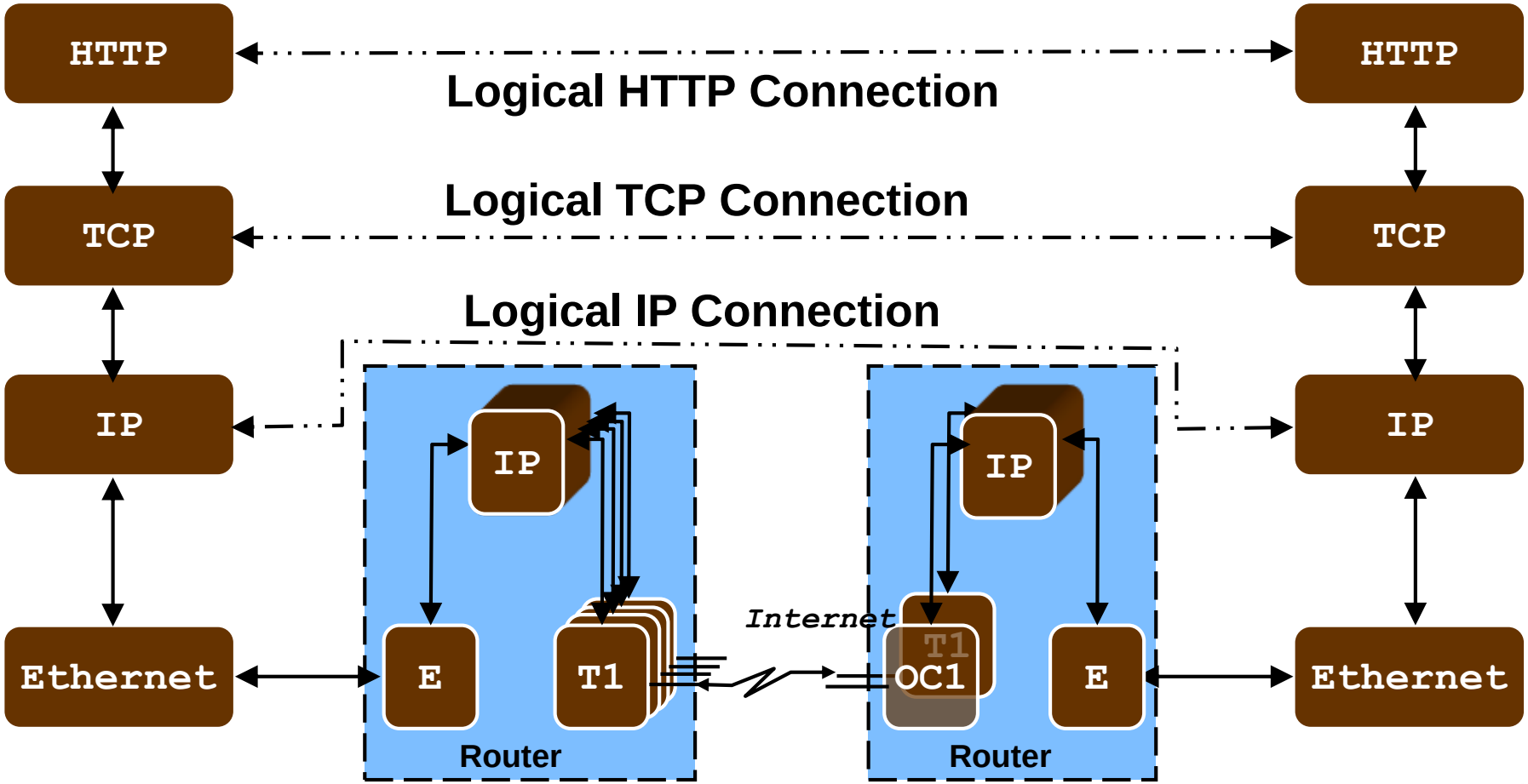
Implications of Layering

- Each layer only needs to deal at its own level, and does not need to be 'aware' of lower layers.

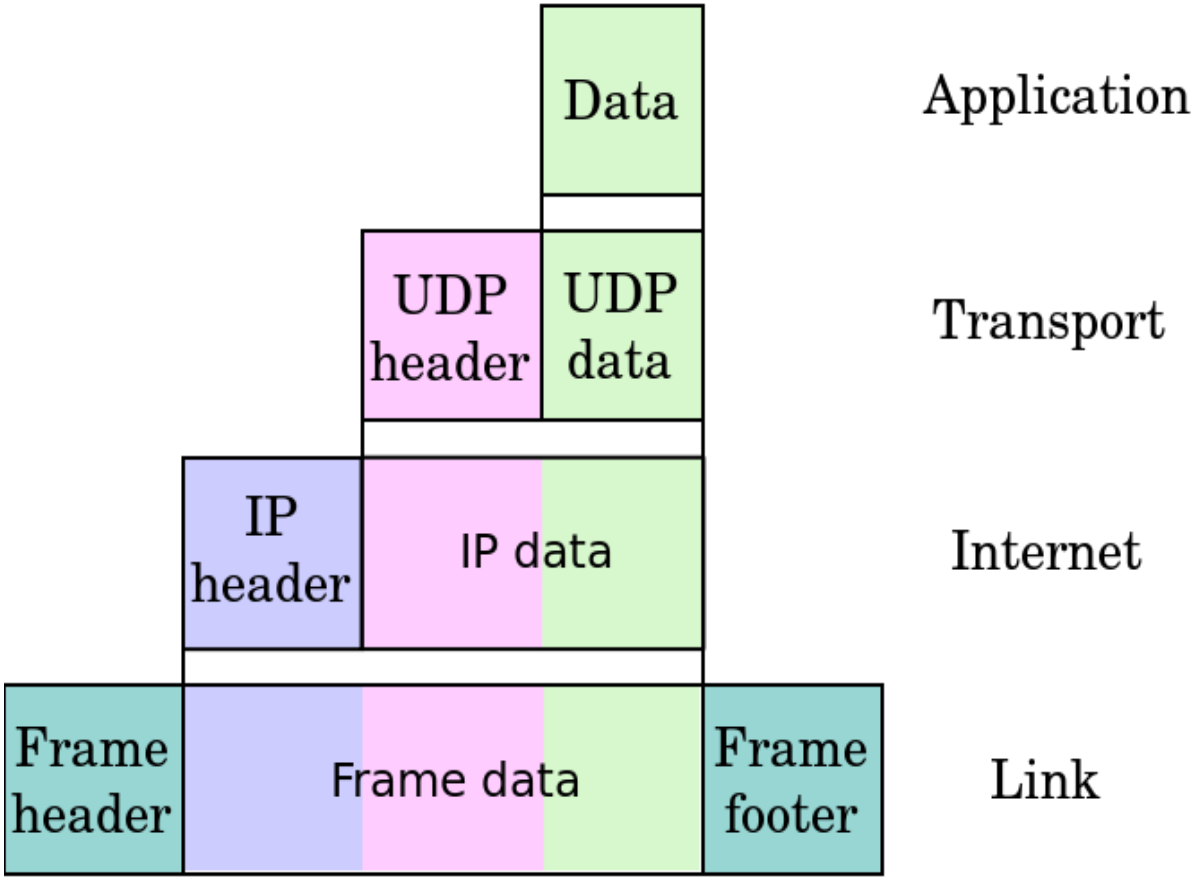


Implications of Layering

- Among the routers, the packets can be moved over different technologies as needed.



Layer headers are added to the payload data



"UDP encapsulation" by en:User:Cburnett

Protocols

Networks are complex!

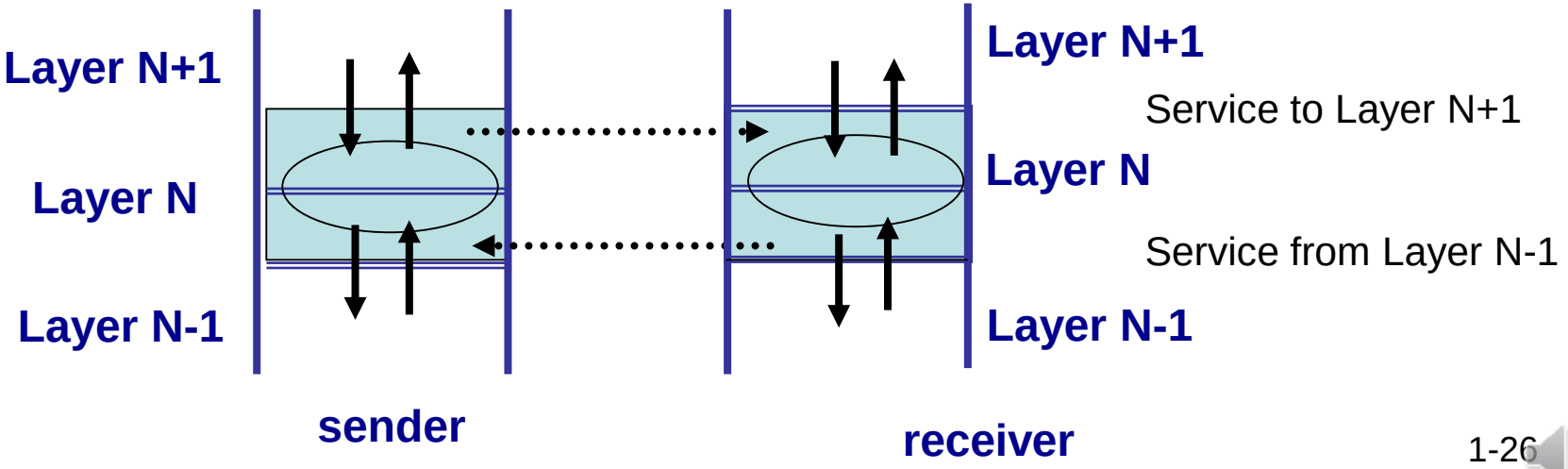
Hosts, routers, software, hardware, links of various media and applications.

For exchange data, high degree of **cooperation** among computer systems needed.

All communication activity in Internet governed by protocols.

Protocol: sets of rules to define how to communicate at each layer and how to interface with adjacent layers. Key features of protocol:

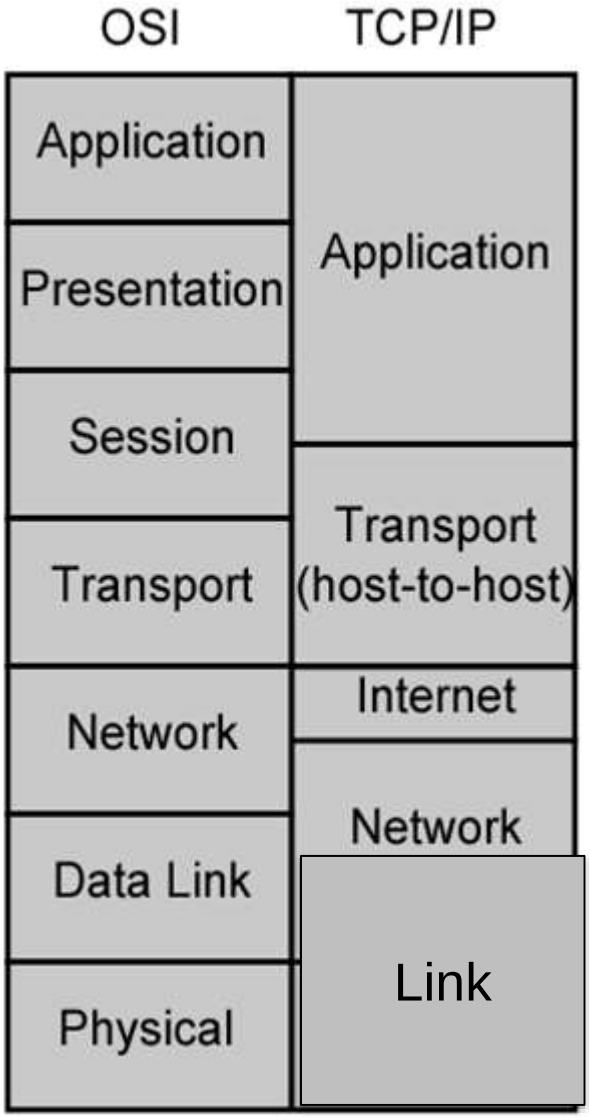
- Syntax: the format of the data blocks
- Semantics: control information for coordination and error handling.
- Timing: speed match and sequencing.



TCP/IP Model vs OSI Model

The OSI model discussed so far is an extension of the original model developed in the 1970's when the Internet was born.

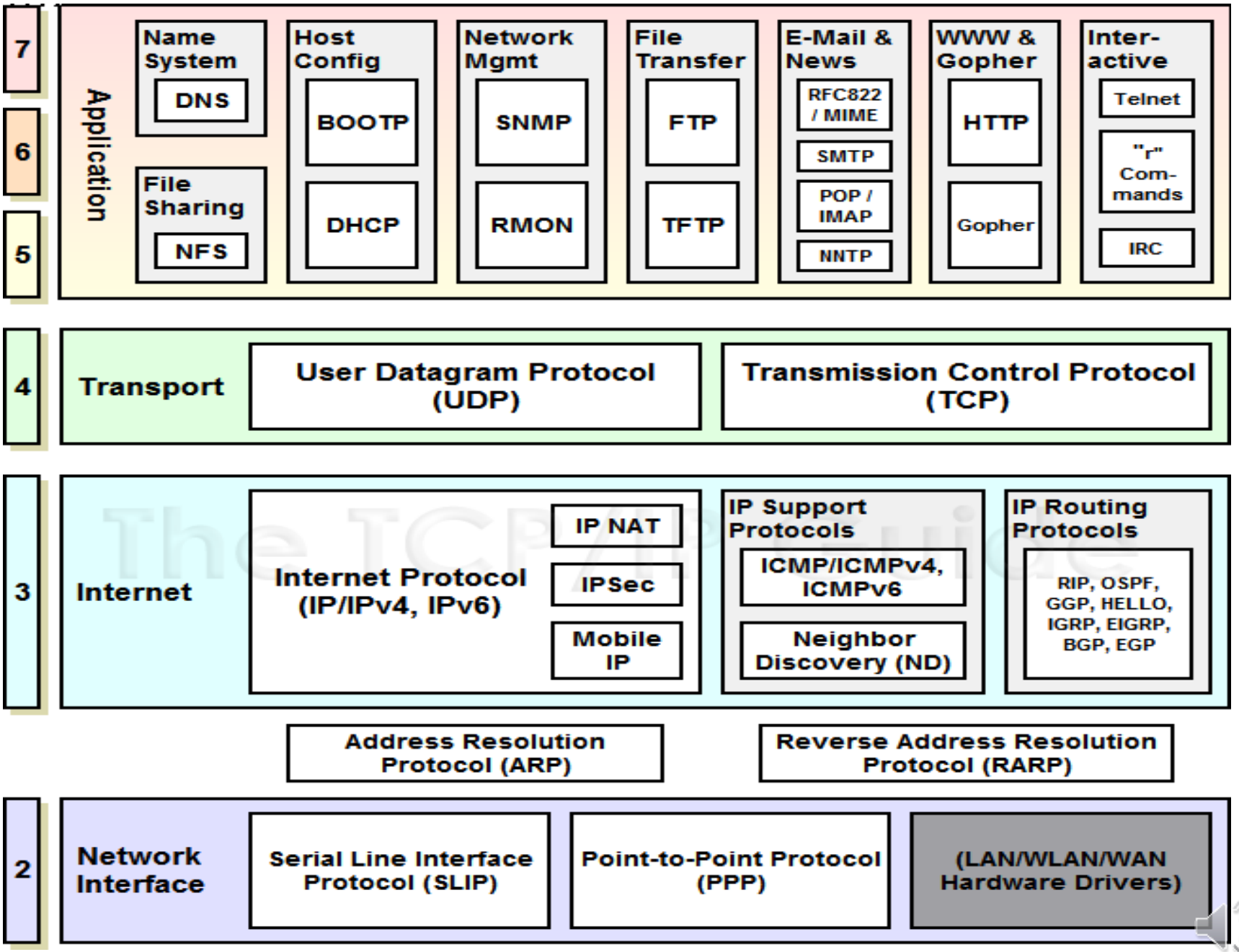
Never really having had a name, it is now conventionally call the TCP/IP Model.



Differences:

- Application Layer
  - In OSI, this has been split into Session, Presentation, and Application Layers.
    - The idea was that session behavior could be abstracted by allowing applications the ability to assume it. An example might be a networked file system such as Dropbox. The login process, which establishes the session need be done only once. Office365 is another example.
    - The presentation layer is more application-specific, and so is more closely tied to the application.

- Datalink Layer
  - In OSI, the physical layer was separated from the link layer in order to emphasize the independence of bit patterns from their underlying technology.


7
6
5
Application
Name System
DNS
File Sharing
NFS
Host Config
BOOTP
DHCP
Network Mgmt
SNMP
RMON
File Transfer
FTP
TFTP
E-Mail & News
RFC822 / MIME
SMTP
POP / IMAP
NNTP
WWW & Gopher
HTTP
Gopher
Inter-active
Telnet
"r" Com-mands
IRC
4
Transport
User Datagram Protocol (UDP)
Transmission Control Protocol (TCP)
3
Internet
Internet Protocol (IP/IPv4, IPv6)
IP NAT
IPSec
Mobile IP
IP Support Protocols
ICMP/ICMPv4, ICMPv6
Neighbor Discovery (ND)
IP Routing Protocols
RIP, OSPF, GGP, HELLO, IGRP, EIGRP, BGP, EGP
Address Resolution Protocol (ARP)
Reverse Address Resolution Protocol (RARP)
2
Network Interface
Serial Line Interface Protocol (SLIP)
Point-to-Point Protocol (PPP)
(LAN/WLAN/WAN Hardware Drivers)