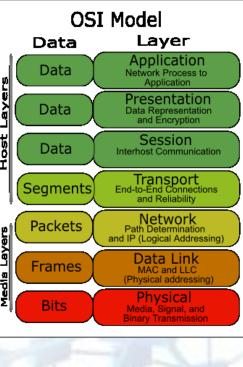# Computer Networks and Applications

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OSI Model

Data	Layer	
Host Layers	Data	Application — Network Process to Application
	Data	Presentation — Data Representation and Encryption
	Data	Session — Interhost Communication
	Segments	Transport — End-to-End Connections and Reliability
Media Layers	Packets	Network — Path Determination and IP (Logical Addressing)
	Frames	Data Link — MAC and LLC (Physical addressing)
	Bits	Physical — Media, Signal, and Binary Transmission

OSI model

7. Application layer

NNTP · SIP · SSI · DNS · FTP · Gopher · HTTP · NFS · NTP · SMPP · SMTP · SNMP · Telnet · DHCP · Netconf · RTP · SPDY · (more)

6. Presentation layer

MIME · XDR · TLS · SSL

5. Session layer

Named pipe · NetBIOS · SAP · L2TP · PPTP · SOCKS

4. Transport layer

TCP · UDP · SCTP · DCCP · SPX

3. Network layer
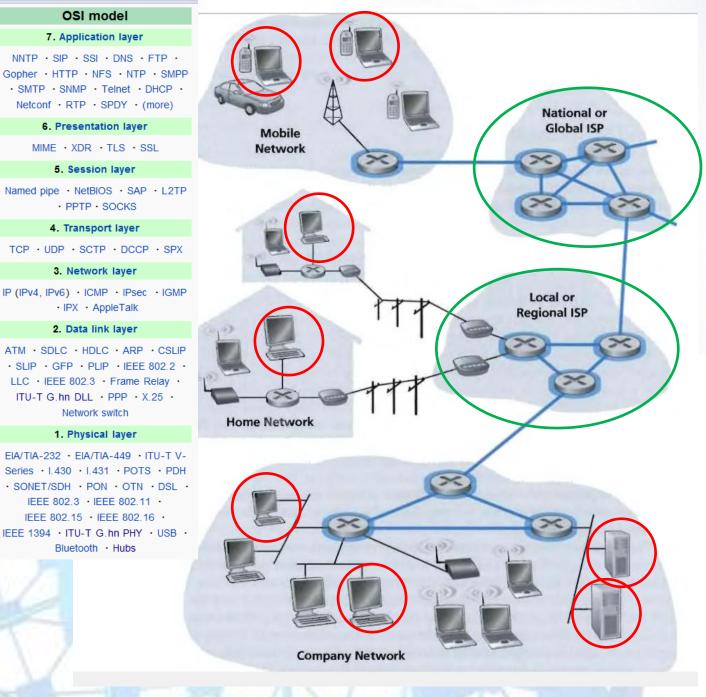
IP (IPv4, IPv6) · ICMP · IPsec · IGMP · IPX · AppleTalk

2. Data link layer
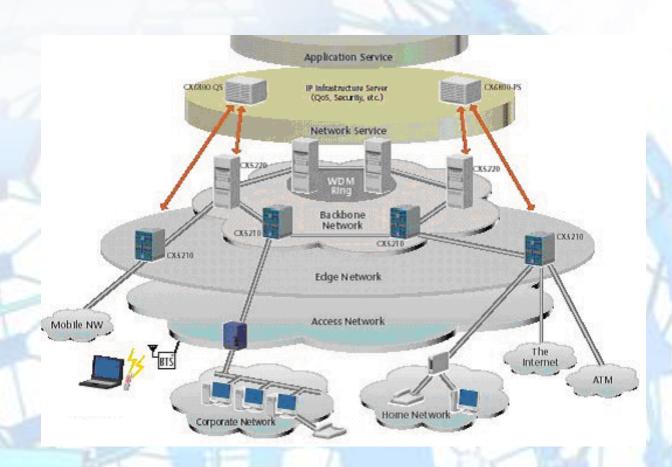
ATM · SDLC · HDLC · ARP · CSLIP · SLIP · GFP · PLIP · IEEE 802.2 · LLC · IEEE 802.3 · Frame Relay · ITU-T G.hn DLL · PPP · X.25 · Network switch

1. Physical layer

EIA/TIA-232 · EIA/TIA-449 · ITU-T V-Series · I.430 · I.431 · POTS · PDH · SONET/SDH · PON · OTN · DSL · IEEE 802.3 · IEEE 802.11 · IEEE 802.15 · IEEE 802.16 · IEEE 1394 · ITU-T G.hn PHY · USB · Bluetooth · Hubs
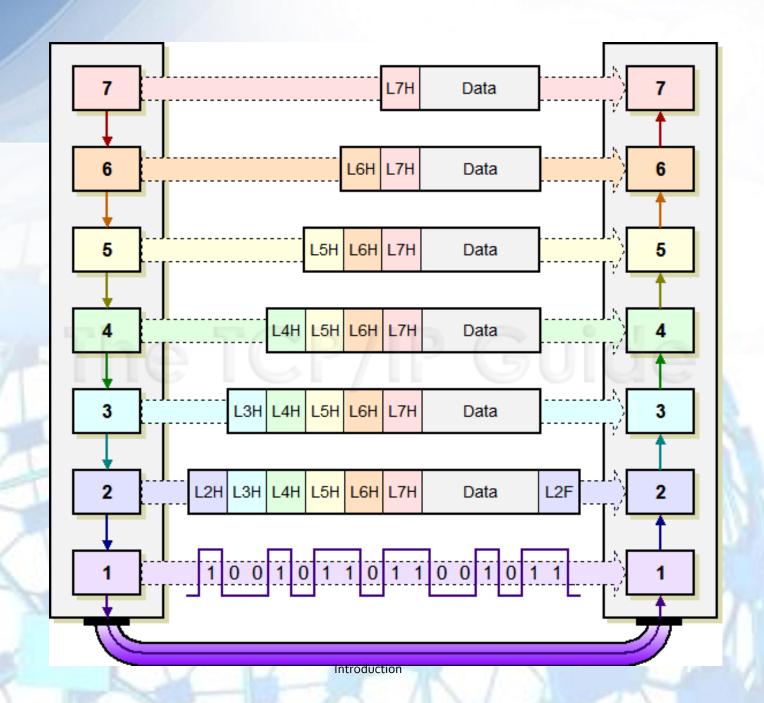
- Physical (Addressing by multiplexing)
  - Communication resource ---- bandwidth
  - How to share the channel --- multiplexing (Addressing in level 1)
- Data Link (Addressing by MAC address)
  - Data transmission across a link ----- flow/error control
  - Interconnecting links ----- switch/bridge → LAN
  - Interface between layer 1-2 ------ MAC
- Network (Addressing by IP)
  - Interconnecting multiple LAN ------ multi-protocol gateway
  - Routing / switching ---- circuit/packet/virtual circuit
- Transport (Addressing by IP+port)
  - End-to-end channels ----connection/connectionless/(un)reliable
- Application

Basic communication concepts

- Theoretical basis for data communication
  - Basic concepts of communication system
  - Communication system model and terminologies
  - Basic information theory
- Transmission
  - Channel and channel capacity
    - Bandwidth, SNR, distance
  - Multiplexing technologies
    - TDMA, FDMA, SDMA, CDMA
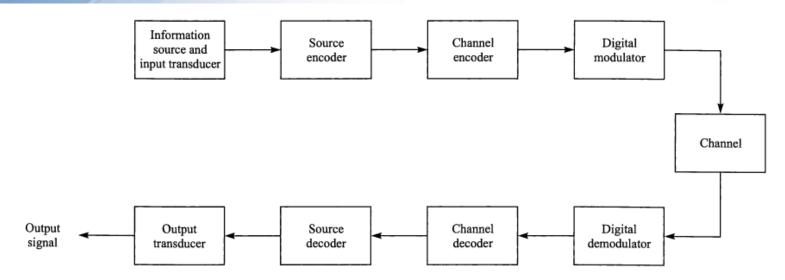- Switching
  - Packet / circuit / virtual circuit

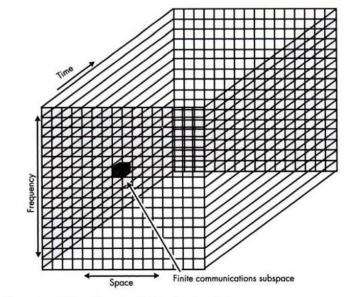**FIGURE 1.1–1**
Basic elements of a digital communication system.

FIGURE 3.2 A *three*-dimensional view of communications space.

Physical layer

- Transmission media
  - Guided media:
    - twisted pairs
    - co-axial cable
    - optic fibre

  - Wireless channel:
    - Microwave
    - Satellite
    - Mobile communication

- Maximum data rate of a channel
  - Channel capacity of a noisy Gaussian channel

$$C = F \log(1 + SNR) = F \log(1 + \frac{P}{\sigma^2})$$

  - Maximum data rate of a noiseless band-limited channel
    - Nyquist's sampling theorem

$$\text{Maximum data rate} = 2F \log_2(V) \text{ bits/sec}$$

Data Link Layer

- Link layer services
  - Framing
  - flow control:
  - error detection:
  - error correction:
  - half-duplex and full-duplex
  - Inter-connection of links
    - Switches
    - Hubs
    - Bridges

Data link layer

- Sub-layer structure of data link layer
  - Media access control (MAC)
    - The media access control (MAC) data communication protocol sub-layer, also known as the medium access control, is a sublayer of the data link layer specified in the seven-layer OSI model (layer 2).

    - It provides addressing and channel access control mechanisms that make it possible for several terminals or network nodes to communicate within a multiple access network that incorporates a shared medium

  - Logic link control (LLC)
    - Multiplexing protocols transmitted over the MAC layer (when transmitting) and decoding them (when receiving).

    - Providing node-to-node flow and error control

- Medium Access Control Sublayer
  - General channel allocation problem
  - Multiple access protocols
    - Static
    - Random
      - ALOHA
      - CSMA / CSMA/CD
      - Collision-free protocols
      - Limited contention protocols
      - WDMA
      - Wireless LAN protocols --- CSMA/CA

  - LAN examples
    - Ethernet (CSMA/CD), Addressing (MAC)
    - Wireless LANS (CSMA/CA)
    - Broadband wireless
    - Bluetooth
    - Data link layer switching (How frames are delivered to the receiver)

Network layer

- Network layer
  - General design issues
    - Services and their implementation
  - Routing algorithms
    - Key task: How to learn the network structure / find the route in distributed network system
    - The optimal principle of routing
    - Shortest path routing
    - Flooding
    - Distance vector routing
    - Link state routing
    - Hierarchical routing
    - Broadcast routing
    - Multicast routing
    - Routing for mobile hosts
    - Routing in Ad Hoc networks
    - Node lookup in peer-to-peer networks

- Congestion control algorithms
  - General principles of congestion control
  - Congestion control in virtual-circuit subnet
  - Congestion control in datagram subnet
  - Load shedding
  - Jitter control
- Internetworking
  - How networks can be connected
  - Interconnecting devices
    - Hub, switch, router
- Network layer in reality
  - IP address and related issues
  - Routing table using CIDR
  - Addressing mapping between IP/MAC addresses:
    - ARP, RARP, BOOTP, DHCP

Transport layer

- The transport service
  - Services provided to the upper layer
  - Transport service primitives
  - Socket

- Elements of transport layer protocols
  - Addressing, connection establish/release
  - Flow control and buffering
  - Multiplexing
  - Crash recovery

- UDP/TCP
  - Comparison
  - How they are used for different applications

Application layer

- DNS

- Electronic mail

- World Wide Web

- Multimedia

Network security

- Network security
  - Introduction
    - OSI security architecture

  - Cryptography
    - Symmetric cryptography
    - Asymmetric cryptography
      - Public key cryptography

  - Security services
    - Confidentiality
    - Authentication
    - Data integrity
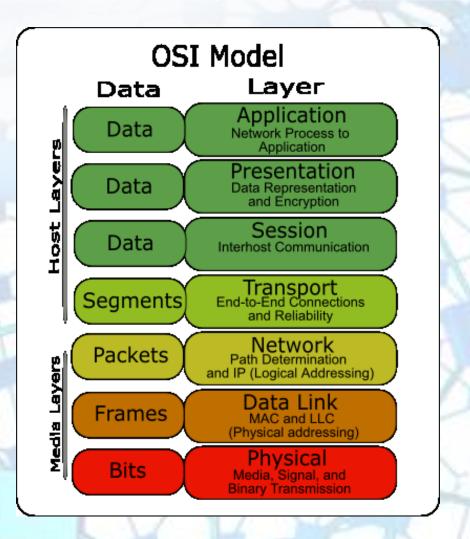
  - Network and Internet security

- Basic concepts
  - Physical
    - Bandwidth, multiplexing, switching
  - Data link
    - FEC, flow control, MAC address, MAC protocols, switch/bridge, LAN, VLAN
  - Network
    - Routing algorithms, IP/CIDR, ICMP, NAT, routing table, routers, internetworking
  - Transport
    - Transport service primitives, TCP/UDP and their applications

- Application
  - Web, DNS, Email

- Security
  - Encryption, symmetric/asymmetric encryption, authentication, data integrity, confidentiality

- Questions to be answered
  - What's the structure of communication systems?
    - Hosts, links/channel, internetworking, information theory

  - How users can exchange information through the network?
    - Multiplexing, MAC, Addressing(MAC/IP), routing/switching, connection establishment

  - How to exchange information safely?
    - FEC, flow control(data link/transport), routing, connection, security

  - What's the essential components of LANs?
    - Framing, MAC, addressing, switching

- How to send data across network?
  - Transport->network->data link-> physical layer
  - How the protocols are implemented in this procedure?

- Internet / TCP/IP
  - How to design a subnetwork?
    - IP, CIDR, routers, routing table
  - What kind of devices/protocols/technologies will be involved in a campus network?
    - LAN (Ethernet/WLAN), MAC, IP, DNS, ARP, NAT, switch, bridge, router, routing, TCP/UDP, VLAN, VPN, security
  - How to access a web?
    - Protocols/hardwares involved in this procedure (access network, Ethernet/WLAN/MAC, routers/routing, IP, TCP, DNS, Web server)

- Network security
  - How to protect data?
    - Integrity, confidentiality, data authentication
  - How to identify users?
    - Authentication
  - How to identify user/protect data
    - Digital signature
  - How to use symmetric/asymmetric encryption and other mechanisms to achieve network security