Wireless Communications
(and Networks)

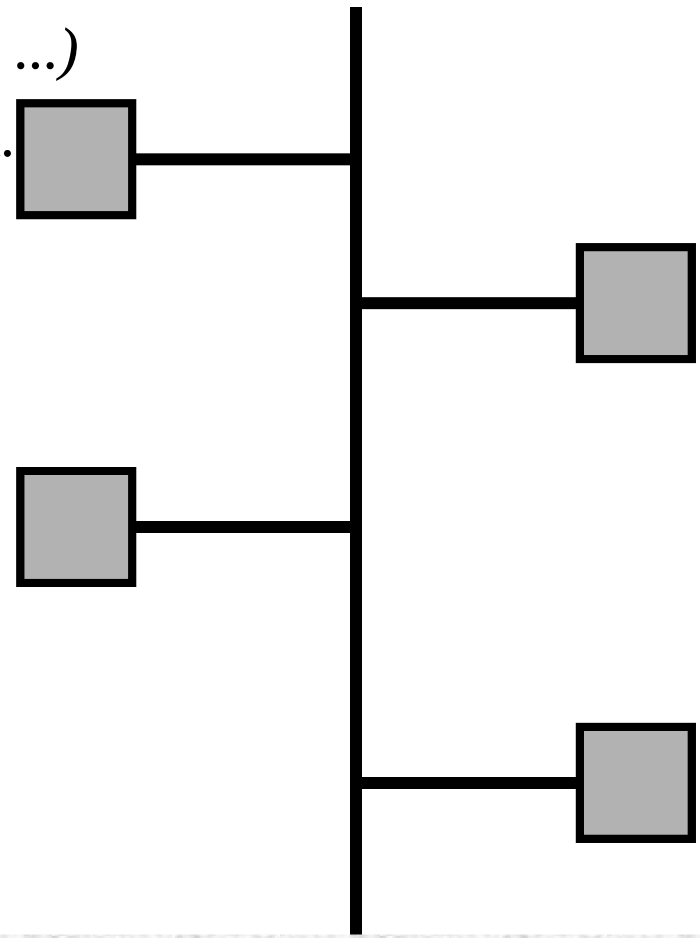
OSI / TCP , IP

Outline

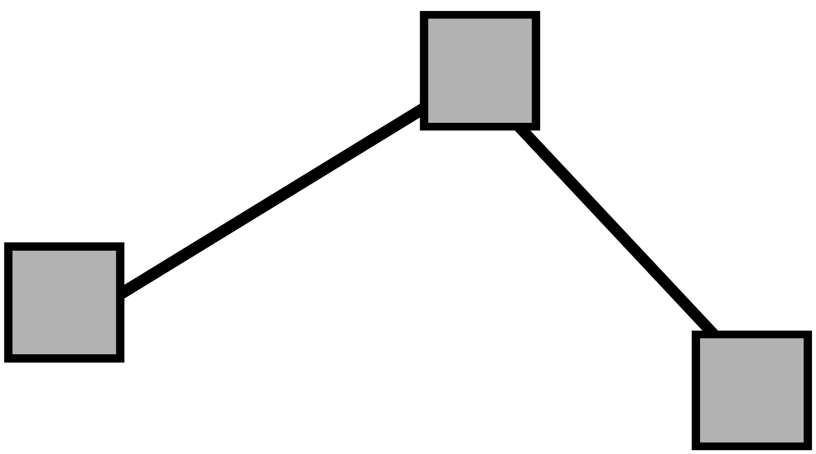
- OSI Reference Model
- TCP/IP Reference Model
- 2G and 2.5 G Cellular Networks

Multiaccess vs. Point-to-point

- Multiaccess means shared medium.
  - many end-systems share the same physical communication resources (*wire*, *frequency*, *...)*
  - There must be some arbitration mechanism.



- Point-to-point
  - only 2 systems involved
  - no doubt about where data came from !



LAN - Local Area Network

- Connects computers that are physically close together (< 1 mile).
  - high speed
  - multi-access
- Technologies:
  - Ethernet 10 Mbps, 100Mbps
  - Token Ring 16 Mbps
  - FDDI 100 Mbps
  - Myrinet 2 Gbps
  - WIFI
  - Bluetooth
  - UWB

WAN - Wide Area Network

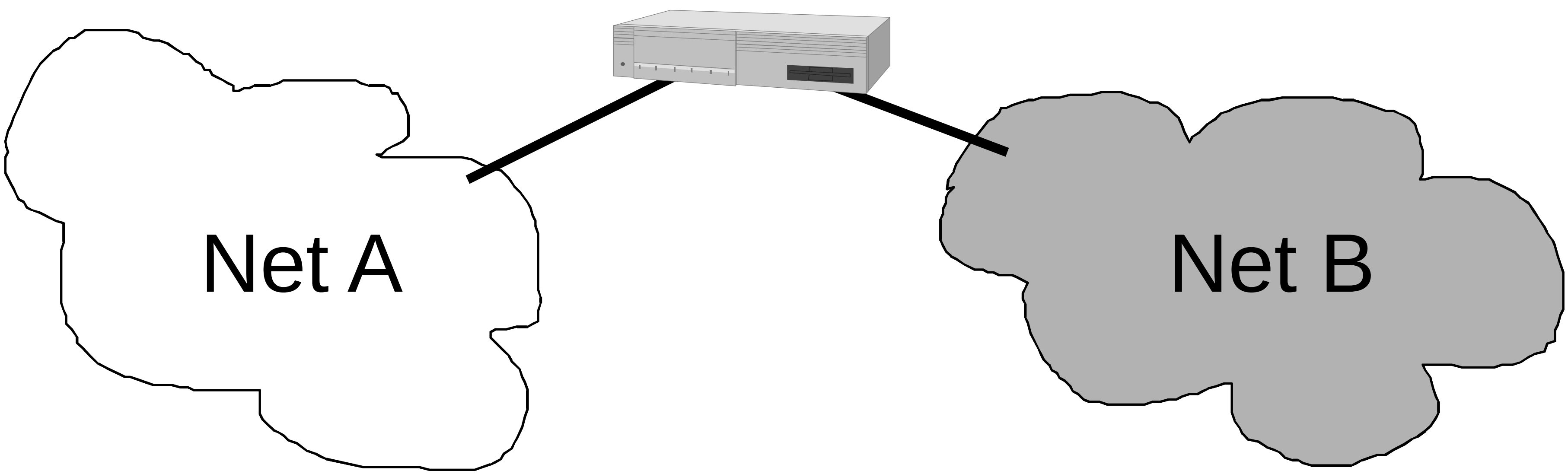
- Connects computers that are physically far apart. “long-haul network”.
  - point-to-point
- Technologies:
  - Telephone lines
  - Satellite communications
  - Fiber

MAN - Metropolitan Area Network

- Larger than a LAN and smaller than a WAN
  - example: campus-wide network
  - multi-access network
- Technologies:
  - coaxial cable
  - microwave
- WIMAX

Internetwork

- Connection of 2 or more distinct (possibly dissimilar) networks.
- Requires some kind of network device to facilitate the connection.

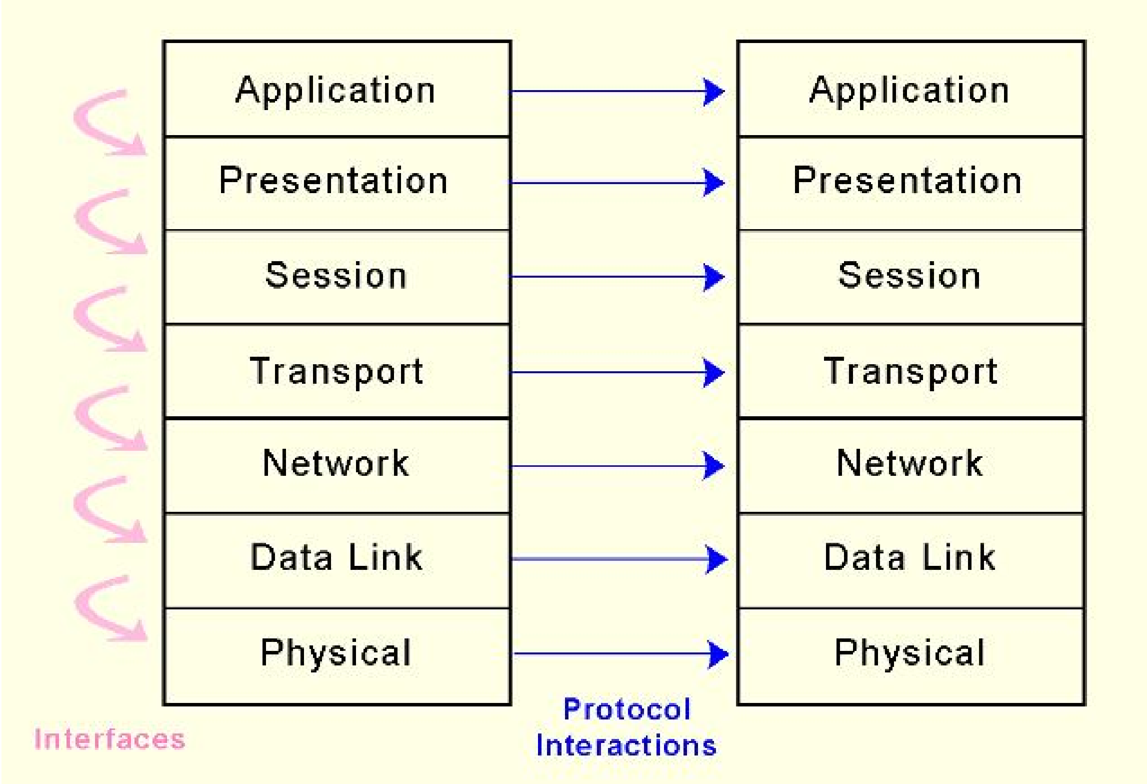


ISO/OSI Reference Model

- To address the growing tangle of incompatible proprietary network protocols, in 1984 the ISO formed a committee to devise a unified protocol standard.
- The result of this effort is the ISO *Open Systems Interconnect Reference Model* (ISO/OSI RM).
- The ISO's work is called a reference model because virtually no commercial system uses all of the features precisely as specified in the model.
- The ISO/OSI model does, however, lend itself to understanding the concept of a unified communications architecture.

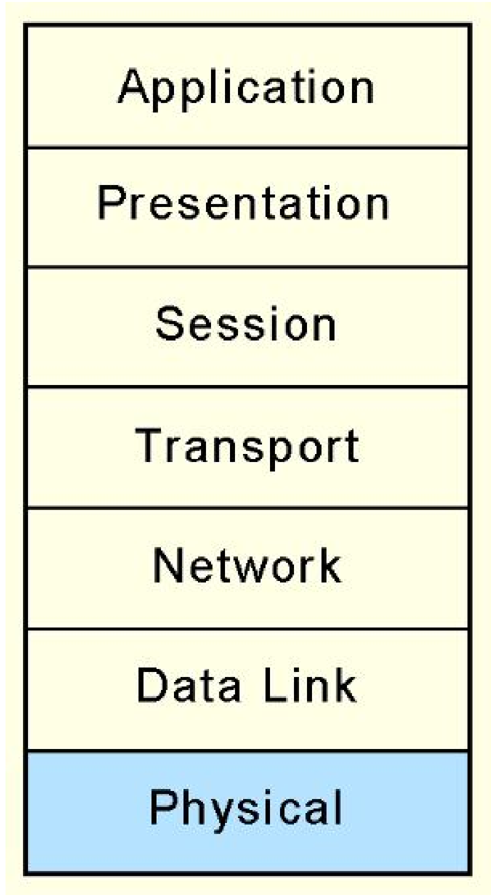
ISO/OSI Reference Model

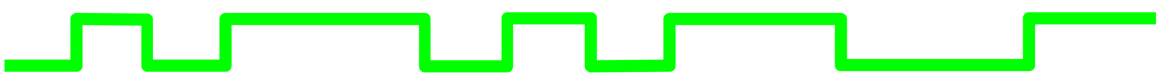
- The OSI RM contains seven protocol layers, starting with physical media interconnections at Layer 1, through applications at Layer 7.
- OSI model defines only the functions of each of the seven layers and the interfaces between them.
- Implementation details are not part of the model.



ISO/OSI Reference Model: Physical Layer

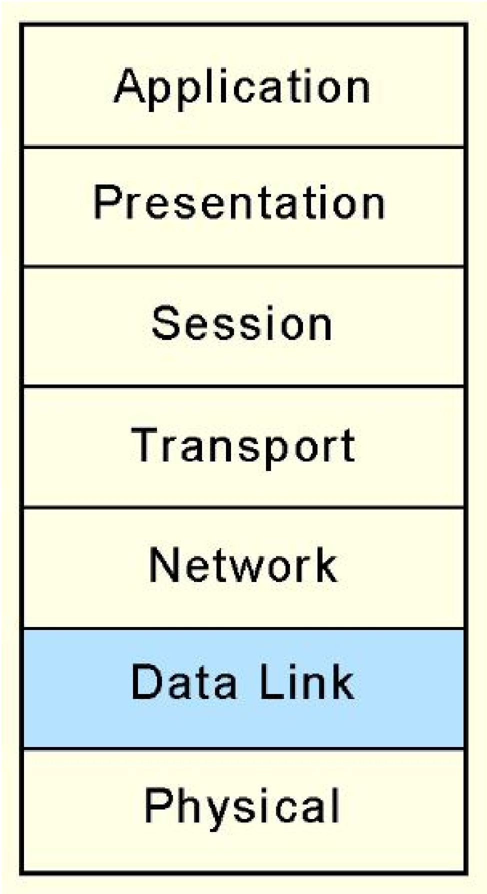
- The Physical layer receives a stream of bits from the Data Link layer above it, encodes them and places them on the communications medium.
- The Physical layer conveys transmission frames, called *Physical Protocol Data Units*, or *Physical PDUs.* Each physical PDU carries an address and has delimiter signal patterns that surround the *payload*, or contents, of the PDU.
- Issues:
  - mechanical and electrical interfaces
  - time per bit
  - distances

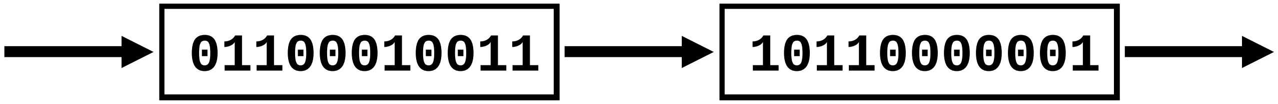




ISO/OSI Reference Model: Data Link

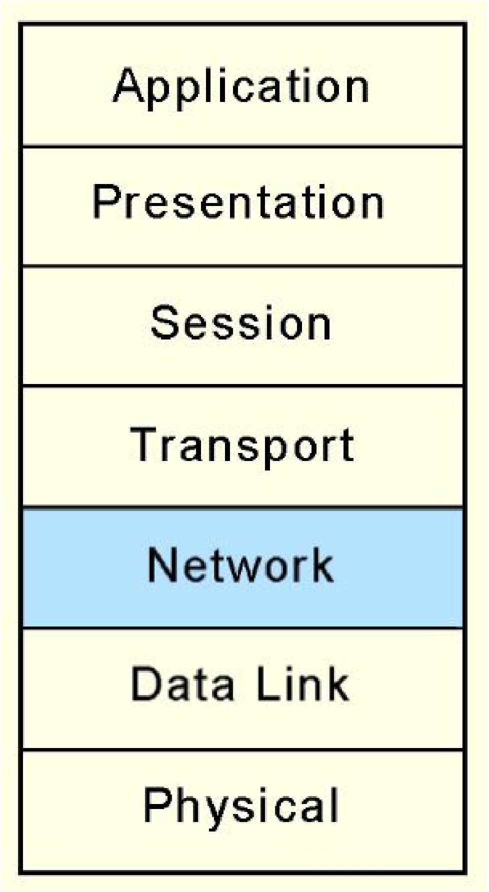
- The Data Link layer negotiates frame sizes and the speed at which they are sent with the Data Link layer at the other end.
  - The timing of frame transmission is called *flow control*.
- Data Link layers at both ends acknowledge packets as they are exchanged. The sender retransmits the packet if no acknowledgement is received within a given time interval. ARQ
- Medium Access Control - needed by mutiaccess networks.
- Issues:
  - *framing* (dividing data into chunks)
    - *header & trailer bits*
  - addressing





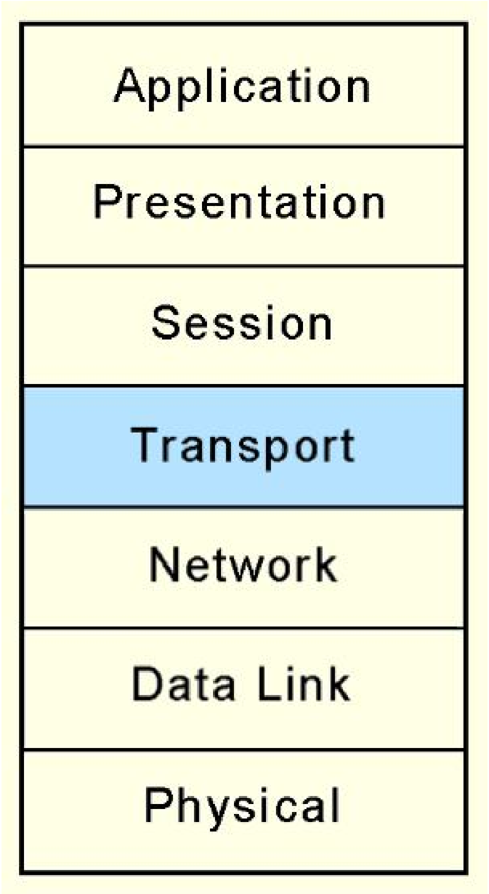
ISO/OSI Reference Model: Network

- At the originating computers, the Network layer adds addressing information to the Transport layer PDUs.
- The Network layer establishes the route and ensures that the PDU size is compatible with all of the equipment between the source and the destination.
- Its most important job is in moving PDUs across *intermediate* nodes.
- Issues:
  - *packet* headers
  - virtual circuits



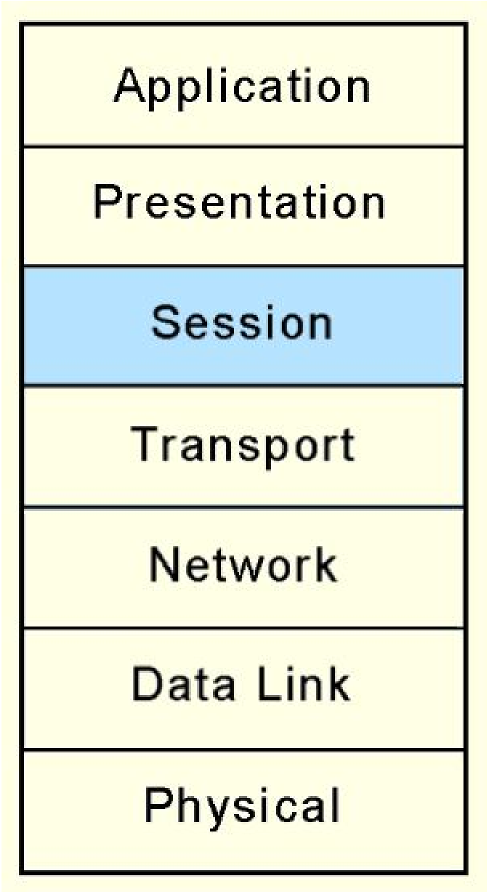
ISO/OSI Reference Model: Transport

- the OSI Transport layer provides end-to-end acknowledgement and error correction through its handshaking with the Transport layer at the other end of the conversation.
  - The Transport layer is the lowest layer of the OSI model at which there is any awareness of the network or its protocols.
- Transport layer assures the Session layer that there are no network-induced errors in the PDU.
- Issues:
  - headers
  - error detection: CRC
  - reliable communication



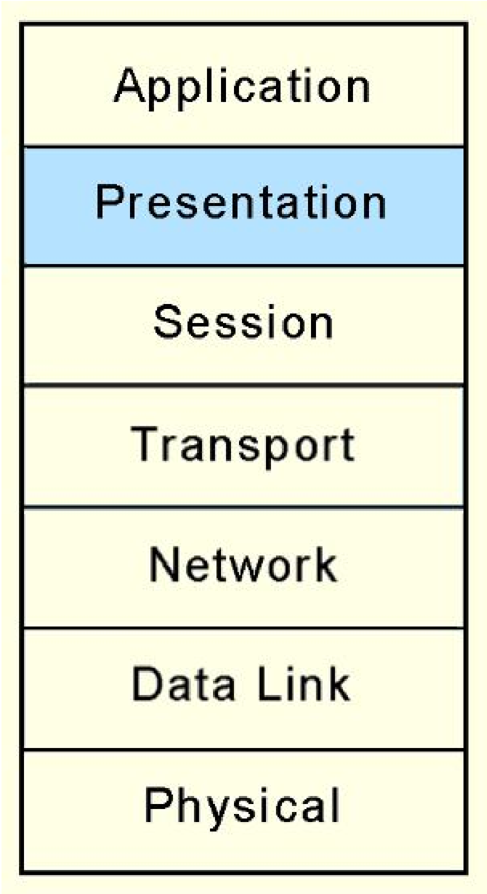
ISO/OSI Reference Model: Session

- The Session layer arbitrates the dialogue between two communicating nodes, opening and closing that dialogue as necessary.
- It controls the direction and mode (*half - duplex* or *full-duplex)*.
- It also supplies recovery *checkpoints* during file transfers.
- Checkpoints are issued each time a block of data is acknowledged as being received in good condition.
- Responsibilities:
  - establishes, manages, and terminates sessions between applications.
  - service location lookup



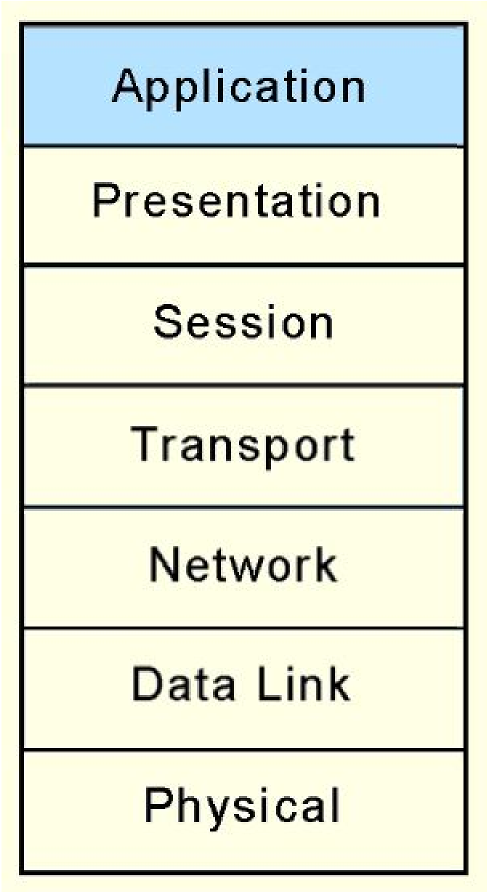
ISO/OSI Reference Model: Presetation

- The Presentation layer provides high-level data interpretation services for the Application layer above it, such as EBCDIC-to-ASCII translation.
- Presentation layer services are also called into play if we use encryption or certain types of data compression.
- Responsibilities:
  - data encryption
  - data compression
  - data conversion



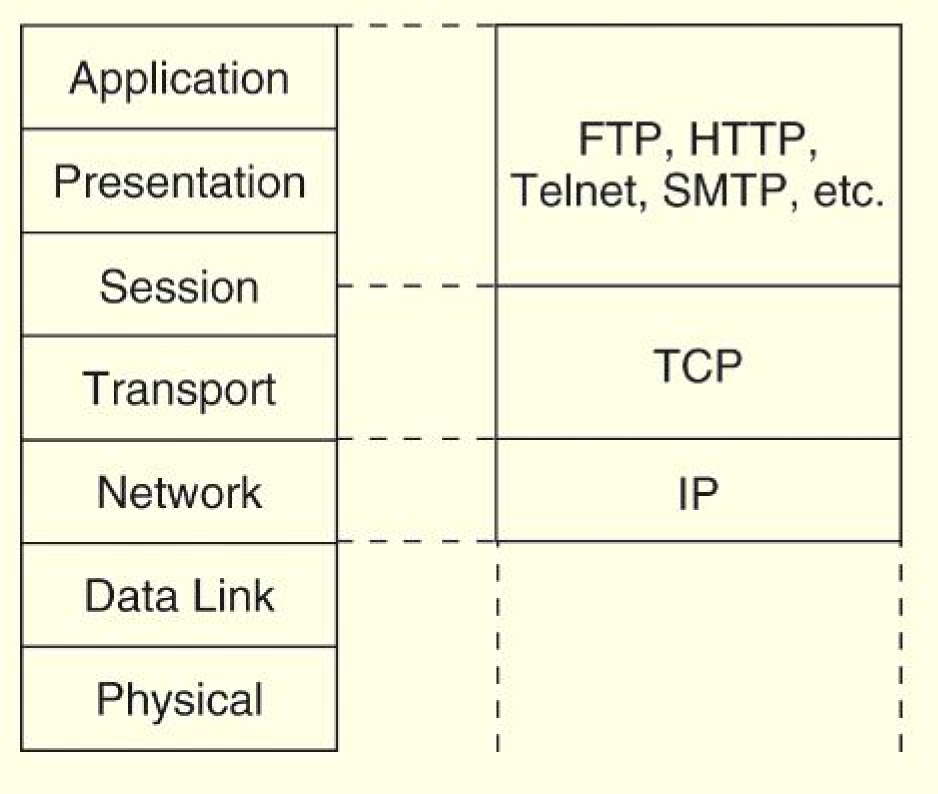
ISO/OSI Reference Model

- The Application layer supplies meaningful information and services to users at one end of the communication and interfaces with system resources (programs and data files) at the other end of the communication.
- All that applications need to do is to send messages to the Presentation layer, and the lower layers take care of the hard part.
- Issues:
  - application level protocols
  - appropriate selection of "type of service"
- Responsibilities:
  - anything not provided by any of the other layers



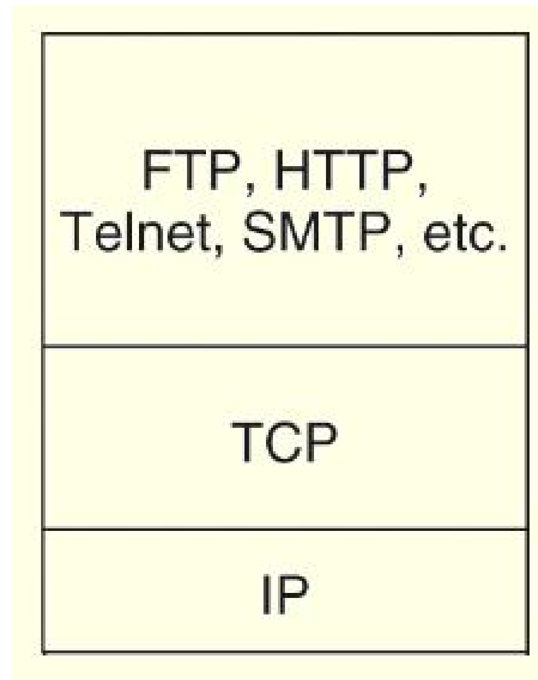
TCP/IP Architecture

- TCP/IP is the de facto global data communications standard.
- It has a lean 3-layer protocol stack that can be mapped to five of the seven in the OSI model.
- TCP/IP can be used with any type of network, even different types of networks within a single session.



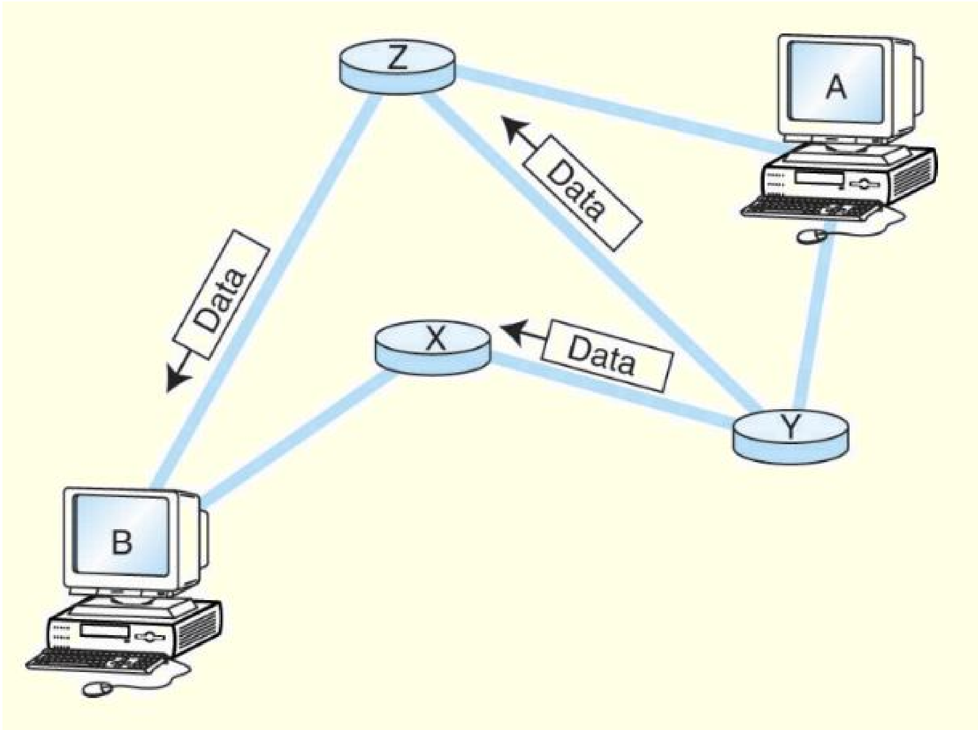
TCP/IP Architecture

- The IP Layer of the TCP/IP protocol stack provides essentially the same services as the Network and Data Link layers of the OSI Reference Model.
- It divides TCP packets into protocol data units called *datagrams*, and then attaches routing information.



TCP/IP Architecture

- The concept of the datagram was fundamental to the robustness of ARPAnet, and now, the Internet.
- Datagrams can take any route available to them without human intervention.

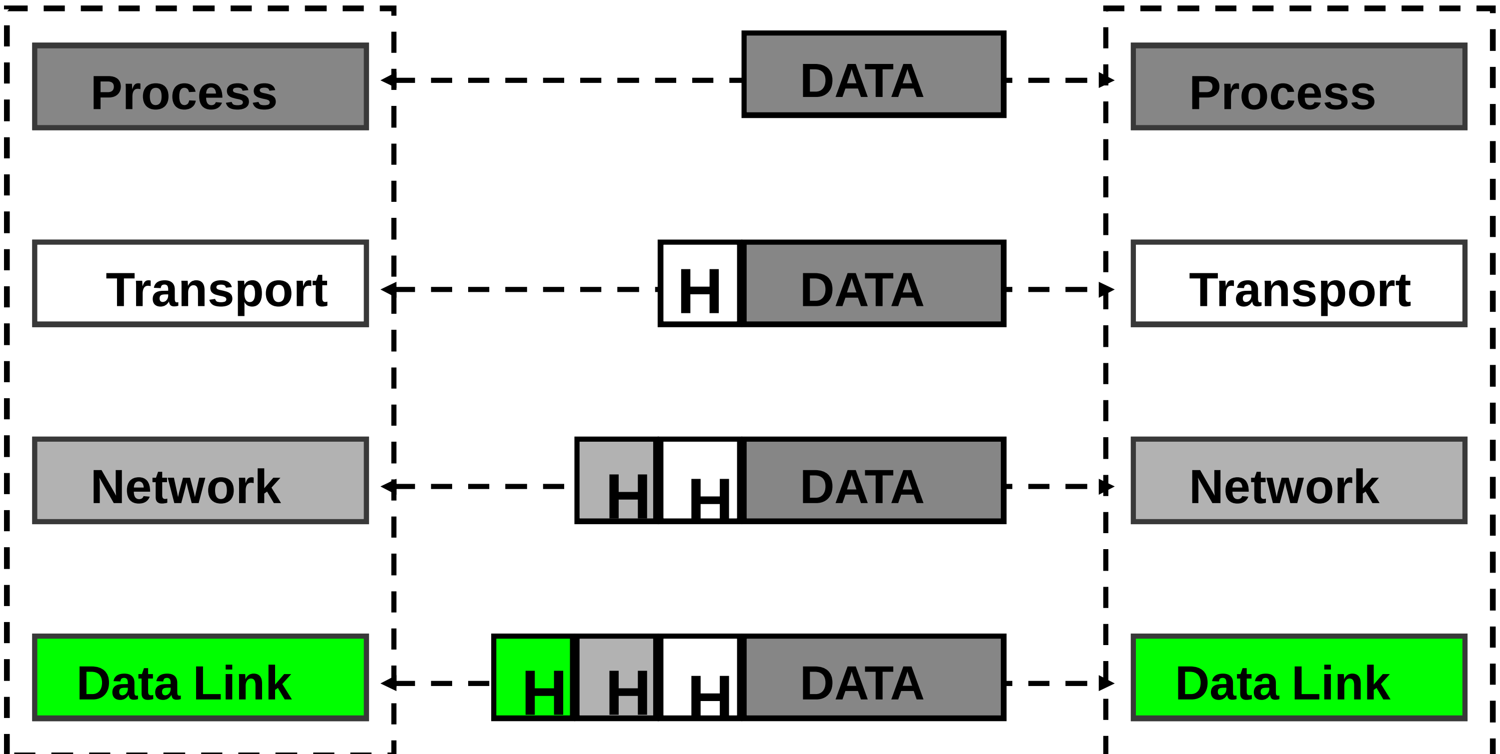


TCP/IP Current and Future

- The current version of IP, IPv4, was never designed to serve millions of network components scattered across the globe.
- It limitations include 32-bit addresses, a packet length limited to 65,635 bytes, and that all security measures are optional.
- Furthermore, network addresses have been assigned with little planning which has resulted in slow and cumbersome routing hardware and software.
- We will see later how these problems have been addressed by IPv6.

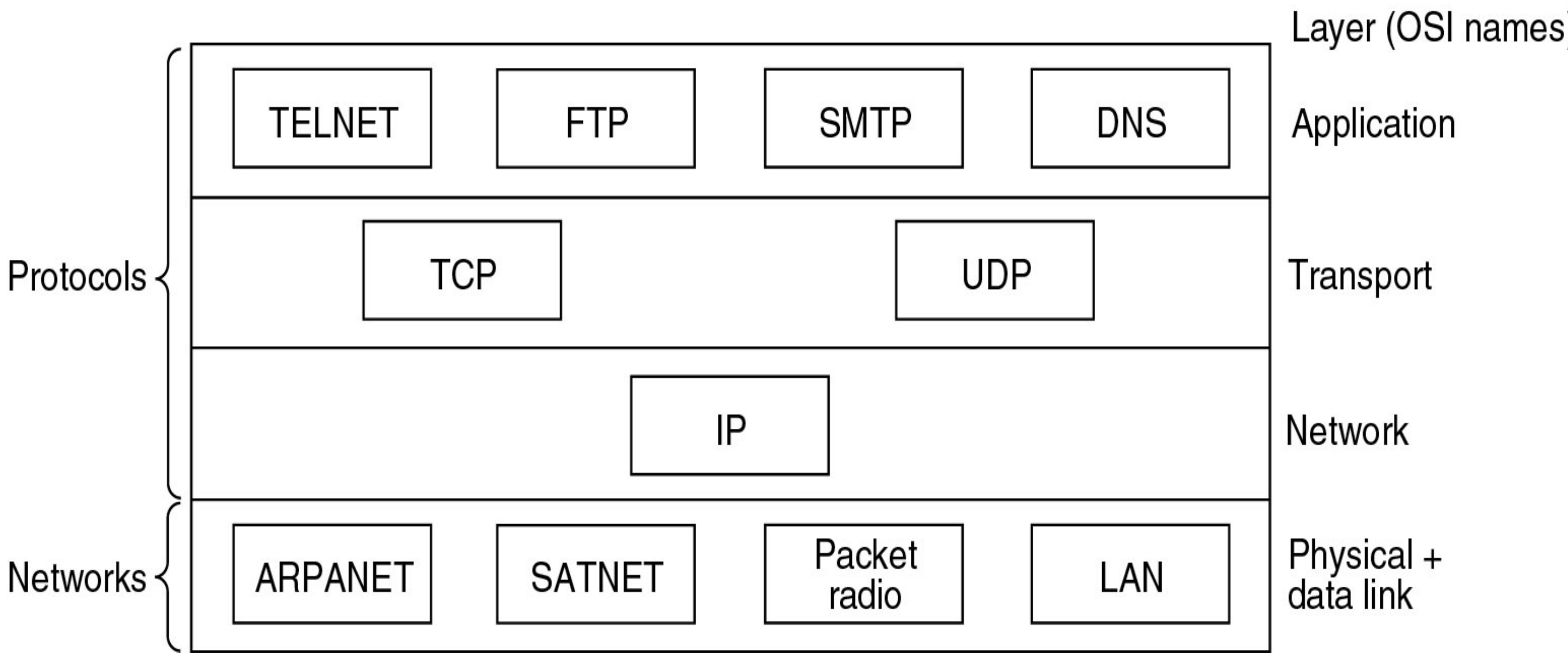
Layering & Headers

- Each layer needs to add some control information to the data to do it's job.
- This information is typically prepended to the data before being given to the lower layer.
- Once the lower layers deliver the the data and control information - the peer layer uses the control information.



Protocols and networks in the TCP/IP model

- How a call is made?



Summary

- Physical: Language between two machines
- Data-Link: communication between machines on the same network.
- Network: communication between machines on possibly different networks.
- Transport: communication between processes (running on machines on possibly different networks).
- Connecting Networks
  - Repeater: physical layer
  - Bridge: data link layer
  - Router: network layer
  - Gateway: network layer and above.

IEEE 802 Standards

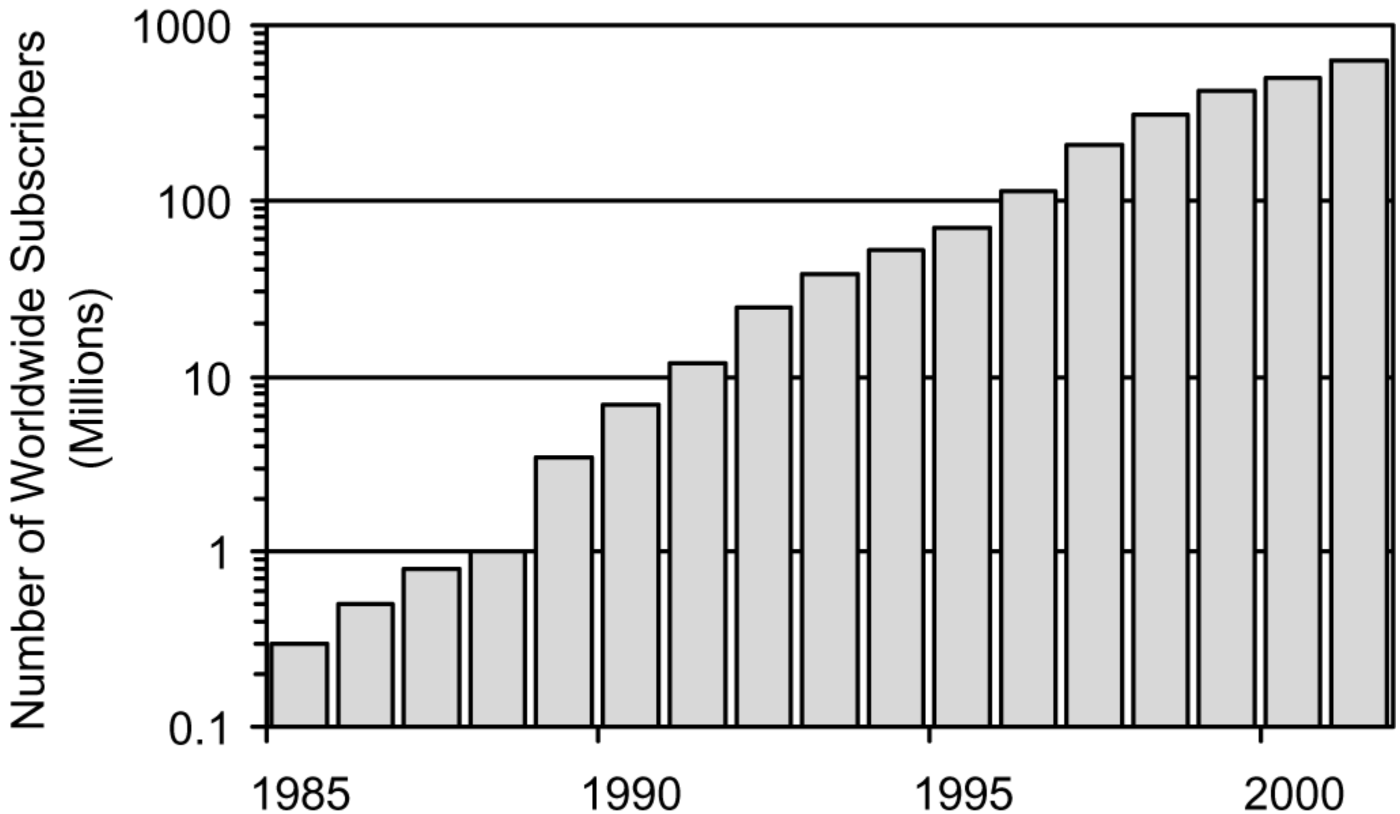
The 802 working groups. The important ones are marked with *. The ones marked with ↓ are hibernating. The one marked with † gave up.

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

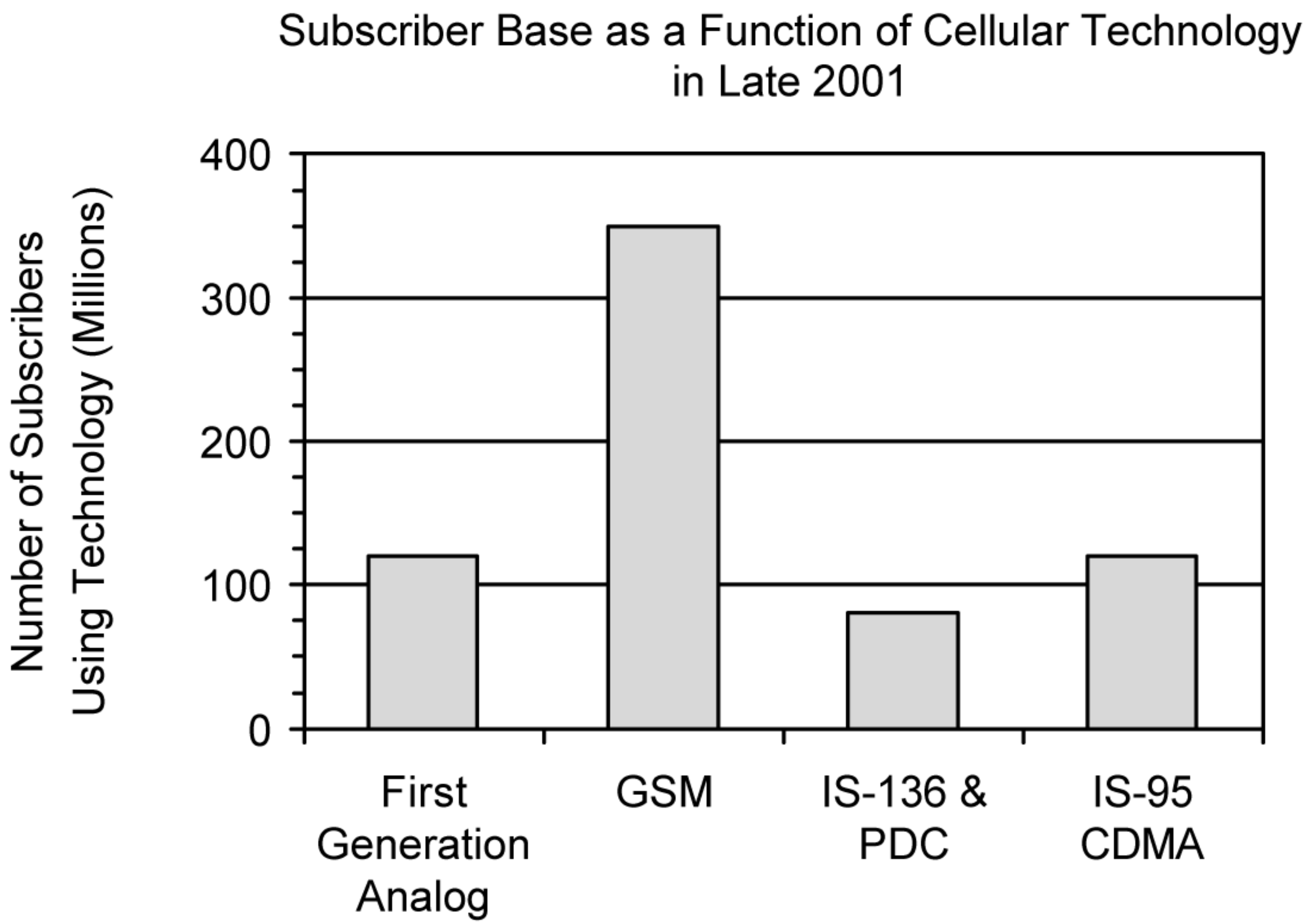
Expansion

- Log scale for y and linear scale for x

Growth of Cellular Telephone Subscribers
Throughout the World



1G 2G Distributions



2G Standard

Table 2.1 Key Specifications of Leading 2G Technologies (adapted from [Lib99])

	cdmaOne, IS-95, ANSI J-STD-008	GSM, DCS-1900, ANSI J-STD-007	NADC, IS-54/IS-136, ANSI J-STD-011, PDC
Uplink Frequencies	824-849 MHz (US Cellular) 1850-1910 MHz (US PCS)	890-915 MHz (Europe) 1850-1910 MHz (US PCS)	800 MHz, 1500 MHz (Japan) 1850-1910 MHz (US PCS)
Downlink Frequencies	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS)	935-960 MHz (Europe) 1930-1990 MHz (US PCS)	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS) 800 MHz, 1500 MHz (Japan)
Duplexing	FDD	FDD	FDD
Multiple Access Technology	CDMA	TDMA	TDMA
Modulation	BPSK with Quadrature Spreading	GMSK with $BT = 0.3$	$\pi/4$ DQPSK
Carrier Separation	1.25 MHz	200 kHz	30 kHz (IS-136) (25 kHz for PDC)
Channel Data Rate	1.2288 Mchips/sec	270.833 kbps	48.6 kbps (IS-136) (42 kbps for PDC)
Voice channels per carrier	64	8	3
Speech Coding	Code Excited Linear Prediction (CELP) @ 13 kbps, Enhanced Variable Rate Codec (EVRC) @ 8 kbps	Residual Pulse Excited Long Term Prediction (RPE-LTP) @ 13 kbps	Vector Sum Excited Linear Predictive Coder (VSELP) @ 7.95 kbps

2G to 3G evolution

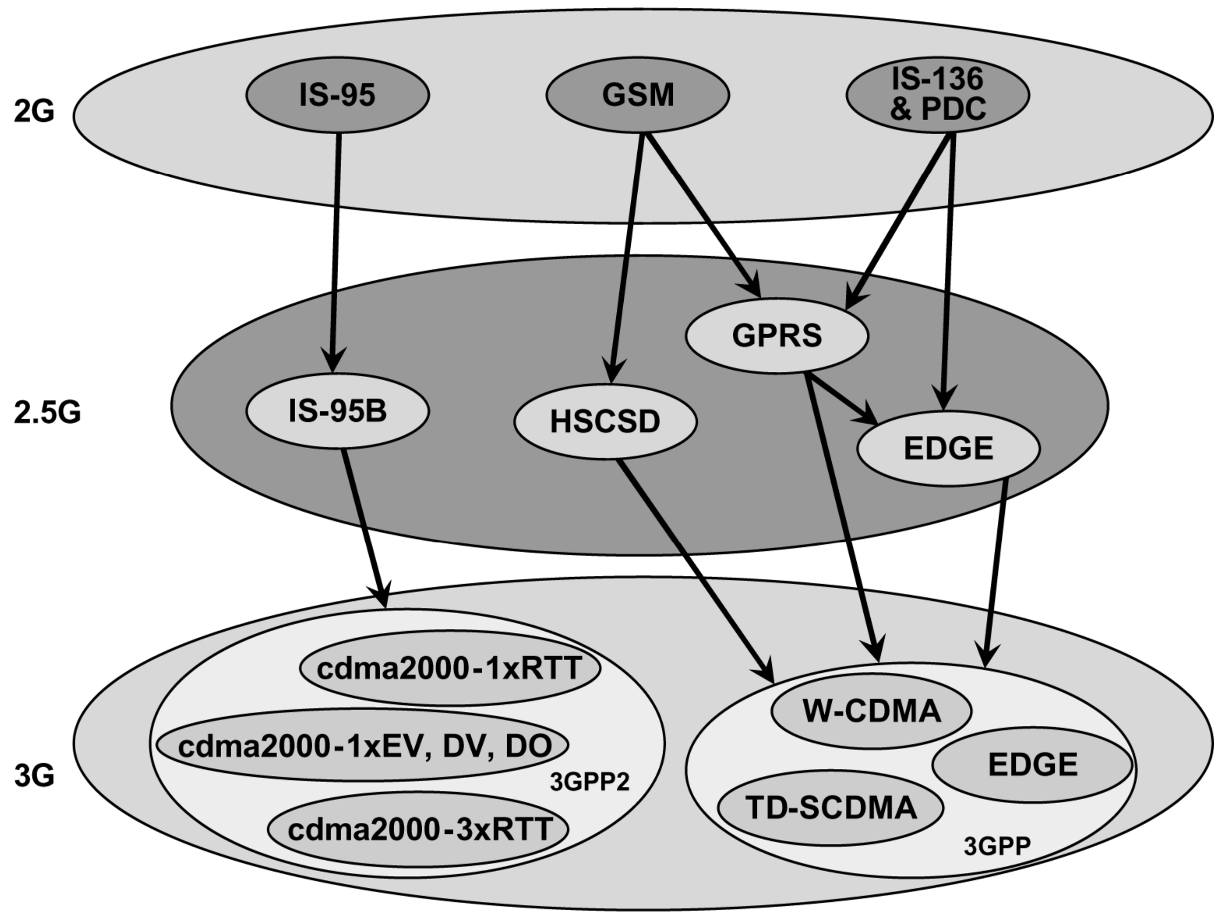


Table 2.2 Current and Emerging 2.5G and 3G Data Communication Standards

Wireless Data Technologies	Channel BW	Duplex	Infrastructure change	Requires New Spectrum	Requires New Handsets
HSCSD	200 KHz	FDD	Requires software upgrade at base station.	No	Yes New HSCSD handsets provide 57.6 Kbps on HSCSD networks, and 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in HSCSD networks.
GPRS	200 KHz	FDD	Requires new packet overlay including routers and gateways.	No	Yes New GPRS handsets work on GPRS networks at 171.2 Kbps, 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in GPRS networks.
EDGE	200 KHz	FDD	Requires new transceiver at base station. Also, software upgrades to the base station controller and base station.	No	Yes New handsets work on EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, and GSM networks at 9.6 Kbps with tri-mode phones. GSM and GPRS-only phones will not work in EDGE networks.
W-CDMA	5 MHz	FDD	Requires completely new base stations.	Yes	Yes New W-CDMA handsets will work on W-CDMA at 2 Mbps, EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, GSM networks at 9.6 Kbps. Older handsets will not work in W-CDMA.
IS-95B	1.25 MHz	FDD	Requires new software in base station controller.	No	Yes New handsets will work on IS-95B at 64 Kbps and IS-95A at 14.4 Kbps. CdmaOne phones can work in IS-95B at 14.4 Kbps.
cdma2000 1xRTT	1.25 MHz	FDD	Requires new software in back-bone and new channel cards at base station. Also need to build a new packet service node.	No	Yes New handsets will work on 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xRTT but at lower speeds.
cdma2000 IxEV (DO and DV)	1.25 MHz	FDD	Requires software and digital card upgrade on 1xRTT networks.	No	Yes New handsets will work on 1xEV at 2.4 Mbps, 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xEV but at lower speeds.
cdma2000 3xRTT	3.75 MHz	FDD	Requires backbone modifications and new channel cards at base station.	Maybe	Yes New handsets will work on 95A at 14.4 Kbps, 95B at 64 Kbps, 1xRTT at 144 Kbps, 3xRTT at 2 Mbps. Older handsets can work in 3X but at lower speeds.