WAN Standards

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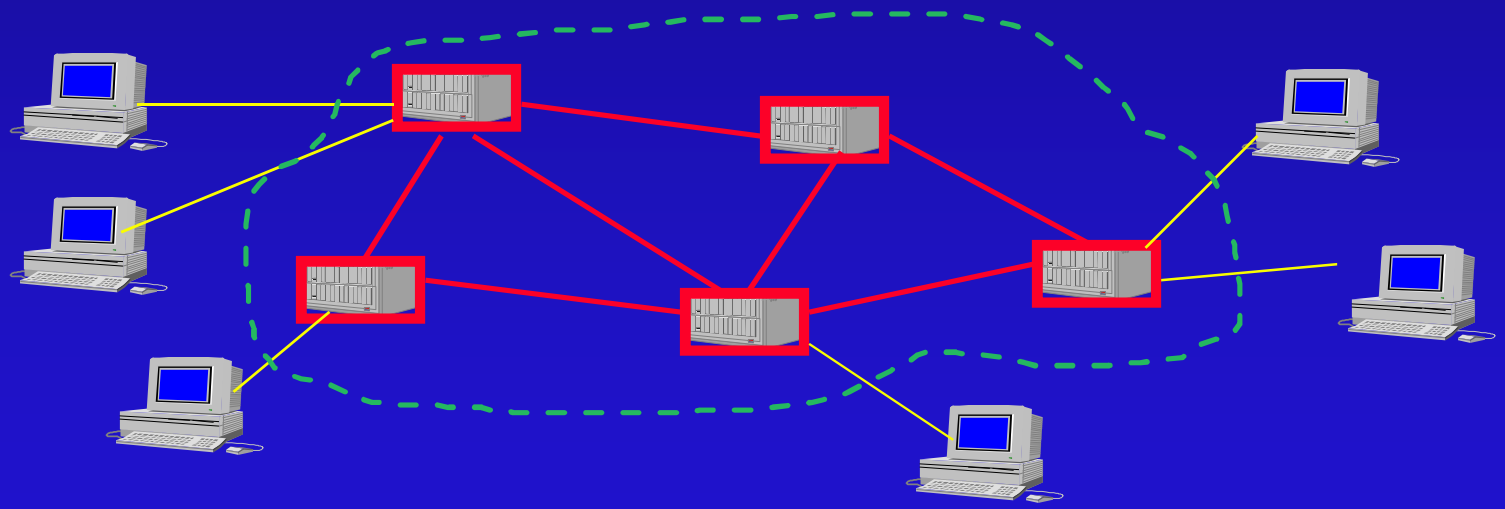
WANs (Wide Area Networks)

WANs are structured with irregular placement of the nodes.



WANs (cont)

- WANs cover a large geographical area.
- WAN consists of a number of interconnected switching nodes. Communication is achieved by transmitting data from source to destination through these intermediate switching nodes to the specified destination device.
- Traditionally, WANs have been implemented using one of two technologies: circuit switching and packet switching. Recently, frame relay and ATM networks have assumed major roles.

WANs (cont)

- Circuit switching: a dedicated communication path is established between two stations through the nodes of the network. Example: the telephone network.
- Packet switching: At each node, a packet is received, stored briefly, and then transmitted to the next node. Example: X.25 network
  - » To compensate errors, there is a considerable amount of overhead built into the packet-switched schemes.
- Frame relay was developed to take advantage of high data rates and low error rates that are available in modern high-speed communication systems. It operates efficiently at user data rates up to 2 Mbps. It uses variable-length packets, called frames.

WANs (cont)

- ATM (Asynchronous Transfer Mode) :
  - » is a culmination of all of the developments in circuit switching and packet switching.
  - » Can be viewed as an evolution from frame relay. ATM uses fixed-length packets, called cells.
- The ISDN is intended to be a worldwide public telecommunications network to replace existing public telecommunications networks and deliver a wide variety of services.
  - » Narrowband ISDN
  - » Broadband ISDN (B-ISDN)

X.25 Networks

- was developed during 1970s by CCITT to provide an interface between public packet-switched networks and their customers. X.25 calls for three layers of functionality: physical layer, data link layer, and packet (or network) layer.
- The physical layer protocol, called X.21, specifies the physical, electrical, and procedural interface between the host and the network.
- Very few public networks actually support this standard. It requires digital, rather than analog signaling on the telephone lines.

X.25 Networks (contd)

- The data link layer protocol deals with transmission errors on the telephone line between the user's equipment (host or terminal) and the public network (router).
- The network layer protocol deals with addressing, flow control, delivery confirmation, interrupts, and related issues.
  - » Establishes virtual circuits and sends packets of up to 128 bytes on them. These packets are delivered reliably in order.
  - » Most X.25 networks work at speeds up to 64 kbps
- Both data link layer and network layer include flow control and error control mechanisms.

X.25 Networks (contd)

- X.25 is connection-oriented. At network layer, X.25 provides multiplexing: a DTE is allowed to establish up to 4095 simultaneous virtual circuits with other DTEs over a single physical DTE-DCE link.
- X.25 supports both switched virtual circuits and permanent ones.
- A switched virtual circuit is created when one computer sends a packet to the network asking to make a call to a remote computer.
  - » Once established, packets are sent over the connection, always arriving in order.
  - » X.25 provides flow control, to make sure a fast sender cannot swamp a slow or busy receiver.

X.25 Networks (contd)

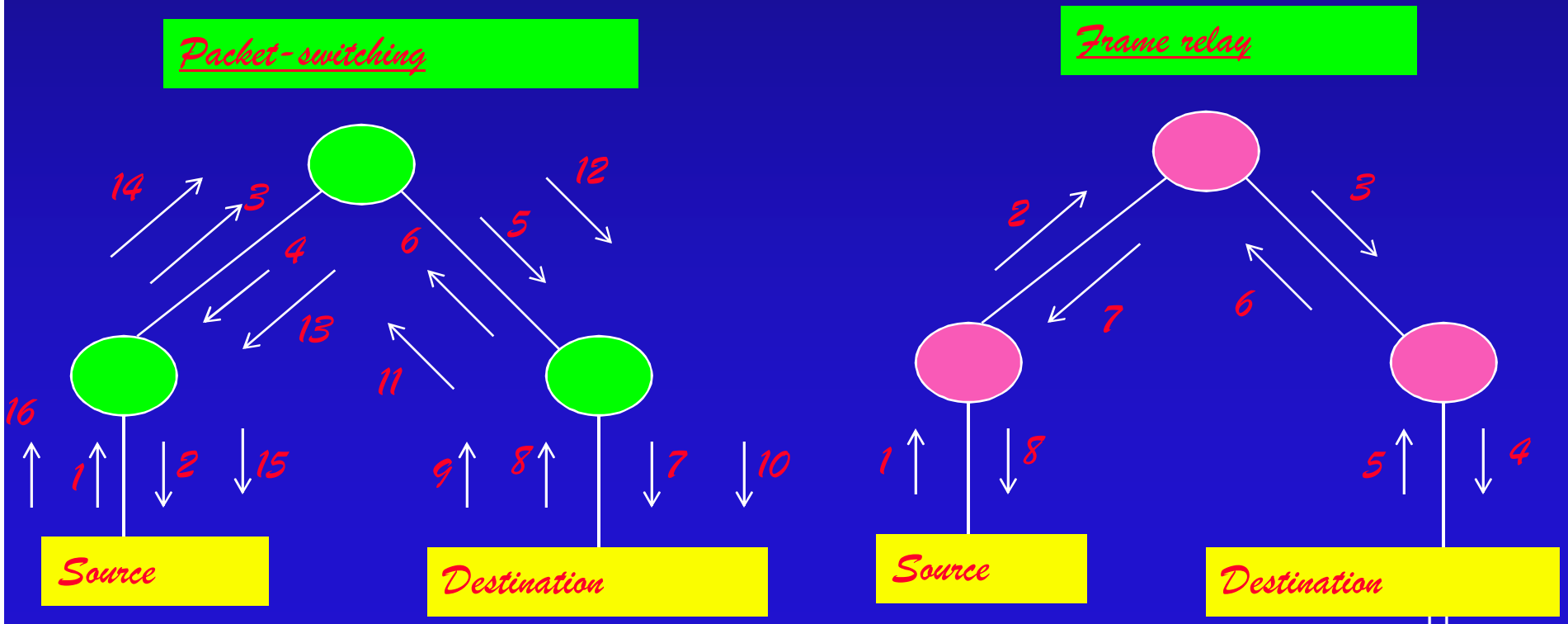
- A permanent virtual circuit
  - » is used the same way as a switched one, but it is set up in advance by agreement between the customer and the carrier.
  - » It is always present, and no call setup is required to use it. It is analogous to a leased line.
- If the user terminal does not speak X.25, then the terminal is connected to a “black box” called a PAD (Packet Assembler Disassembler) whose function is defined in the document X.3.
  - » The protocol X.28 is defined between terminal and PAD.
  - » The protocol X.29 is defined between PAD and the network.

Frame Relay

- Frame relay is designed to eliminate much of the overhead that X.25 imposes on end-user systems and on the packet-switching network.
- Frame relay can best be thought of as a virtual leased line on which data bursts may be sent at full speed, but the long-term average usage must be below a predetermined level. Therefore, the carrier charges much less for a virtual line than a physical one.
- Frame relay competes with leased lines and X.25 permanent virtual circuits, except that frame relay operates at higher speeds, usually 1.5 Mbps.

Frame Relay (contd)

- The principal disadvantage of frame relay, compared to X.25, is that we lost the ability to do link-by-link flow and error control.



Frame Relay (contd)

- Frame relay protocol architecture consists of two separate planes of operation:
  - » a control (C) plane, which deals with the establishment and termination of logical connections. C-plane protocols are between a subscriber and the network.
  - » a user (U) plane, which is responsible for the transfer of user data between subscribers. U-plane protocols provide end-to-end functionality.
- By streamlining functions, Frame Relay adjusts its bandwidth to handle bursty traffic.

ISDN, B-ISDN, and ATM

- Telephone companies are faced with a fundamental problem: maintaining multiple networks. Also, want to control cable television network
- The solution was to invent a single new network that will replace the entire telephone system and all the specialized networks.
- The new wide area service is first called ISDN (Integrated Services Digital Network) that has as its primary goal the integration of voice and nonvoice services.

ISDN, B-ISDN and ATM (contd)

- The ISDN bit pipe supports multiple channels interleaved by time division multiplexing. Several channel types have been standardized:
  - A: 4-kHz analog telephone channel
  - B: 64-kbps digital PCM channel for voice or data
  - C: 8-kbps or 16-kbps digital channel
  - D: 16-kbps digital channel for out-of-band signaling
  - E: 64-kbps digital channel for internal ISDN signaling
  - H: 384-kbps, 1536-kbps, or 1920-kbps digital channel
- Three combinations of channels:
  - Basic rate: 2B+1D
  - Primary rate: (1) 23B+1D (U.S. and Japan), (2) 30B+1D (Europe)
  - Hybrid: 1A+1C

ISDN, B-ISDN and ATM (contd)

- B-ISDN offers video on demand, live television from many sources, full motion multimedia electronic mail, CD-quality music, LAN interconnection, high-speed data transfer.
- The underlying technology that makes B-ISDN possible is called ATM (Asynchronous Transfer Mode) because it is not synchronous (i.e, not tied to a master clock).
- ATM is the standard technology for switching and multiplexing in B-ISDN. (Multiplexing determines how sources of data streams share a single communication channel (e.g., TDM, FDM, asynchronous TDM). Switching determines how message will be sent on the medium from source to destination (e.g., circuit switching, virtual circuit packet switching, packet switching, etc)).

ISDN, B-ISDN and ATM (contd)

- The basic idea behind ATM is to transmit all information in small, fixed-size packets called cells.
  - » Cells are 53 bytes long, of which 5 bytes are header and 48 bytes are payload.
- ATM networks are connection-oriented (I.e., a path is established before communication takes place).
  - » The actual service offered is connection oriented, but it is implemented internally with packet switching, not circuit switching.
  - » Two kinds of connections are offered: (i) permanent virtual circuits that remain in place for months and years, (ii) switched virtual circuits that are like telephone calls: they are set up dynamically as needed.

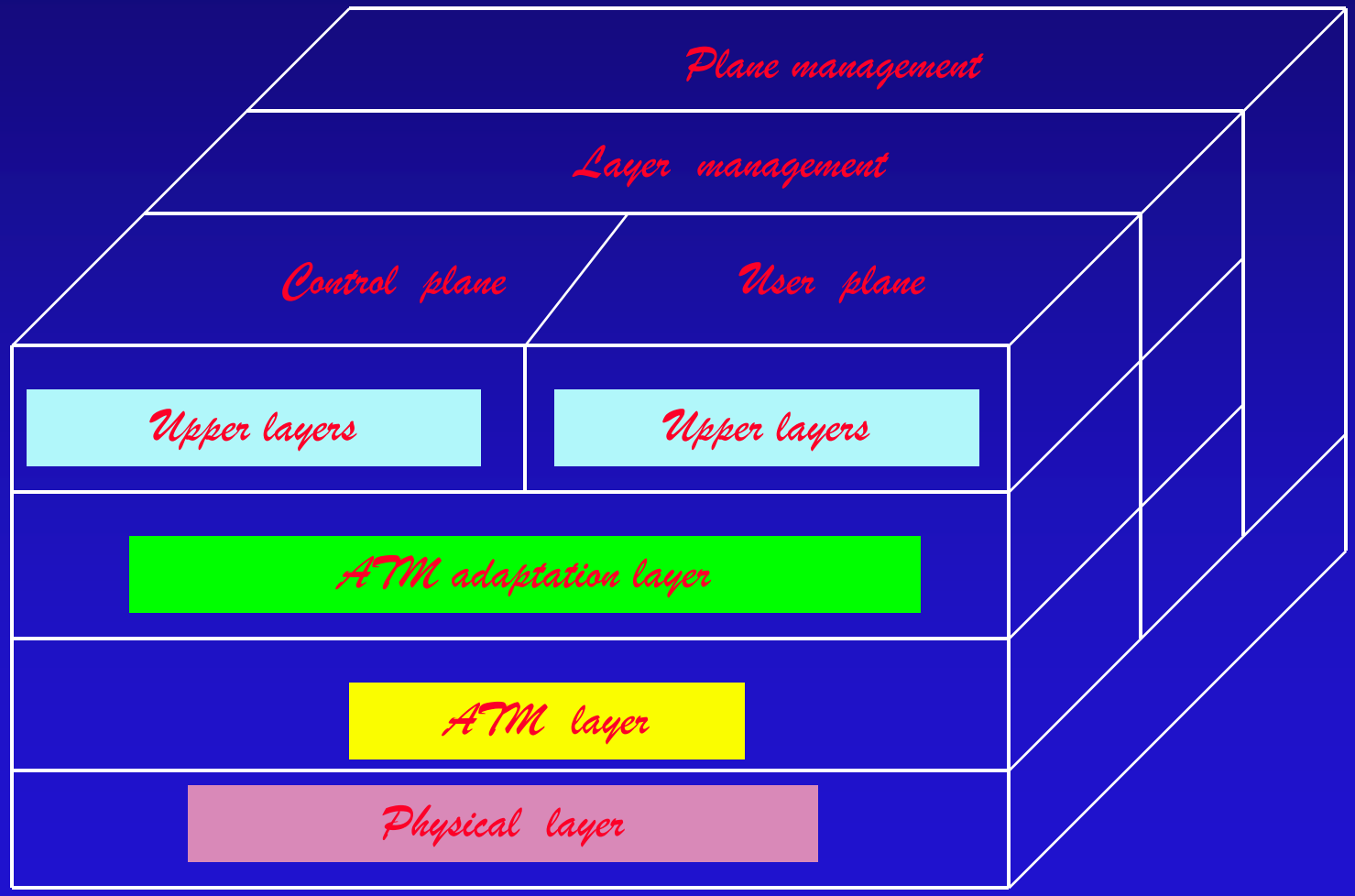
ISDN, B-ISDN and ATM (contd)

- ATM networks are organized like traditional WANs, with lines and switches (routers).
- The intended speeds for ATM networks are 155.52 Mbps and 622.08 Mbps to make them compatible with SONET that is the standard used on fiber optic links.
- ATM uses cell switching because
  - » it is highly flexible can handle both constant rate traffic (audio, video) and variable rate traffic (data) easily,
  - » at the very high speeds, digital switching of cells is easier than using traditional multiplexing techniques, especially using fiber optics
  - » cell switching can provide broadcasting, circuit switching cannot.

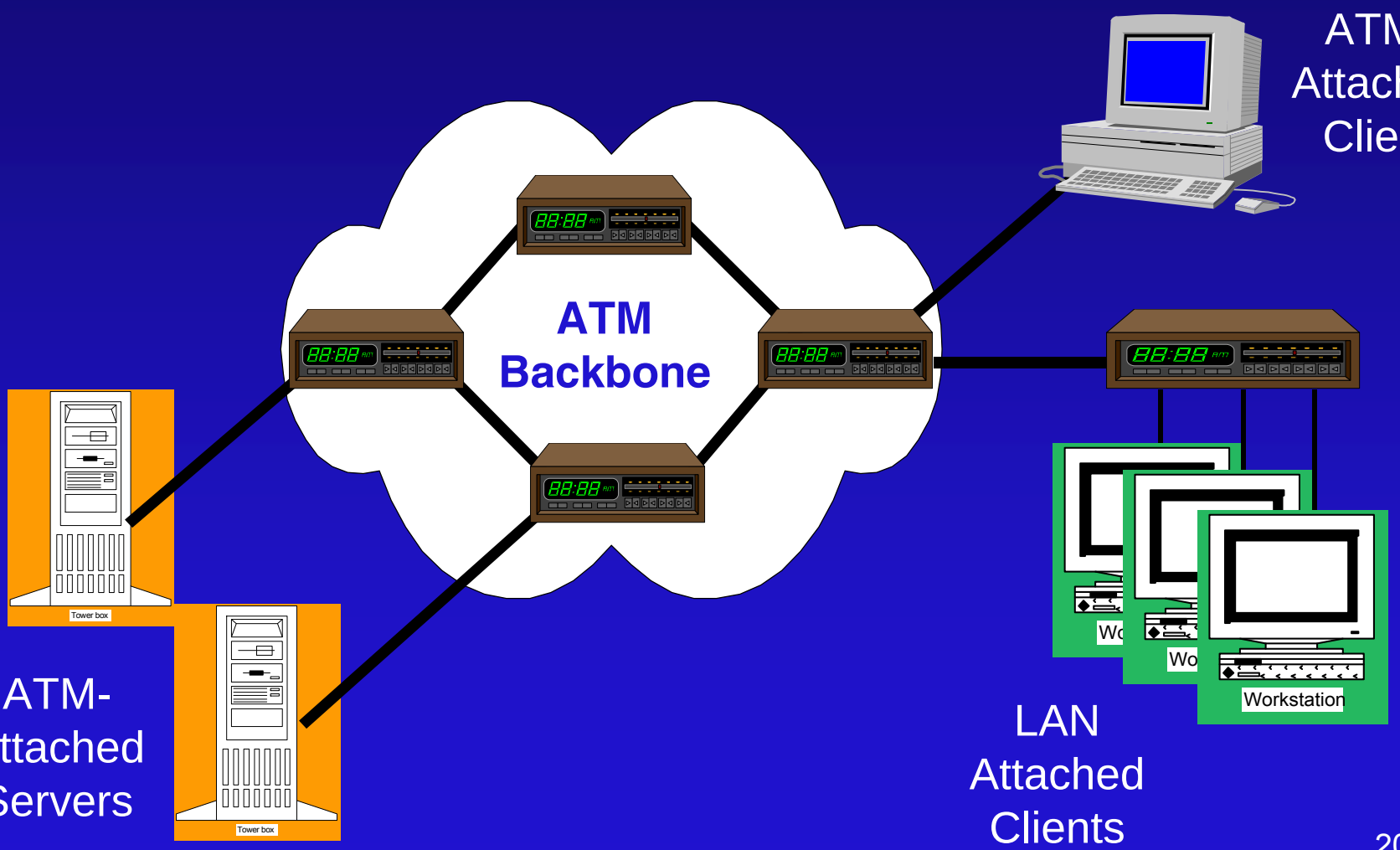
ISDN, B-ISDN and ATM (contd)

- B-ISDN using ATM has its own reference model, different from the OSI model and also different from the TCP/IP model. The model
  - consists of three layers, the physical, ATM layer, ATM adaptation layers, plus whatever the users want to put on top of that.
  - The physical layer deals with the physical medium: voltages, bit timing, etc.
  - The ATM layer deals with cells and cell transport: defines the layout of cells, deals with establishment and release of virtual circuits, and congestion control.
  - The AAL (ATM Adaptation Layer segments incoming packets from the upper layers, transmits the cells individually and reassembles them at the other end.
- ATM model is three-dimensional. The user plane deals with data transport, flow control, error correction, and other user functions. The control plane is concerned with connection management. The layer management and plane management functions relate to resource management and interlayer coordination.

he B-ISDN ATM Reference Model



ATM Backbone



Internet

- Is a large collection of interconnected networks, all of which use TCP/IP protocol suite
- began with the development of ARPANET in 1969

  (ARPA: Advanced Research Project Agency)
- ARPANET protocols were not suitable for running over multiple networks. This led to the invention of the TCP/IP model and protocols by Cerf and Kahn in 1974.
- TCP/IP became the only official protocol on Jan. 1, 1983. The glue that holds the Internet together is the TCP/IP protocol stack.

Internet (contd)

- A machine is on the Internet if it runs the TCP/IP protocol stack, has an IP address, and can send IP packets to any machine on the Internet.
- Until the early 1990s, Internet users were academic, industrial, and government researchers. But, WWW (World Wide Web) brought millions of nonacademic users.
- WWW made the underlying facilities of the Internet easier to use.

Enough!