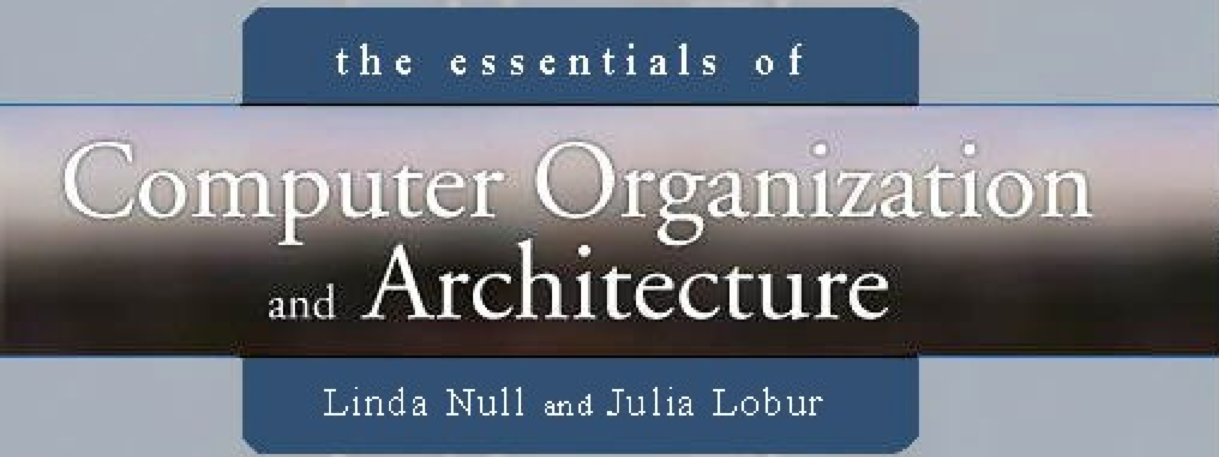


Chapter 11

Network Organization and Architecture

Chapter 11 Objectives

- Become familiar with the fundamentals of network architectures.
- Learn the basic components of a local area network.
- Become familiar with the general architecture of the Internet.

11.1 Introduction

- The network is a crucial component of today’s computing systems.
- Resource sharing across networks has taken the form of multitier architectures having numerous disparate servers, sometimes far removed from the users of the system.
- If you think of a computing system as collection of workstations and servers, then surely the network is the system bus of this configuration.

11.2 Early Business Computer Networks

- The first computer networks consisted of a mainframe host that was connected to one or more front end processors.
- Front end processors received input over dedicated lines from remote communications controllers connected to several dumb terminals.
- The protocols employed by this configuration were proprietary to each vendor’s system.
- One of these, IBM’s SNA became the model for an international communications standard, the ISO/OSI Reference Model.

11.3 Early Academic and Scientific Networks

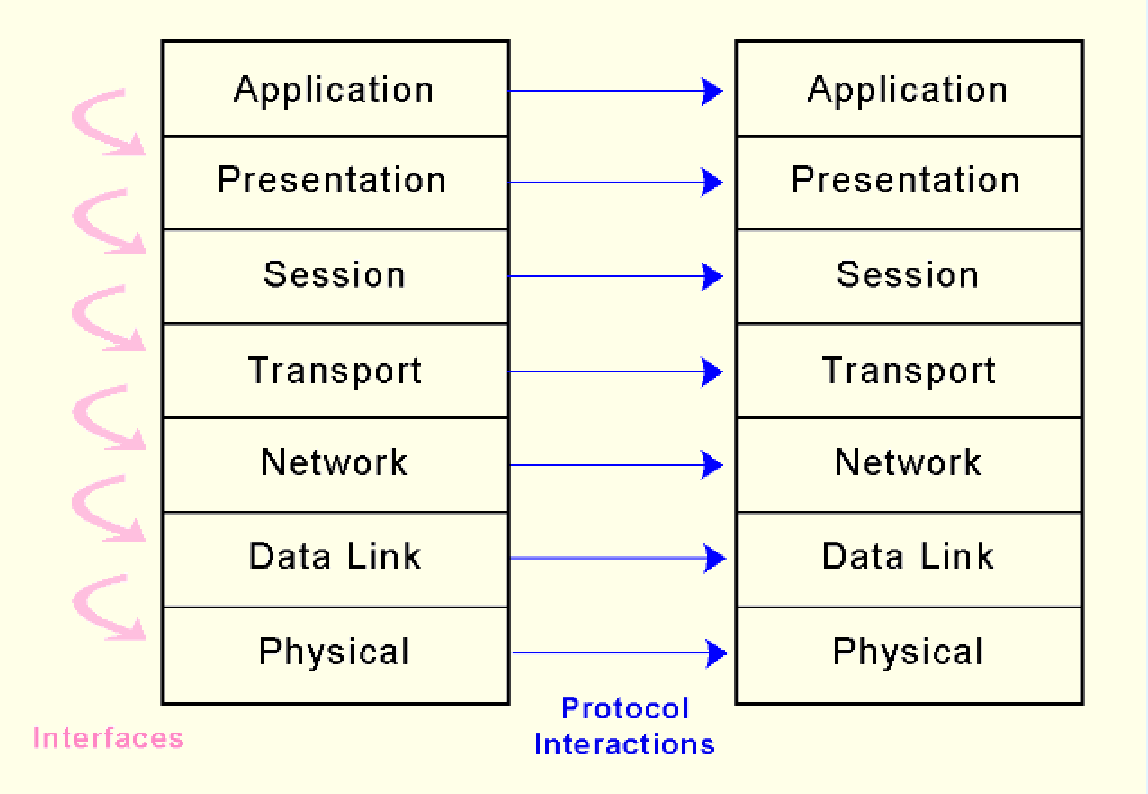
- In the 1960s, the *Advanced Research Projects Agency* funded research under the auspices of the U.S. Department of Defense.
- Computers at that time were few and costly. In 1968, the Defense Department funded an interconnecting network to make the most of these precious resources.
- The network, DARPANet, designed by Bolt, Beranek, and Newman, had sufficient redundancy to withstand the loss of a good portion of the network.
- DARPANet, later turned over to the public domain, eventually evolved to become today's Internet.

11.4 Network Protocols I
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.

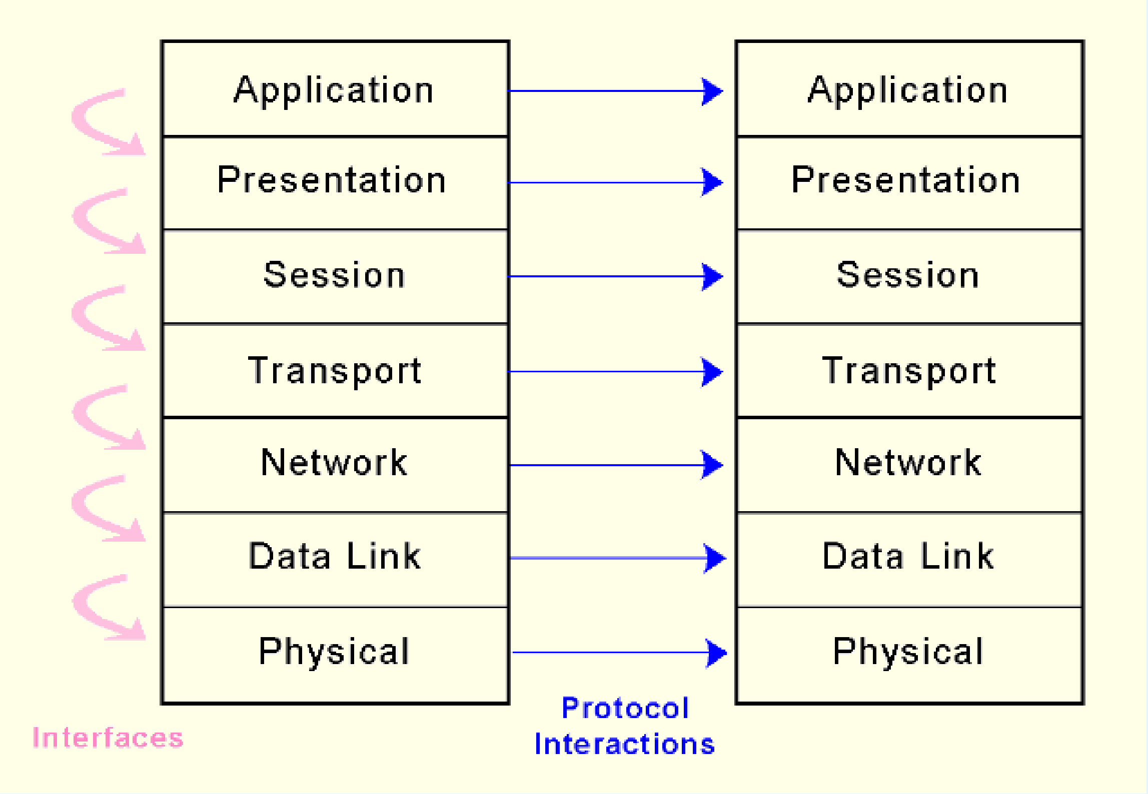
11.4 Network Protocols I ISO/OSI Reference Model

- The OSI RM contains seven protocol layers, starting with physical media interconnections at Layer 1, through applications at Layer 7.



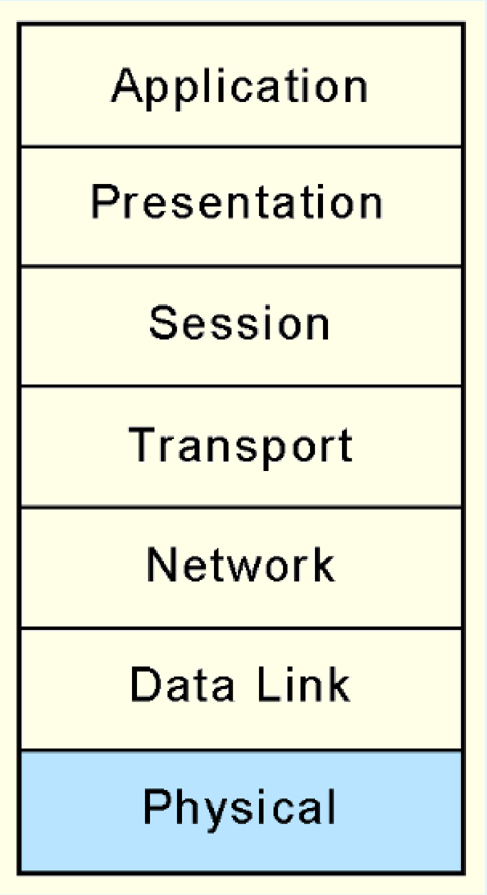
11.4 Network Protocols I ISO/OSI Reference Model

- 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.



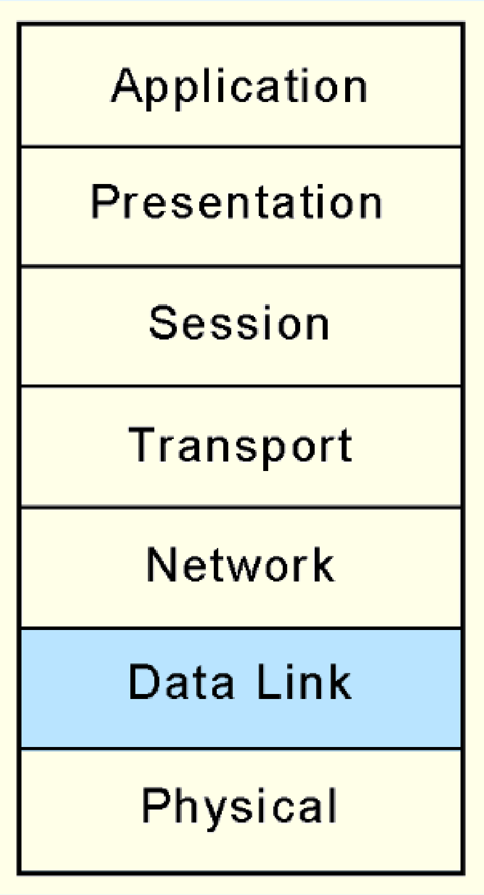
11.4 Network Protocols I ISO/OSI Reference Model

- 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.



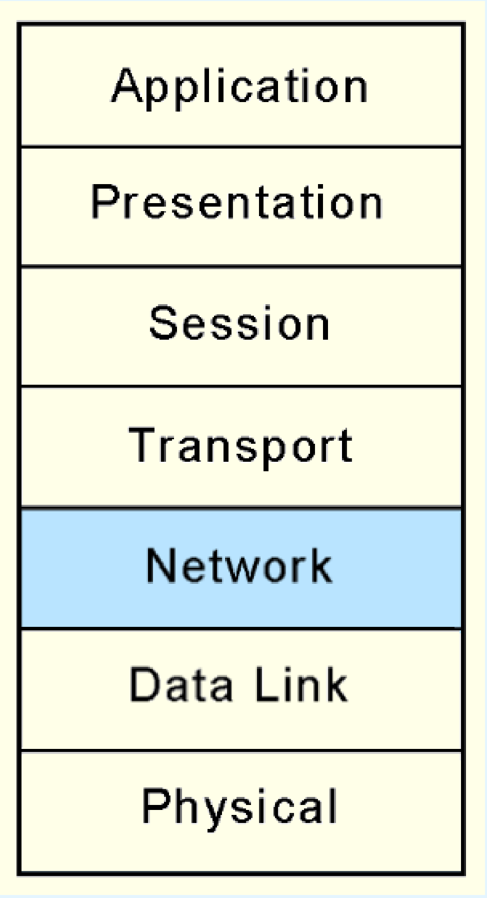
11.4 Network Protocols I
ISO/OSI Reference Model

- 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.



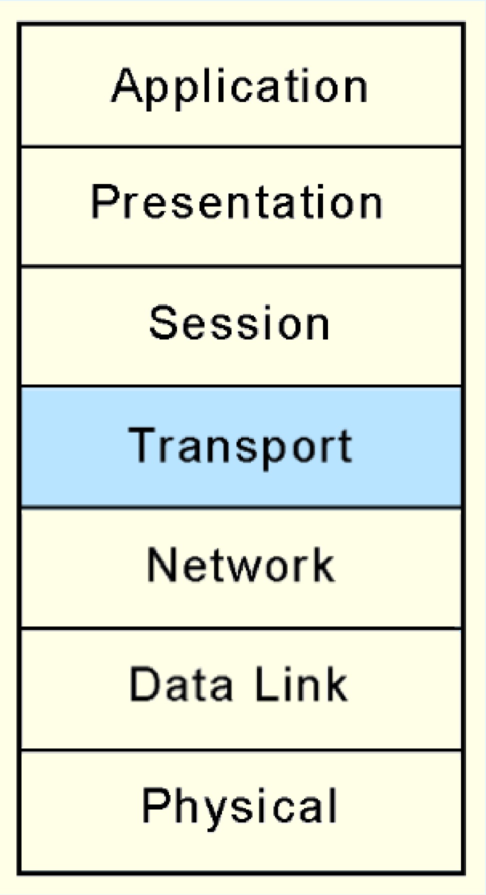
11.4 Network Protocols I ISO/OSI Reference Model

- 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.



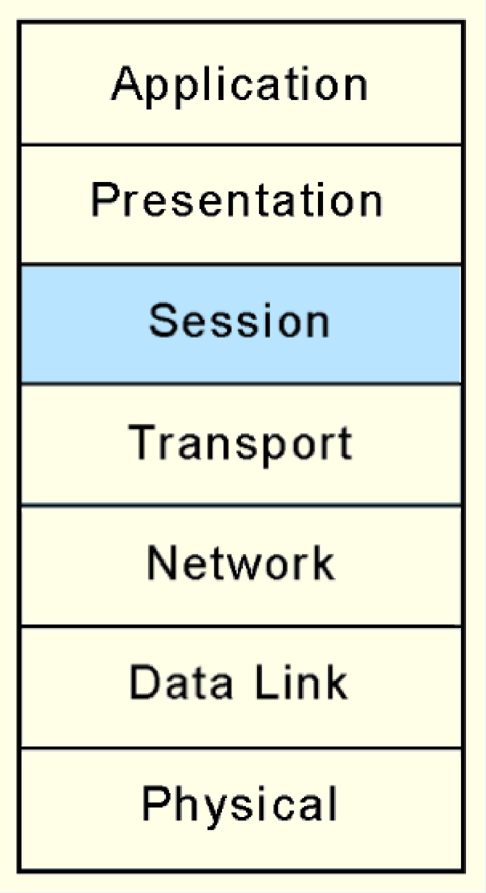
11.4 Network Protocols I
ISO/OSI Reference Model

- 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.



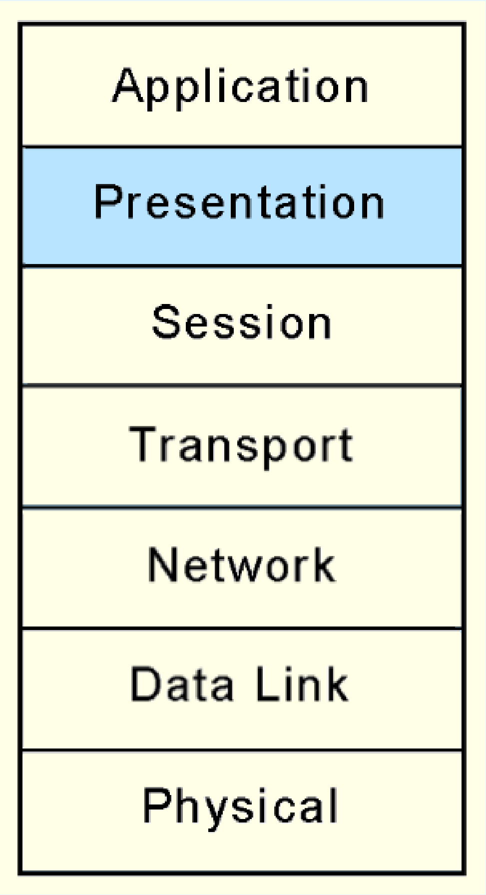
11.4 Network Protocols I ISO/OSI Reference Model

- 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.



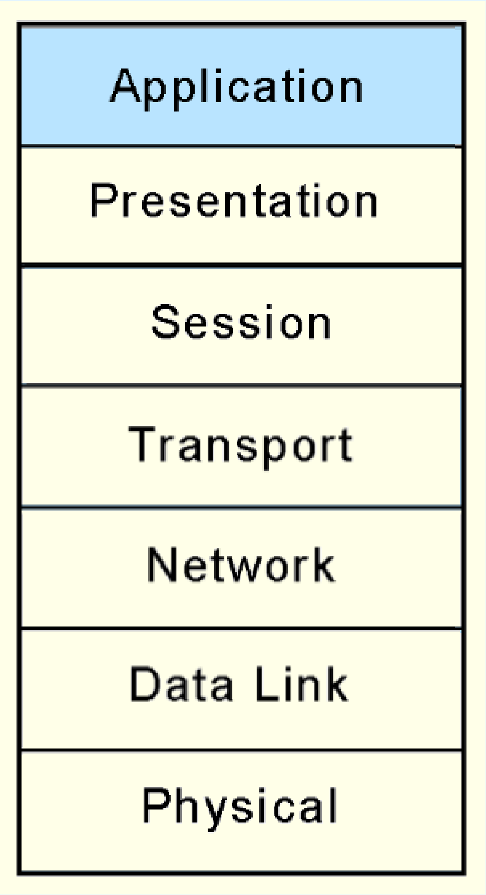
11.4 Network Protocols I ISO/OSI Reference Model

- 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.



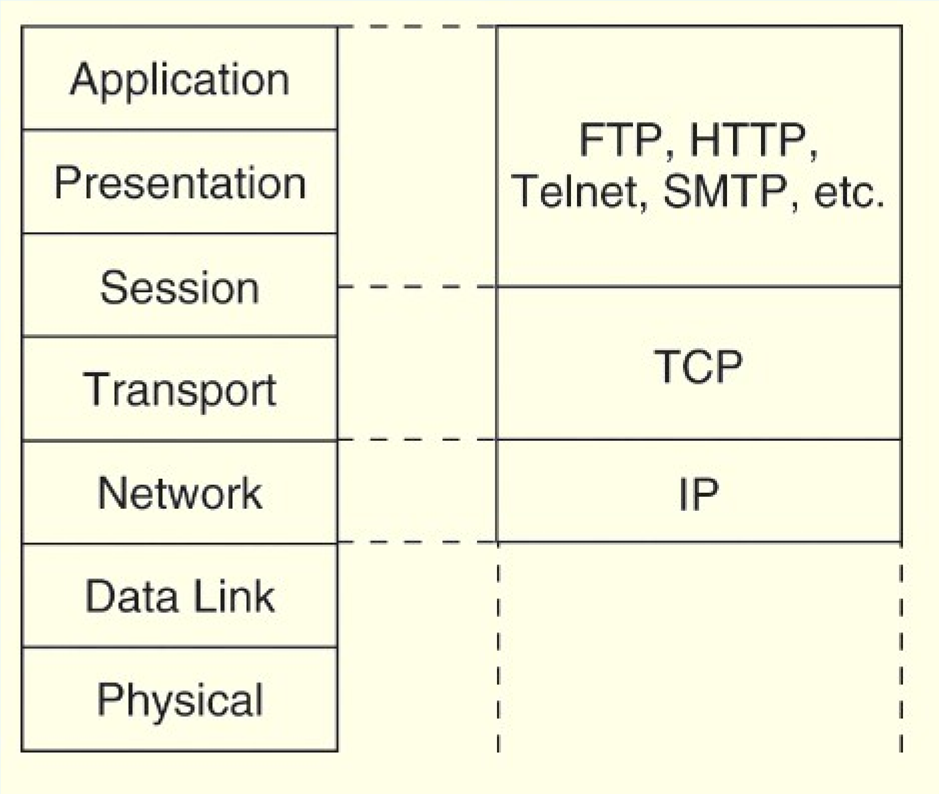
11.4 Network Protocols I
ISO/OSI Reference Model

- 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.



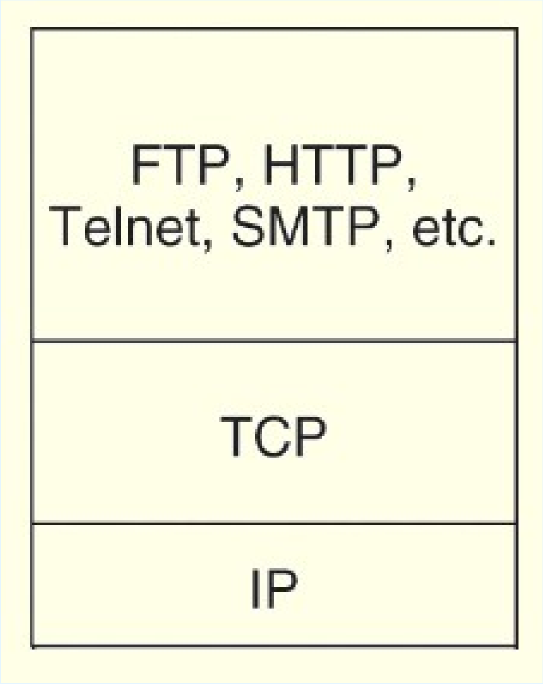
11.4 Network Protocols II
TCP/IP Architecture

- 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.



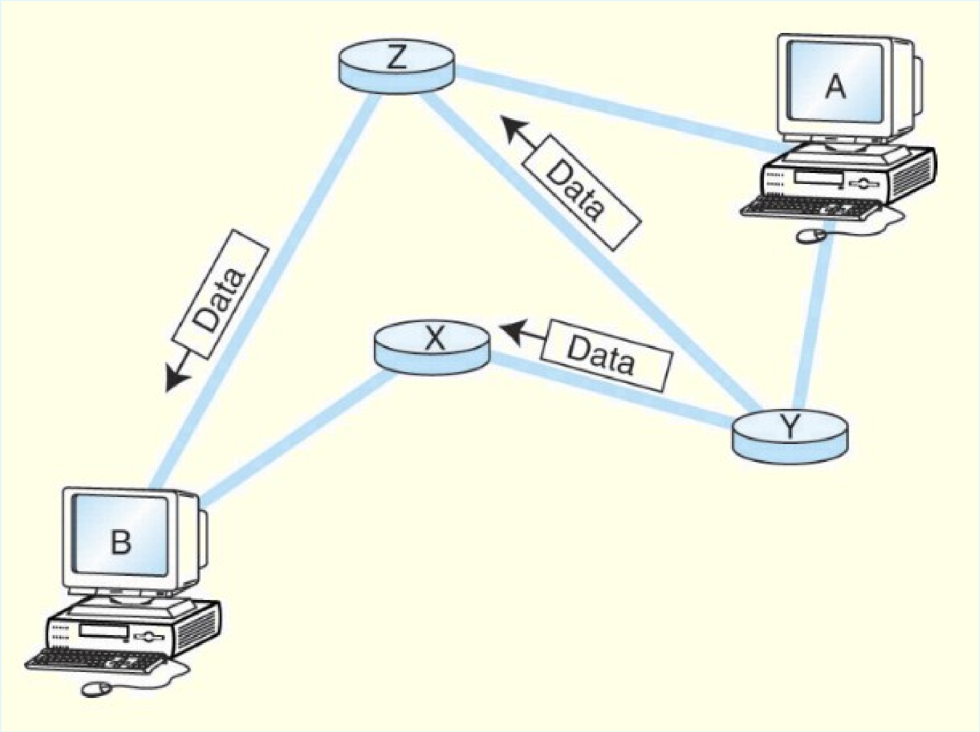
11.4 Network Protocols II
TCP/IP Architecture

- 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.



11.4 Network Protocols II 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.

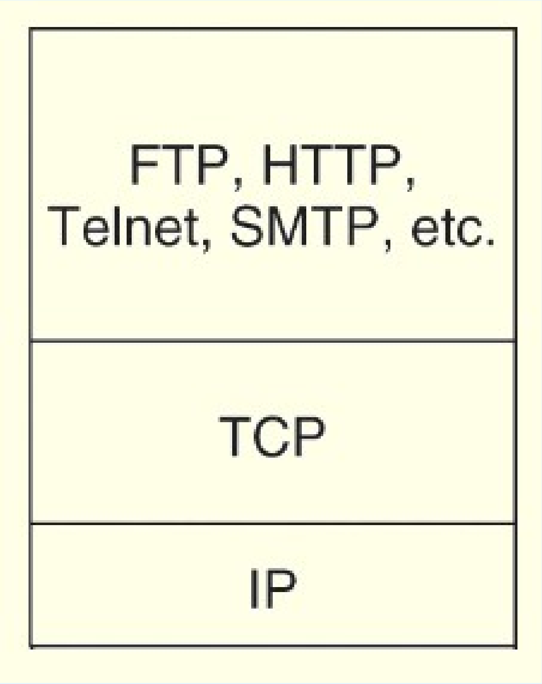


11.4 Network Protocols II
TCP/IP Architecture

- 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.

11.4 Network Protocols II
TCP/IP Architecture

- *Transmission Control Protocol* (*TCP*) is the consumer of IP services.
- It engages in a conversation-- a *connection*-- with the TCP process running on the remote system.
- A TCP connection is analogous to a telephone conversation, with its own protocol "etiquette."



11.4 Network Protocols II
TCP/IP Architecture

- As part of initiating a connection, TCP also opens a service access point (SAP) in the application running above it.
- In TCP, this SAP is a numerical value called a *port*.
- The combination of the port number, the host ID, and the protocol designation becomes a *socket*, which is logically equivalent to a file name (or *handle*) to the application running above TCP.
- Port numbers 0 through 1023 are called “well-known” port numbers because they are reserved for particular TCP applications.

11.4 Network Protocols II
TCP/IP Architecture

- TCP makes sure that the stream of data it provides to the application is complete, in its proper sequence and that no data is duplicated.
- TCP also makes sure that its segments aren't sent so fast that they overwhelm intermediate nodes or the receiver.
- A TCP segment requires at least 20 bytes for its header. The data payload is optional.
- A segment can be at most 65,656 bytes long, including the header, so that the entire segment fits into an IP payload.

11.4 Network Protocols II
TCP/IP Architecture

- In 1994, the Internet Engineering Task Force began work on what is now IP Version 6.
- The IETF's primary motivation in designing a successor to IPv4 was, of course, to extend IP's address space beyond its current 32-bit limit to 128 bits for both the source and destination host addresses.
  - This is a seemingly inexhaustible address space, giving 2^{128} possible host addresses.
- The IETF also devised the *Aggregatable Global Unicast Address Format* to manage this huge address space.

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