

Autumn Semester 2014

CSE 3461 / 5461:
**Computer Networking
&
Internet Technologies**

Instructor: Prof. Kannan Srinivasan

08/28/2014

Announcement

Drop before Friday evening!

Logistics

- My office hours: T Th 2:05-3:05pm (Dreese 681)
My website: <http://cse.ohio-state.edu/~kannan>
- TA: Rupam Kundu
Contact the TA for lab assignments
- CSE 3461: UG (3 credits), CSE 5461: G (2 credits)
- Required Textbook: Data & Computer Communications (9th Edition)
by William Stallings
Some homework problems are from the textbook
- C programming expertise is a MUST!!

k. srinivasan

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Logistics

- Grading:
 - Homework / Lab Assignments: 35% (**4 or 5** Homework and **3-4** Lab) (Not Equal!)
 - Homework assignments due at the beginning of class
 - Hard copy submission for Homework
 - Lab Assignments are not independent
 - Hard copy **&** soft copy submissions for Lab assignments
 - Midterm: 25% (TBD, in-class, closed book)
 - Final: 35% (**December 2nd 2014**, in-class, closed book)
 - Class Attendance: 5% (Attendance will be checked frequently)
- OSU Honor Code (check online)
- Check course website for assignments and handouts
Handouts will **NOT** be distributed

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- *The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point*

"The Mathematical Theory of Communication"

Claude Shannon

Studying Assignment: Chapters 1 & 2 in the textbook

Scope of the Course

- The scope of this course is broad, covering three general areas:
 - data communications,
 - networking, and
 - protocols.
- Data communications deals with the transmission of signals in a reliable and efficient manner.
- Networking deals with the technology and architecture of the communications networks used to interconnect communicating devices.
- A communication protocol is a set of rules governing the exchange of data between two entities
- Protocol architecture is a structured set of modules that implements the communication function

Contemporary Communication

- Trends
 - traffic growth at a high & steady rate
 - development of new services
 - advances in technology
- Significant change in requirements
 - emergence of high-speed LANs (local area networks)
 - corporate WAN (wide area network) needs
 - digital electronics
- What is a computer network? What does it include?
 - end-systems: workstations, servers, smart-phones
 - communication links: fiber, copper, radio, satellite
 - communication nodes: routers, switches, bridges

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Simplified Basic Communication Model

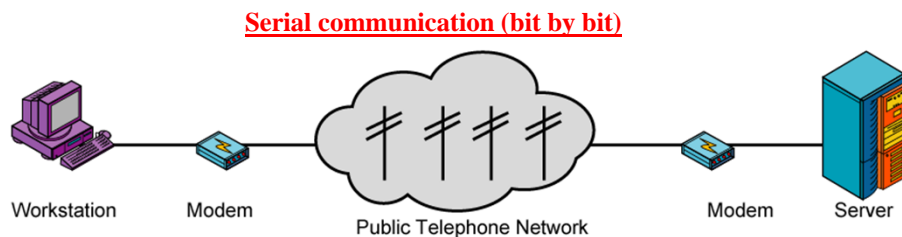


Figure 1.2

(b) Example

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Communication Tasks

- Source: Generates data to be transmitted
- Transmitter: Converts data into transmittable signals
- Transmission System: a single line or a complex network
- Receiver: Converts received signal into data
- Destination: Takes incoming data

Table 1.1

Transmission system utilization	Addressing
Interfacing	Routing
Signal generation	Recovery
Synchronization	Message formatting
Exchange management	Security
Error detection and correction	Network management
Flow control	

Networking

- Growth of number & power of computers is driving need for interconnection
- Point to point communication is not usually practical since:
 - devices are too far apart
 - large set of communication devices would need impractical number of connections
- Also seeing rapid integration of voice, data, image & video technologies
- Solution is a communications network
- Two broad categories of communications networks:
 - Local Area Network (LAN)
 - Wide Area Network (WAN)

Wide Area Networks – WANs

- Large geographical area
- Crossing public rights of way
- Rely in part on common carrier circuits
- Typically, a WAN consists of a number of interconnected switching nodes.
- WANs employ point-to-point approach and switching.
- Technologies used:
 - circuit switching
 - packet switching
 - frame relay
 - Asynchronous Transfer Mode (ATM)

Wide Area Networks Technologies

- **Circuit switching:**
 - Dedicated communications path established for the duration of the conversation; comprising a sequence of physical links between nodes with a logical channel dedicated to the connection
 - E.g. telephone network
- **Packet switching:**
 - Small chunks (packets) of data at a time
 - Packets passed from node to node between source and destination
 - Data may be received out of sequence
 - Used for terminal to computer and computer to computer communications

Wide Area Networks Technologies (continued)

- Frame relay:
 - evolution from packet switching
 - packet switching systems have large overheads to compensate for errors, but modern systems are more reliable and errors can be caught in by end systems
 - most overhead for error control is stripped out
 - user data rates up to 2Mbps
- Asynchronous Transfer Mode – ATM:
 - evolution of frame relay
 - little overhead for error control
 - fixed packet (called cell) length
 - designed to work in the range of 10s and 100s of Mbps

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Local Area Networks – LANs

- Smaller scope
 - building or small campus
- Usually owned by same organization as attached devices
- Data rates much higher than those of WAN
- Use broadcasting
- Switched LAN systems are being introduced
 - switched Ethernet (most common)
 - may be single or multiple switches
 - ATM LAN
- Wireless LANs
 - mobility
 - ease of installation
- **Metropolitan Area Networks – MANs**: Middle ground

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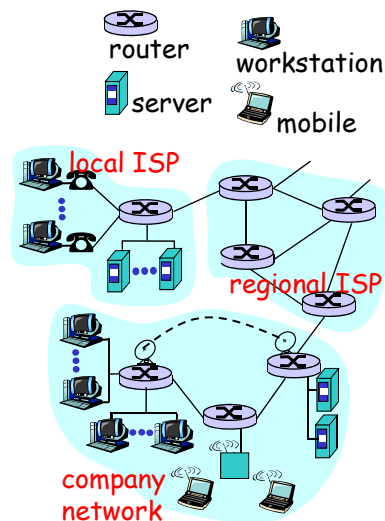
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Internet

- Internet evolved from ARPANET (started in late 1960)
- ARPANET:
 - first operational packet network
 - applied to tactical radio & satellite nets also
 - had a need for interoperability
 - led to standardized TCP/IP protocols

What's the Internet: "nuts and bolts" view A

- millions of connected computing devices: *hosts*, *end-systems*
 - pc's workstations, servers
 - PDA's phones, toasters running *network apps*
- *communication links*
 - fiber, copper, radio, satellite
- *routers*: forward packets (chunks) of data through network



Key Internet Elements

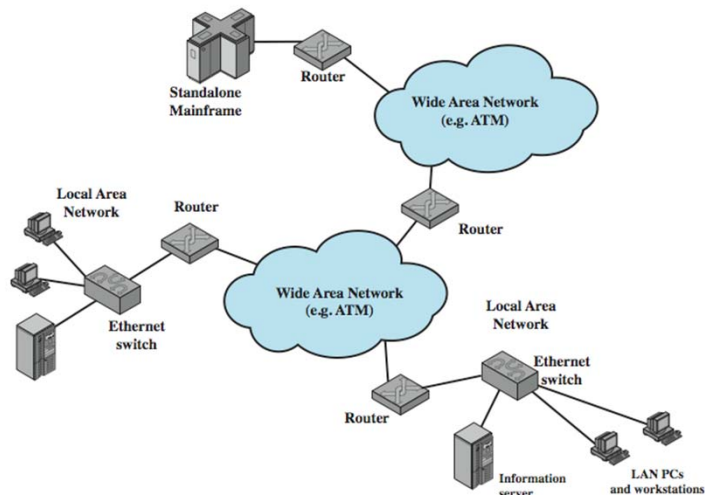


Figure 1.4

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Internet Architecture

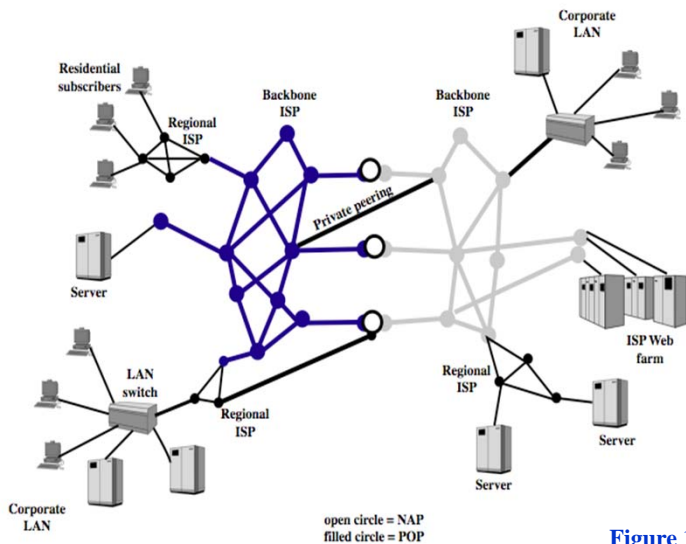


Figure 1.5

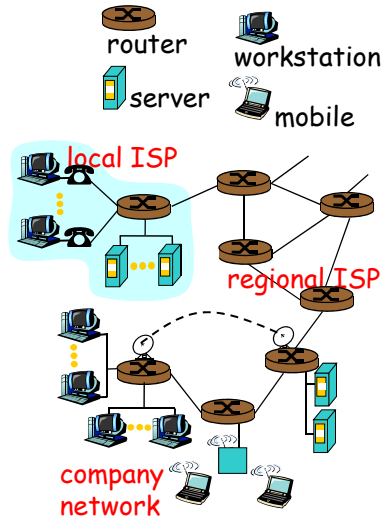
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What's the Internet: "nuts and bolts" view B

- *protocols*: control sending, receiving of messages
 - e.g., TCP, IP, HTTP, FTP, PPP
- *Internet: "network of networks"*
 - loosely hierarchical
 - public Internet vs. private intranet
- *Internet standards*:
 - RFC: Request for comments
 - IETF: Internet Engineering Task Force



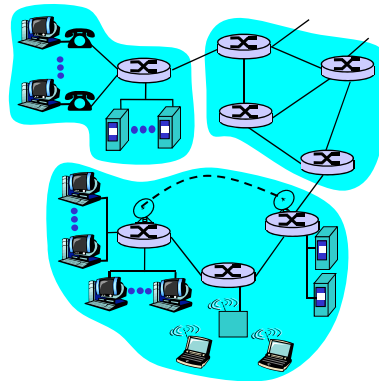
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What's the Internet: a service view

- *communication infrastructure* enables distributed applications:
 - WWW, email, games, e-commerce, database, voting, file (MP3) sharing
- *communication services provided*:
 - connectionless
 - connection-oriented



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What's a protocol?

human protocols:

- "what's the time?"
 - "I have a question"
 - introductions
- ... specific messages sent
- ... specific actions taken when messages received, or other events

network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols
- *protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt*

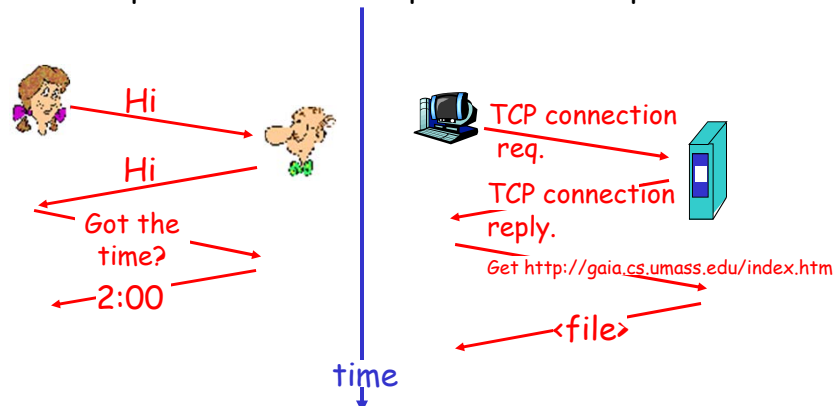
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What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocol?

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Need For Protocol Architecture

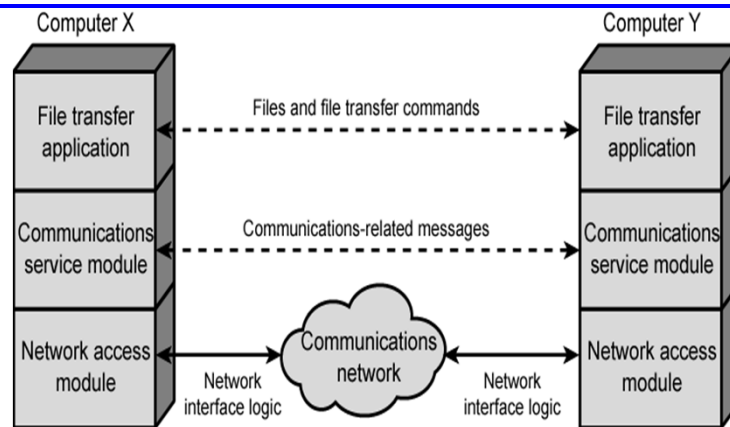
- Example: File transfer
 - source must activate communication path or inform network of destination
 - source must check destination is prepared to receive
 - file transfer application on source must check if destination file management system will accept and store file for his user
 - may need file format translation
- Instead of implementing the complex logic for this as a single module
 - task has to be broken into subtasks
 - implemented separately in layers in stack
 - functions needed in both systems
 - peer layers communicate

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Simplified Network Architecture



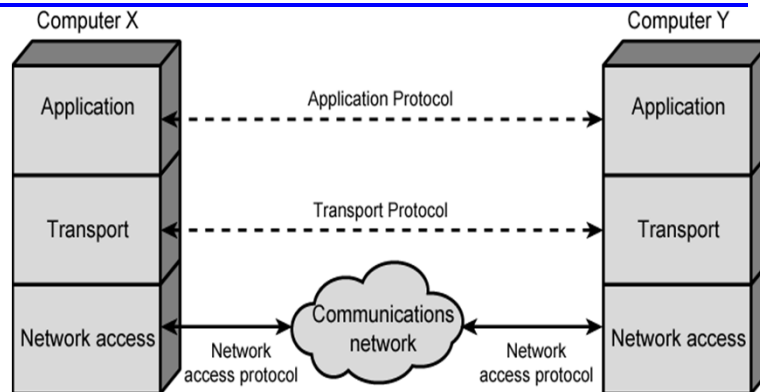
- Key elements of a protocol
 - syntax: concerns the format of data blocks
 - semantics: includes control info & error handling
 - timing: includes speed matching & sequencing

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Protocols in Three Layer Architecture



- Protocol architecture is a structured set of modules that implements the communication function
- A communication protocol is a set of rules governing the exchange of data between two entities

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Three Layer Model

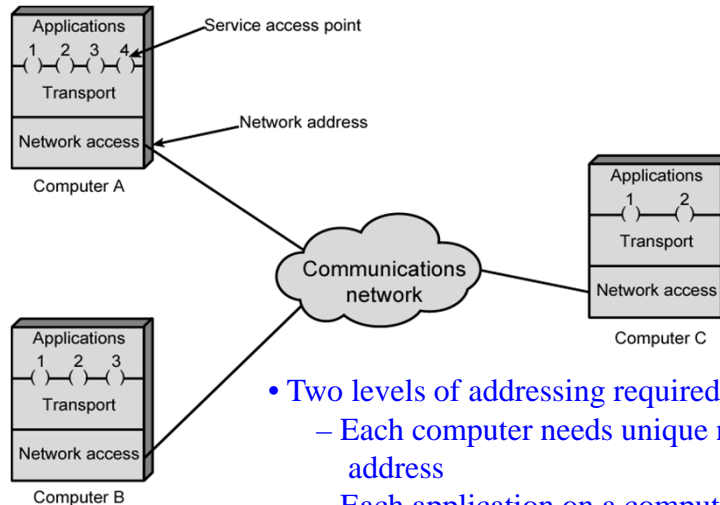
- Network Access Layer
 - exchange of data between the computer and the network
 - sending computer provides address of destination
 - dependent on type of network used (LAN, packet switched etc.)
- Transport Layer
 - reliable data exchange
 - independent of network being used
 - independent of application
- Application Layer
 - support for different user applications, e.g. e-mail, file transfer

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Addressing in Three Layer Architectures



- Two levels of addressing required:
 - Each computer needs unique network address
 - Each application on a computer needs a unique address within the computer

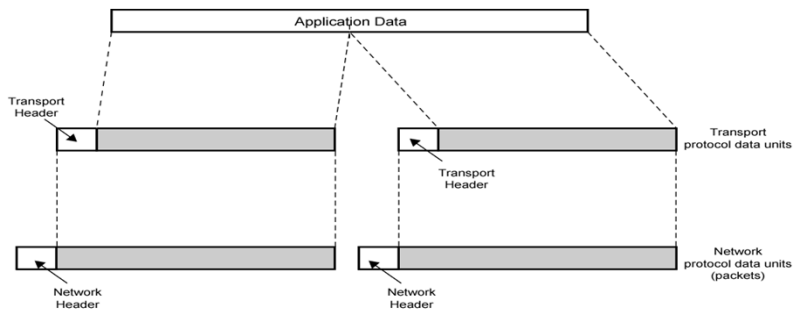
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Protocol Data Units - PDU

- At each layer, protocols are used to communicate
- Transport layer may fragment user data
 - Each fragment has a transport header with destination SAP, sequence number and error detection code; This gives a transport protocol data unit
- Network layer adds network header with network address for destination computer; This gives a network protocol data unit

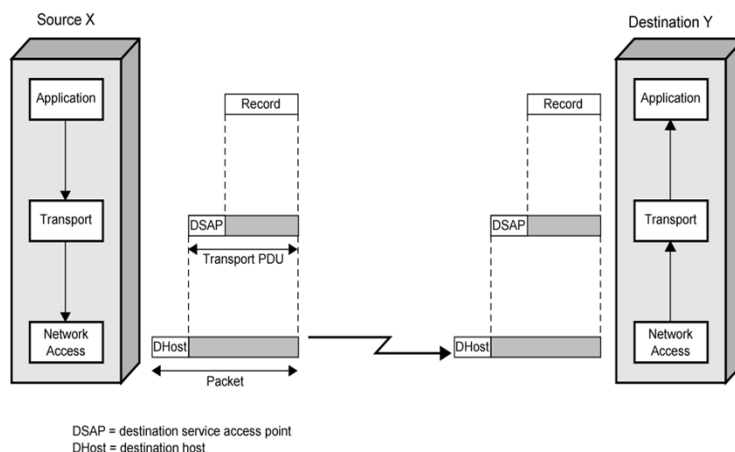


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Operation of Protocol Architecture



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Standardized Protocol Architecture

- Required for devices to communicate
- Vendors have more marketable products
- Customers insist on standards based equipment
- Two standards:
 - OSI (Open Systems Interconnection) Reference model
 - Developed by the International Organization for Standardization (ISO)
 - A theoretical system delivered too late!
 - Never lived up to early promises
 - TCP/IP protocol suite
 - Most widely used
 - It is the de facto standard

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TCP/IP Protocol Architecture

- Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)
- Used by the global Internet
- Protocol suite comprises a large collection of standardized protocols (by the Internet Activities Board – IAB).
- No official model but a working one:
 - physical layer
 - network access layer (data link layer)
 - internet layer (IP)
 - host to host or transport layer
 - application layer

TCP/IP Protocol Suite

- **Physical Layer**
 - concerned with physical interface between computer and network
 - concerned with issues like:
 - characteristics of transmission medium
 - signal levels
 - data rates
 - other related matters
- **Network Access Layer**
 - exchange of data between an end system and attached network
 - concerned with issues like :
 - destination address provision
 - invoking specific services like priority
 - access to & routing data across a network link
 - allows layers above to ignore link specifics

TCP/IP Protocol Suite (continued)

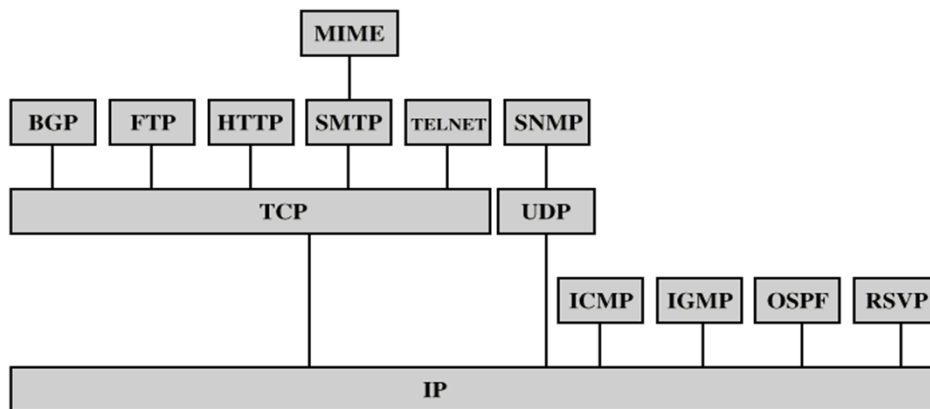
- **Internet Layer (IP)**
 - routing functions across multiple networks
 - for systems attached to different networks
 - using IP protocol
 - implemented in end systems and routers
 - routers connect two networks and relays data between them
- **Transport Layer**
 - common layer shared by all applications
 - provides reliable delivery of data
 - in same order as sent
 - commonly uses TCP
- **Application Layer**
 - provide support for user applications
 - need a separate module for each type of application

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Some Protocols in TCP/IP Suite



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Figure 2.5

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TCP/IP Concepts

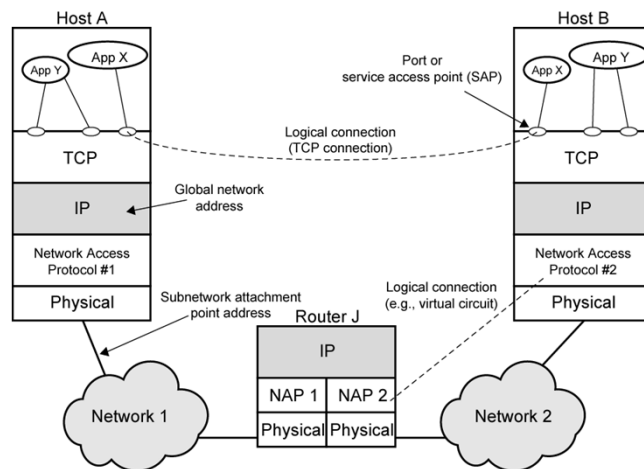


Figure 2.1

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Address Requirements

- Two levels of addressing required
- Each host on a subnet needs a unique global network address
 - its IP address
- Each application on a (multi-tasking) host needs a unique address within the host
 - known as a port
- In addition there may be a local network address assigned to a host

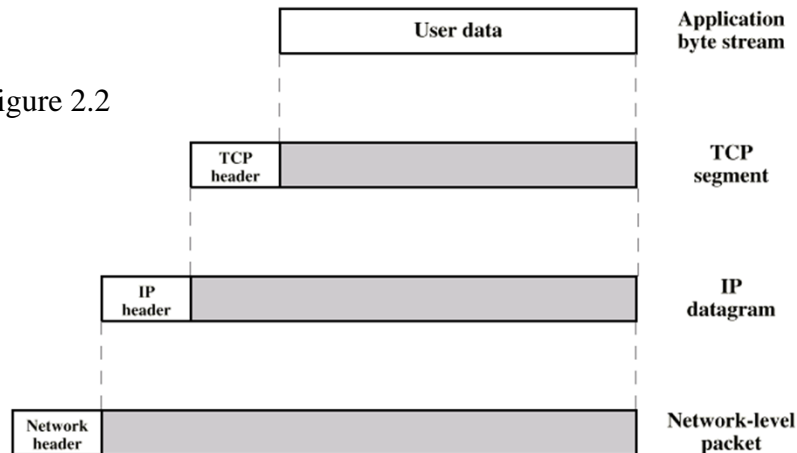
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PDUs in TCP/IP

Figure 2.2



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OSI Layers

- **Physical:** transmission of unstructured bit stream over physical medium
- **Data Link:** Higher layers may assume error free transmission
- **Network:** Transport of information, not needed on direct links and higher layers do not need to know about underlying technology
- **Transport:** Exchange of data between end systems, error free, in sequence, no losses, no duplicates
- **Session:** Control of dialogues between applications
- **Presentation:** data formats and coding, data compression, encryption
- **Application:** Means for applications to access OSI environment

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TCP/IP vs. OSI

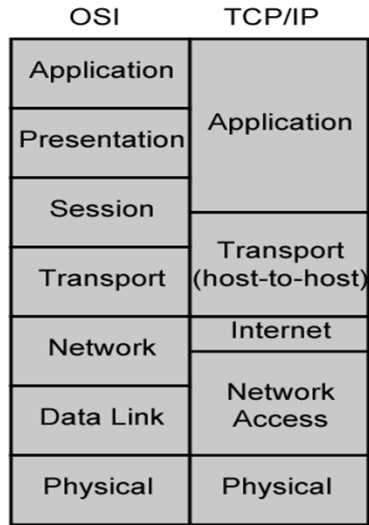
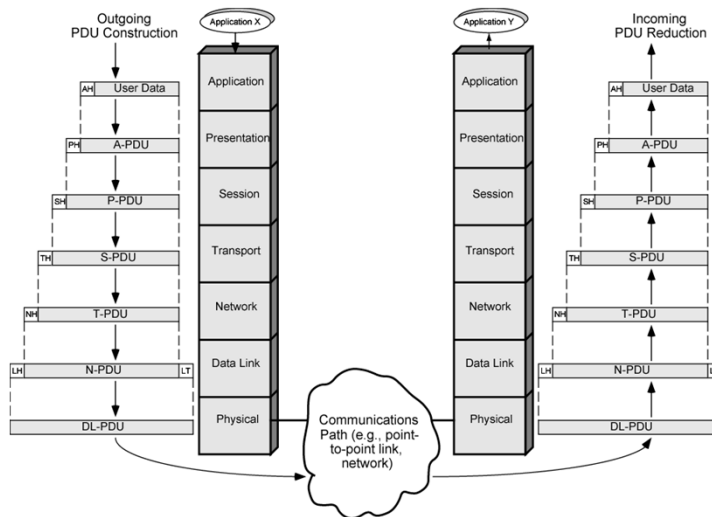
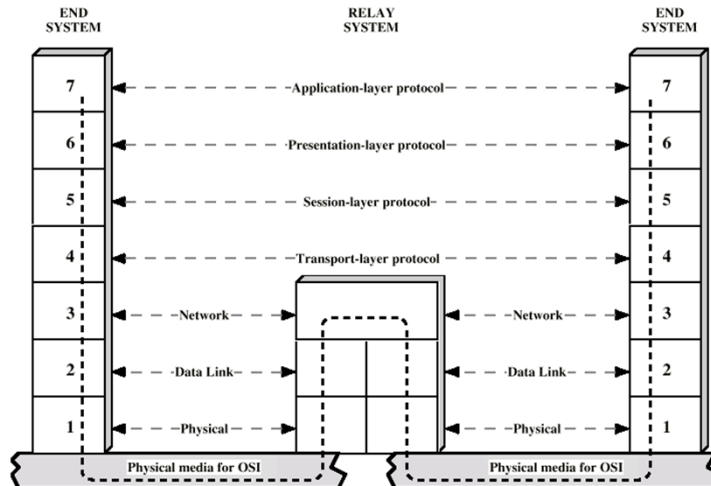


Figure 2.7

The OSI Environment



OSI Protocols



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OSI – The Model

- Layered model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers
- Services between adjacent layers expressed in terms of primitives and parameters
- Primitives specify function to be performed
- Parameters pass data and control information

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