

## Computer Networking

- **Definition**
  - ◆ **Computers communicating on Network**
- **Packet Switching Networks**
  - ◆ **Most networks divide into small blocks called *packets* for transmission**
  - ◆ **Each packet sent individually**
  - ◆ **Such networks are called *packet networks* or *packet switching networks***

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## Packet Switching Motivation

- **Coordination - helps transmitter and receiver determine which data have been received correctly and which have not**
- **Resource sharing - allows multiple computers to share network infrastructure**
- **Networks enforce *fair use* - each computer can only send one packet at a time**

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## Internetworking

- **It is desired to have a single network**
  - ◆ **Interconnect LANs using WAN**
  - ◆ **Access any computer on a LAN remotely via WAN technology**
- **Department of Defense sponsor research**
  - ◆ **ARPA = Advanced Research Projects Agency**
  - ◆ **Systems Survivability utilizing Redundancy**
  - ◆ **Early 1980's ARPANET was the first**

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## ARPANET

- **Developed with Government Funding**
- **Specification made Available to Public**
  - ◆ **Open System**
  - ◆ **Any company could build compatible system**
  - ◆ **ARPANET Internetworking Protocol = TCP/IP**
- **TCP/IP becomes the standard**
  - ◆ **Connecting LANs and WANs**
- **ARPANET is now called the Internet**

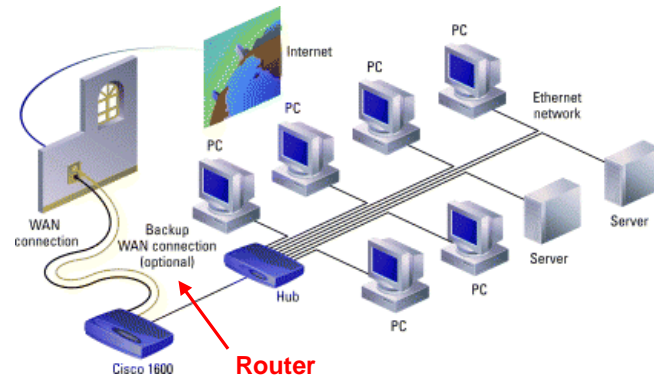
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### Routers Accommodate Multiple Types of Networks

- **Routers can interconnect different network technologies.**
  - ◆ Using diverse networking technologies
  - ◆ Actively changing computer networking technologies
- **Routers Can Interconnect WANs and LANs**
  - ◆ Least expensive to connect to the Internet
  - ◆ Connect a router to an existing network with Internet connection

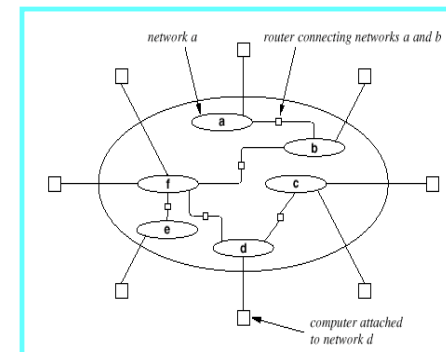
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### Network with Router



### The Reality Of Internal Structure

- **The Internet contains a complex physical structure transparent to the users**

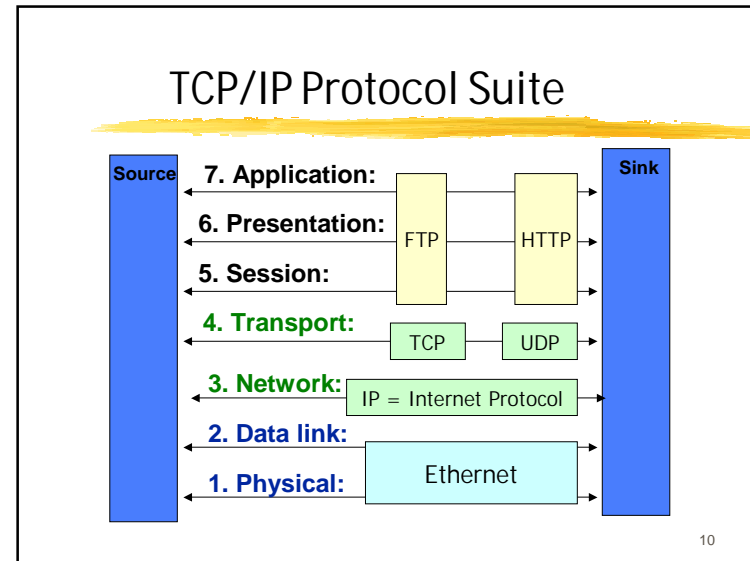


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### TCP/IP Protocol Suite

- **Combination of two Protocols**
- **IP = Internet Protocol**
  - ◆ Provides basic end to end communication
  - ◆ Layer 3: Network Layer of OSI Model
- **TCP = Transmission Control Protocol**
  - ◆ Provides Reliable data transport
  - ◆ Layer 4: Transport Layer of OSI Model

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### IP = Best-effort delivery

- **IP provides service equivalent to LAN**
- **Does *not* guarantee to prevent**
  - ◆ Duplicate datagrams
  - ◆ Delayed or out-of-order delivery
  - ◆ Corruption of data
  - ◆ Datagram loss
- **Reliable delivery provided by transport layer (OSI-4) using TCP**

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### IP Address Syntax

- **IP address is four bytes or 32 bits**
- **Unique across entire Internet**
- **Usually described with each byte represented with a decimal number between 0 and 255**

32-bit Binary Number				Equivalent Dotted Decimal
1000001	00110100	00001110	00000000	129 . 52 . 6 . 0
11000000	00000101	00110000	00000011	192 . 5 . 48 . 3
00001010	00000010	00000000	00100101	10 . 2 . 0 . 37
10000000	00001010	00000010	00000011	128 . 10 . 2 . 3
10000000	10000000	11111111	00000000	128 . 128 . 255 . 0

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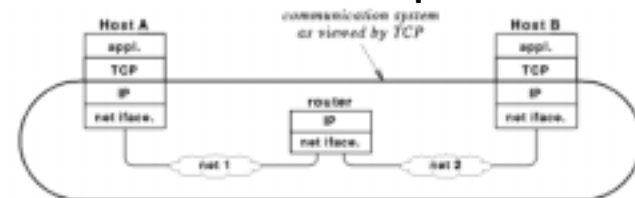
## TCP

- Transmission Control Protocol (TCP) is most widely used transport protocol
- Provides reliable data delivery by using IP unreliable datagram delivery
- Compensates for loss, delay, duplication and similar problems in Internet components
- TCP handles the problems that IP does not handle without duplicating the work that IP does.

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## Delivering TCP

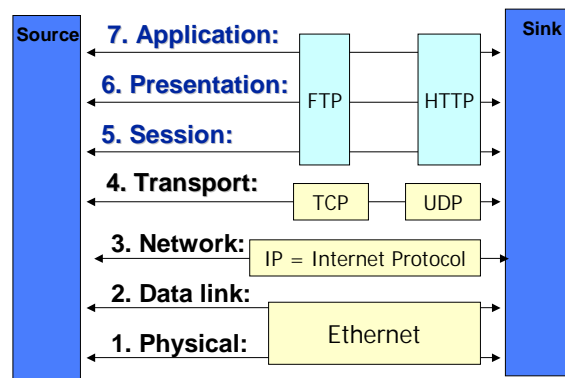
- TCP travels in IP datagrams
- Internet routers only look at IP header to forward datagrams
- TCP at destination interprets TCP



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## OSI Model

(Open Systems Interconnection)



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## Top 3 OSI Model Layers

- Layer 7: Application
  - ◆ Application-specific protocols such as HTTP, FTP, and SMTP (electronic mail)
- Layer 6: Presentation
  - ◆ Common formats for representation of data
- Layer 5: Session
  - ◆ Management of sessions such as login to a remote computer

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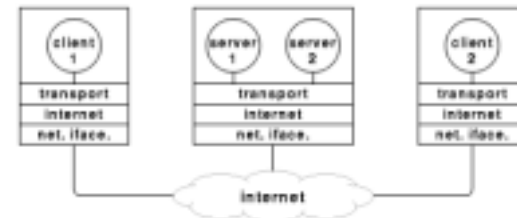
## Client Server Applications

- Application-level protocols provide high-level services
  - ◆ FTP
  - ◆ World Wide Web
  - ◆ DNS
  - ◆ Electronic mail
  - ◆ Remote Log In
- All of these applications use client-server architecture

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## Multiple services on one computer

- Sufficiently powerful computer - multi-tasking OS - may run multiple servers
- Servers run as independent processes and can manage clients simultaneously



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## Global Information Infrastructure

- Infrastructure = Basic Service on which society depends
  - ◆ Roads, telephones, mail, electricity, Internet
- Internet is general purpose and efficient
  - ◆ Almost any network application can use
  - ◆ Supports a wide variety of services
  - ◆ TCP/IP provides basic communication facilities
  - ◆ Accommodates changes in computers, networks, and services

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## What are intranets?

- Use Internet Technology on Corporate LAN
- Intranet applications
  - ◆ Policy and procedure manuals
  - ◆ Product and pricing information
  - ◆ Employee information
  - ◆ Job openings
  - ◆ Documents needing signatures
  - ◆ Schedules and calendars
  - ◆ Access to databases
  - ◆ Access to groupware

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## The Domain Name System

- **IP assigns 32-bit addresses to hosts**
  - ◆ Binary addresses easy for computers to manage
  - ◆ All applications use IP addresses through the TCP/IP protocol software
  - ◆ Difficult for humans to remember:  
134.82.11.70
- **The Domain Name System (DNS) provides translation between symbolic names and IP addresses**

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## Structure of DNS names

- **Each name consists of a sequence of alphanumeric groups separated by periods**
- **Examples:**
  - www.cs.ad.umuc.edu
  - www.ad.umuc.edu
  - www.irs.gov
- **Names are hierarchical, with most-significant component on the right**

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## DNS naming structure

- **Top Level Domains (right-most components; also known as TLDs) defined by global authority (InterNIC)**

com	Commercial organization
edu	Educational institution
gov	Government organization
mil	Military organization
jp	Country (Japan)
- **InterNIC**
  - ◆ Network Information Center (SRI)
  - ◆ \$35/year to \$25/year

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## DNS naming structure

- **Organizations apply for names in a top-level domain:**
  - umuc.edu
  - irs.gov
  - mcdonalds.com
- **Organizations determine own internal structure**
  - ad.umuc.edu
  - audit.irs.gov

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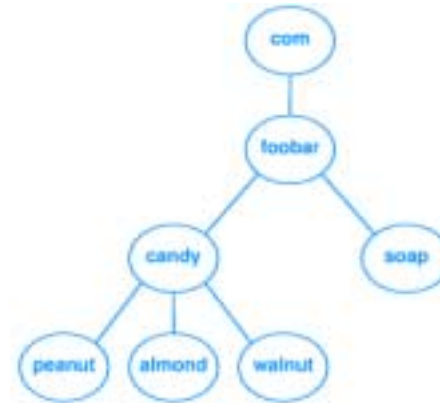
## Geographic structure

- Top-level domains are US-centric
- Geographic TLDs used for organizations in other countries:  

TLD	Country
.uk	United Kingdom
.fr	France
.ch	Switzerland
.fm	Federated States of Micronesia
- Countries define their own internal hierarchy: ac.uk co.jp and .edu.au

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## Example DNS hierarchy



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## Name resolution

- Resolver software typically available as library procedures
  - ◆ Implement DNS application protocol
  - ◆ Configured for local servers
- Calling program is client
  - ◆ Constructs DNS message - a DNS request
  - ◆ Sends message to local DNS server
  - ◆ DNS reply contains IP address for the name in the request

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## DNS caching

- DNS resolution can be very inefficient
  - ◆ Every host referenced by name triggers a DNS request
  - ◆ Every DNS request for the address of a host in a different organization goes through the root server
- Servers and hosts use caching to reduce the number of DNS requests
  - ◆ Cache is a list of recently resolved names and IP addresses

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