Session 2

Background

Lecture Objectives

- Understand how an Internet resource is accessed
- Understand the high level structure of the "Internet cloud"
- Understand the high level structure of the TCP/IP protocols
- Understand how a computer finds the IP address of a host using DNS
- Know the structure of MIME type standards

Reference

- Mime types
  http://en.wikipedia.org/wiki/Internet_media_type

What is a URL?

- A short string that identifies a resource on the Web
- Stands for Uniform Resource Locator
  - Uniform - varied and new types of resources
  - Resource - Anything that has identity (e.g., image)
- Reduces the tedium of connecting to a host, selecting a path, selecting a resource, etc. into a single string that:
  - Can be saved as a bookmark in your browser
  - Can be saved as an object in your Java code

URL Example

http://www.cs.sunysb.edu

Protocol identifier *Resource name*

- Protocol Identifier - Indicates the name of the protocol to be used to fetch the resource
- Resource name is the complete address of the resource
- Resource name may be appended with a fragment / reference / named anchor (denoted by #) or include a query string (denoted by ?)

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URL Resource Name

- For http, the name includes: host name, path name to the file, port number (optional), and location within the resource (optional)
- The resource is not necessarily a file, it can be generated dynamically

important concept

- A trailing slash (www.sun.com/) is shorthand for the file named /index.html

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Relative URLs

- Contains only enough information to reach the resource relative to (in the context of) another URL
- Used within HTML files

```
<td> <a href="LectureCode.html" >Intro</a></td>
```

- specified relative to the location of the file in which they are contained

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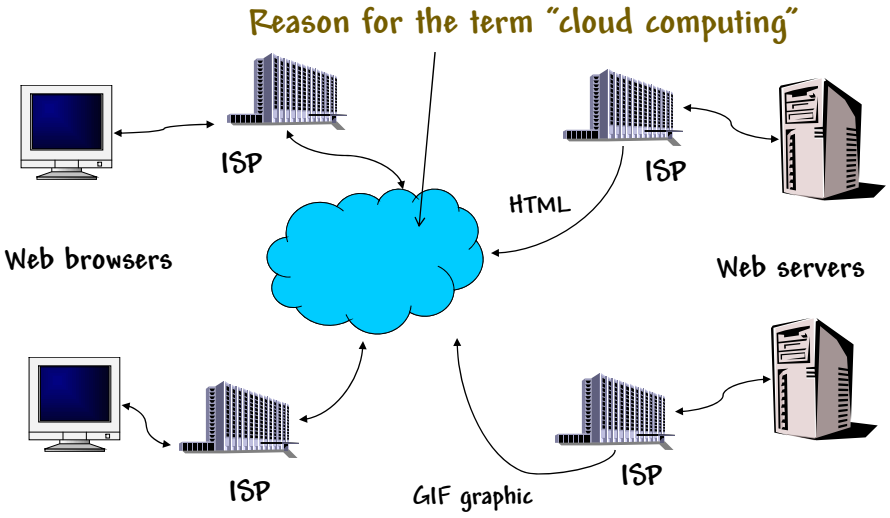
Web Architecture



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Internet Origins

- Late 1960s
  - ARPA (Advanced Research Projects Agency)
  - Funded research project
  - ARPANet - redundant network, connecting research labs and US Government installations
- 1970s - 1980s
  - Enormous growth in US sponsored Internet
- 1990s
  - US Government turns Internet over to independent global agencies

DARPA has changed its name (back and forth) to ARPA

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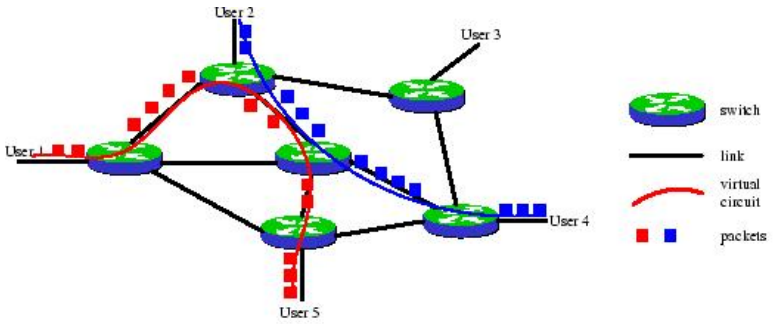
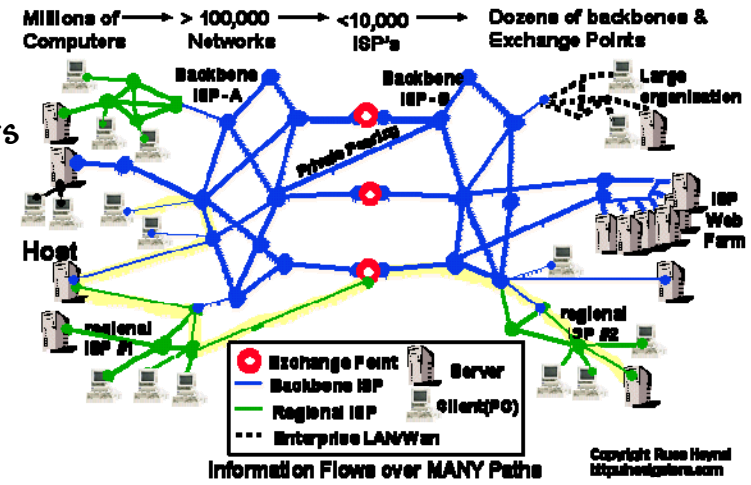
ARPANet Principles

- Free and open information sharing
- Datagram message packets - data carried in chunks (not streams)
- Uniform protocol for communications between dissimilar computers

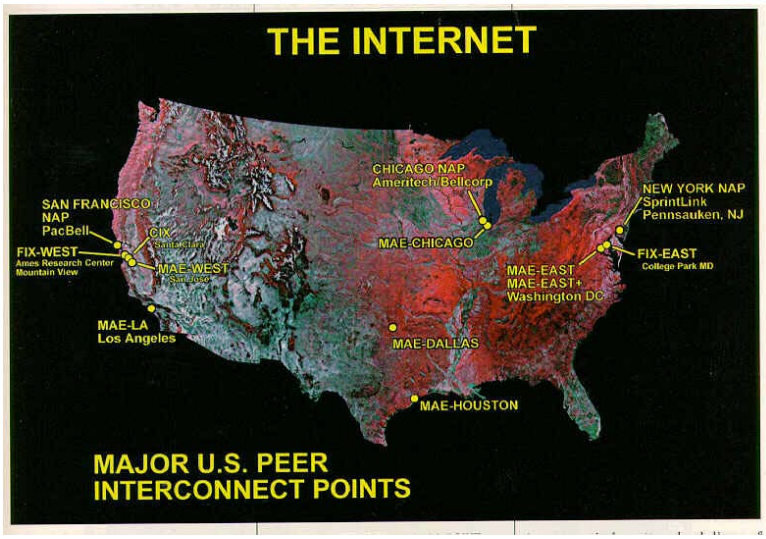


Internet Physical Layer

- Multiple backbones
- Multiple ISPs
- Multiple exchange points



Internet Interconnect Points



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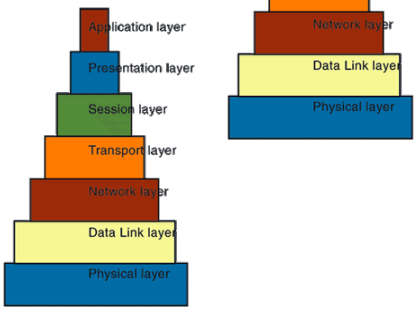
Terms

- Protocols - control the sending and receiving of information over the Internet
- Physical media - cable, copper wire, fiber, radio spectrum
- Routers - intermediate switching devices
- Route (or path) - sequence of physical media and routers to complete end-to-end communication
- Packet switching - decomposing a message into packets and routing the packets to a destination

Protocol Stacks

- Makes interfaces portable and maintainable
- Each layer of the stack only interfaces with the adjacent layers
- Protocol conversion occurs between the same layer on different computers
- Examples
  - ISO/OSI



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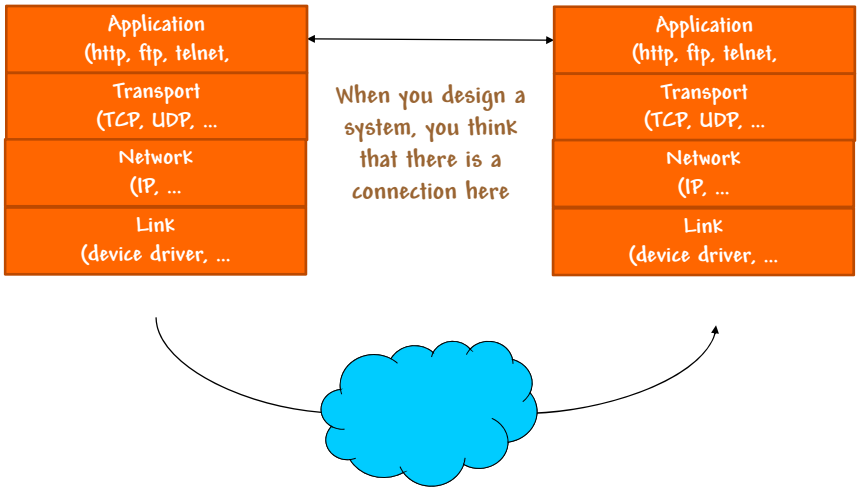
Internet Protocol Stacks



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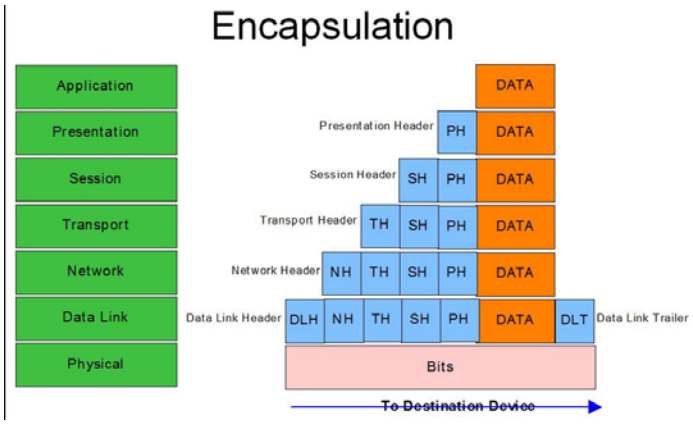
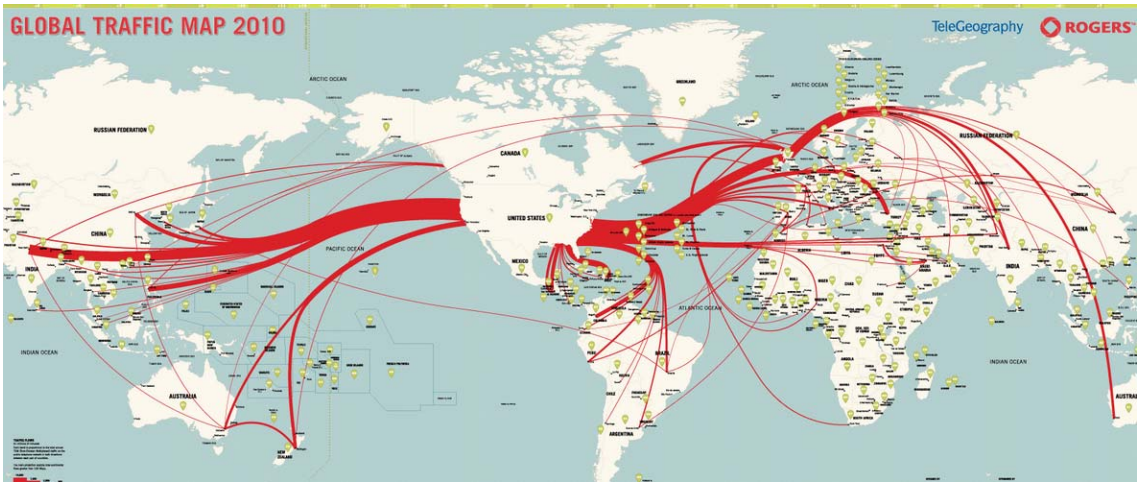
Data Encapsulation

- Layer to layer interface usually involves encapsulation of data
- Encapsulation - wrapping the data with information that describes the data and helps route the data



Global Traffic



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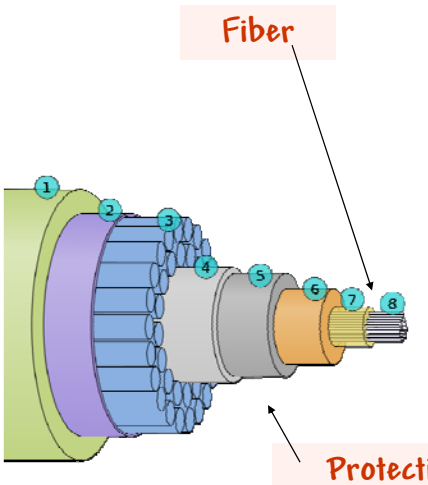
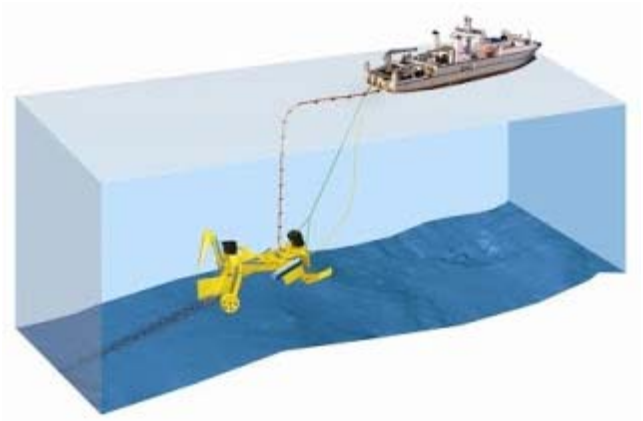
Transoceanic Cables





Asia Backbone

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Transport Protocols

- Internet connection-oriented service is implemented through buffers at the sending and receiving end

- TCP
- Transmission Control Protocol
- Connection based
- Reliable flow of data between two computers

- UDP
- User Datagram Protocol
- Connectionless service
- Order of delivery is not guaranteed

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TCP/IP

- IP (Internet Protocol) - network layer protocol that specifies the format of information that is sent and received among routers and end nodes

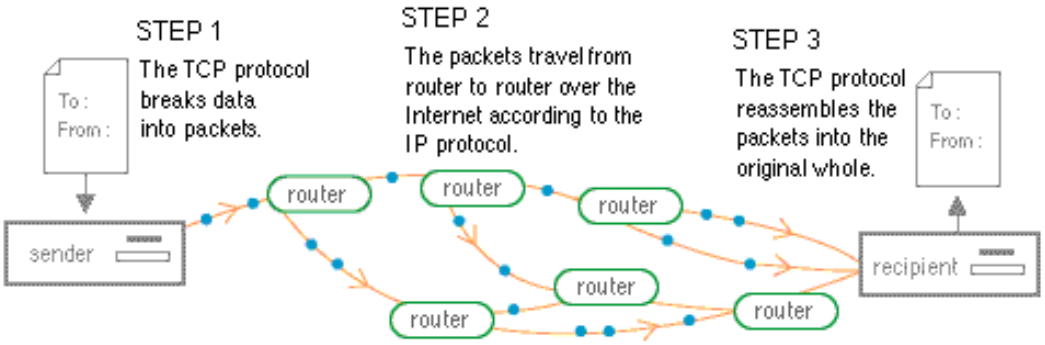

Figure 2. How data travels over the Net.

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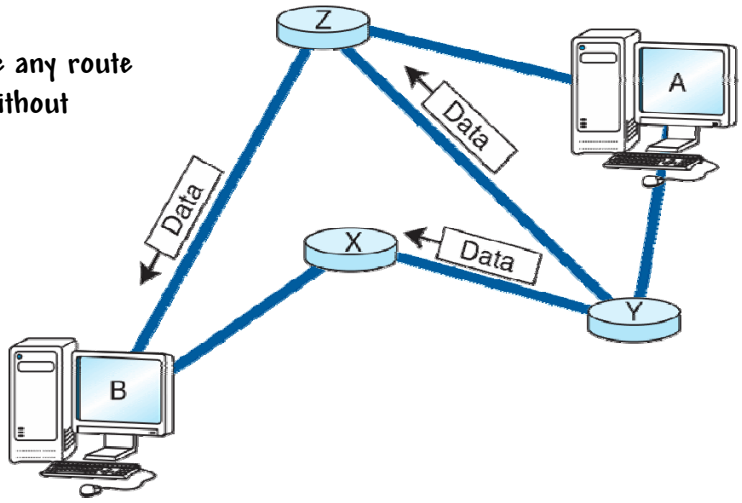
TCP/IP Network Architecture

- Datagrams can take any route available to them without human intervention



IPv4

- Current version of IP
- Not adequate to serve millions of network components scattered across the globe.
- Limitations
  - 32-bit addresses
  - a packet length limited to 65,635 bytes
  - all security measures are optional
- Network addresses have been assigned with little planning resulting in slow and cumbersome routing hardware and software

IP Addressing

- Hosts and other devices have network interfaces identified by an IP address
- IP (IPv4) addresses are 32-bit numbers represented as four groups of 8 bits (byte)
- Written in dotted-decimal notation
- IP address consists of
  - Network ID - portion of the IP address that defines the network to which the device is connected
  - Host ID - portion of the IP address that defines the host

stonybrook.edu

129.49.2.176

Record Type: IP Address

2^{32} possible IP addresses (not enough)

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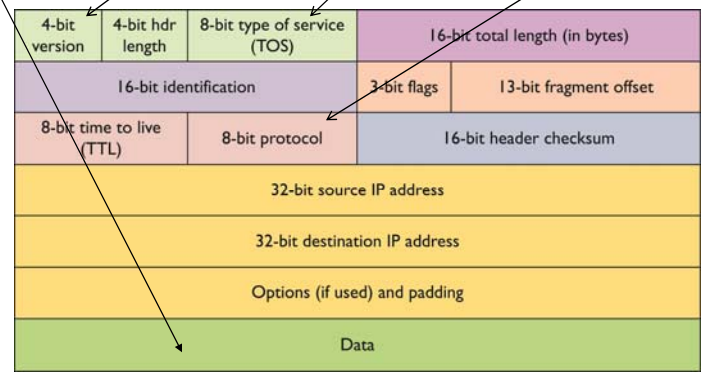
IP Packet

- Header
- Data section (payload)

IPv4 or IPv6

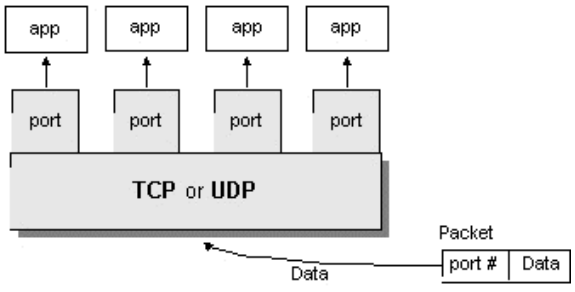
Can be used to distinguish differing levels of service

Usually TCP or UDP



Application Interface

- Interface is designated by a port number
- Socket - combination of the port number, the host ID, and the protocol designation (equivalent to a file name to the application running above TCP)



Port Numbers

- Port numbers 0 through 1023 are reserved for particular TCP applications
- Examples
  - telnet - 23
  - smtp - 25
  - http - 80

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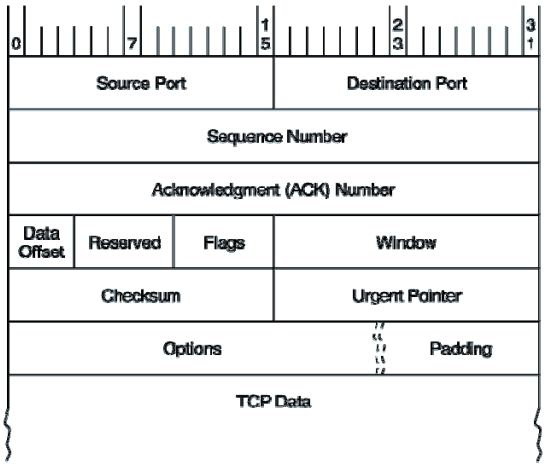
TCP Segment Format



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IPv6

- In 1994, the Internet Engineering Task Force began work on what is now IP Version 6
- Motivation
  - Extend IP's address space beyond its current 32-bit limit to 128 bits for both the source and destination host addresses
  - Slow roll-out

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How Does a Browser Work?

- It reads a named resource (usually an HTML document) on an Internet-based server
- Begins to display the page
- Finds all the URLs in the HTML
- Requests the resources associated with the other URLs (e.g., images)
- Includes the additional resources in the display of the page

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How Does the Internet Find a Host?

- URL contains a host name, (e.g., www.cnn.com)
- Internet routers identify hosts by their IP address
  - 4 bytes, presented in dotted-decimal notation
    - decimal numbers, separated by periods (e.g., 121.7.106.83)
    - Each number is between 0 and 255 (8-bit binary number)
  - 2^{32} possible IP addresses in IP V4 (theoretical maximum)
- DNS (Domain Name System) is a directory service that translates host names (sometimes referred to as domain names) into IP addresses

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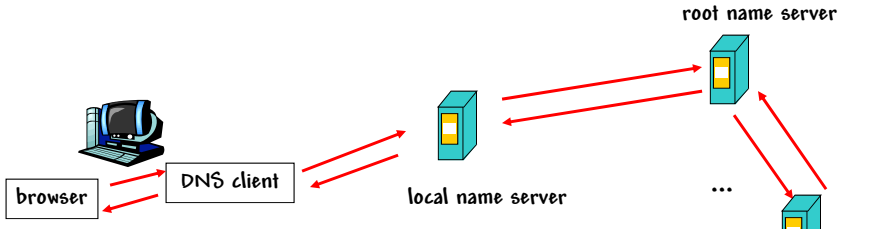
How DNS Works



- Browser passes host name to DNS client.
- DNS client looks up IP address from the distributed database located on the DNS name servers
  - Local
  - Root
  - Authoritative

There are 13 root server identities (A, B, C, ..., M), but many of them are aliased

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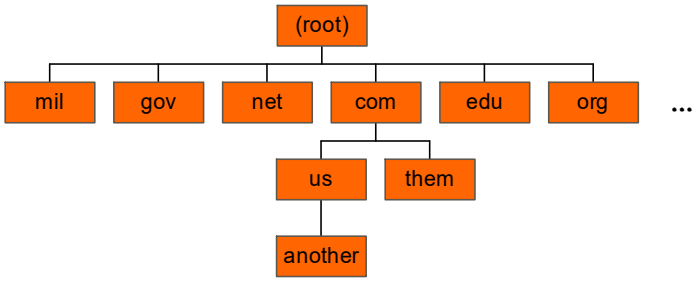
Domain Name Service

- Used to map host names (contained within a URL) into network addresses (32 bit IP address)
- Name space (partial)



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Other DNS Services

- Host aliasing - a host can have one or more alias names (e.g., ibm.com and www.ibm.com), one of which is the canonical hostname
- Aliasing by service - a company can use the same host name for its Web server, mail server, ftp server, etc. even though these are different computers with different IP addresses
- Load distribution - a set of IP addresses can be associated with a canonical hostname. DNS will return the set of addresses, varying the order of addresses each time it is accessed

How many hosts do you think are associated with google.com?

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DNS Concepts to Remember

- DNS provides name to address mapping
- DNS is implemented through local address caching
- DNS is a distributed database service
  - Very reliable
  - Not always fast
  - Not always up to date

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Cyber Security Issues

- Internet is inherently insecure
- Industries and country economies are increasingly dependent on the Internet
- Many successful cyber attacks
- Examples of cyber warfare (e.g., Estonia, Georgia, 2016 US elections)
- "Open" countries are particularly vulnerable to attack
- Limited experience with response options

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Vulnerabilities of the Internet[1]

- Routing among ISPs - Border Gateway Protocol routes packets across the Internet, but there is no checking of authenticity of messages
- No governance of the Internet beyond domain names
- Operational messages are unencrypted
- Malware can be easily propagated
- Decentralized design

An advanced packet sniffer on an Ethernet network can look at all the traffic

1. Clarke, R, Cyber War

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What is a MIME Type?

- Multipurpose Internet Mail Extensions
- Designed for the interchange of data among various e-mail systems
- Allows for universal interchange of data
- Defines naming of file types
- Organized into 8 base type categories

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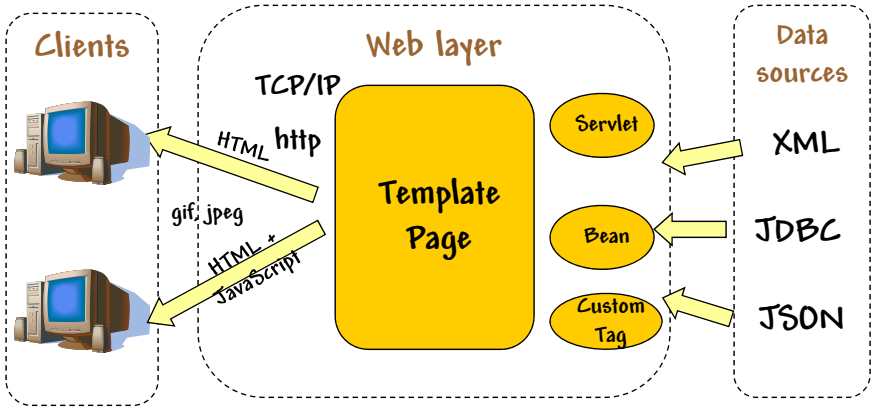
Extended Web Architecture



The host-host data transfers usually involve one MIME file

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"Base" Media Types

- application - application and miscellaneous
- audio - audio data
- example
- image - image data
- message - news, e-mail, etc.
- model - models (e.g., geometric)
- multipart - multipart
- text - HTML, CSS, etc.
- video - video data

e.g., image/png

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MIME Type Concepts to Remember

- Internet files have standard formats so that data can be exchanged easily between very different computers (hardware, OS, etc.)
- Sender specifies the type and receiver interprets the data accordingly, taking into account all the differences in internal data representation

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Did You Achieve the Lecture Objectives?

- Understand how an Internet resource is accessed
- Understand the high level structure of the "Internet cloud"
- Understand the high level structure of the TCP/IP protocols
- Understand how a computer finds the IP address of a host using DNS
- Know the structure of MIME type standards

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