The Internet

- In the 1970s, it would take *weeks or even months* for Charlie's mail to reach his pen pal residing in some faraway country.
- In the 1990s, international phone calls costing *several dollars* a minute can be made.
- Today, Charlie and his pen pal are able to communicate over immense distances, across dozens of national borders, with *near-zero cost*, no human assistance, and *mere seconds* of lag-time between the transmission and receipt of the message.

How this is possible?

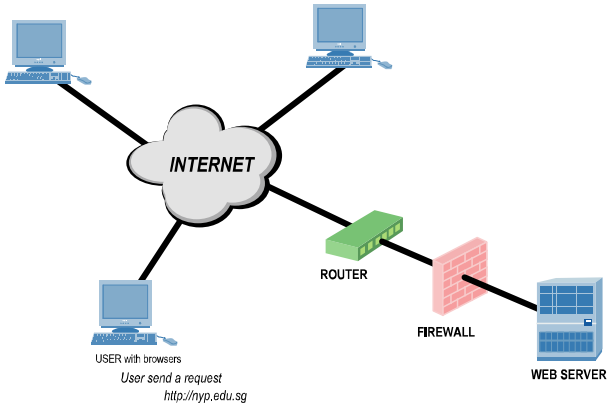
- An extensive network of connected computers
- Every computer on the network must have (standard protocols)
  - an unique address ("Internet Protocol address," or "IP address")
  - a common definition of the packets of data
    - a 24 to 32 byte header and a packet size of up to 576 bytes.
    - The header contains information on the origin and destination address of each packet and the total size of the packet.
    - Example: Voice, Text etc

What is the Internet?

- The Internet is the publicly available worldwide system of *interconnected computer networks*.
- It's made up of thousands of smaller commercial, academic, domestic, and government networks.
- It provides an infrastructure for the use of *electronic mail, bulletin boards, file archives, hypertext documents, databases*, and other information resources.
- The Internet is the Information Superhighway.

The Internet

- Web browsers, web servers, firewall & router



What is a Router?

- Is a network device that forwards packets from one network to another.
  - Packets are sent by the fastest route and can move information around broken sections of the Internet. Not all packets are sent by the same route.

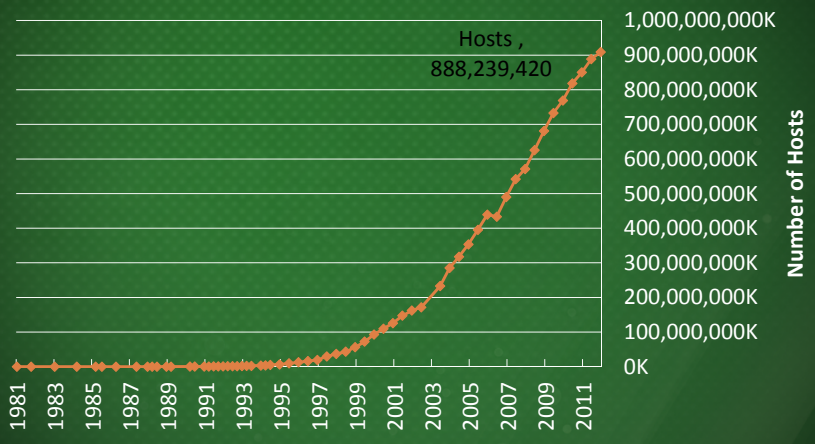
What is a Firewall?

- The primary method for keeping a computer secure from intruders.
- A firewall allows or blocks traffic into and out of a private network or the user's computer.

Brief History of the Internet

- 1968 - DARPA (Defense Advanced Research Projects Agency) contracts with BBN (Bolt, Beranek & Newman) to create ARPAnet
- 1970 - First five nodes:
  - UCLA (University of California, Los Angeles)
  - Stanford
  - UC Santa Barbara (University of California, Santa Barbara)
  - University of Utah, and
  - BBN
- 1974 - Transmission Control Program (TCP)
- 1977 – First internet. E-mail takes off.
- 1979 – News Groups born.
- 1984 – Use TCP/IP. Domain Name Server (DNS) introduced.
- 1991 – WWW is released.

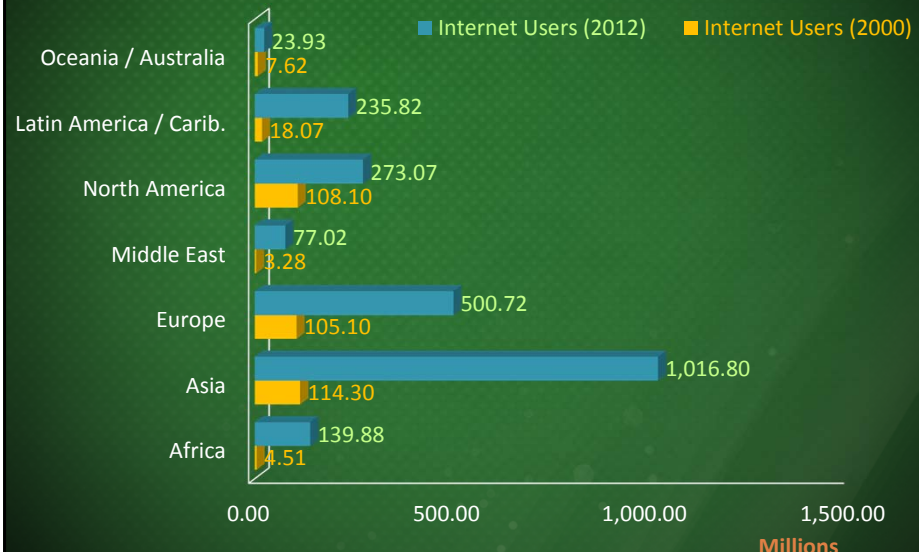
Number of Internet Hosts



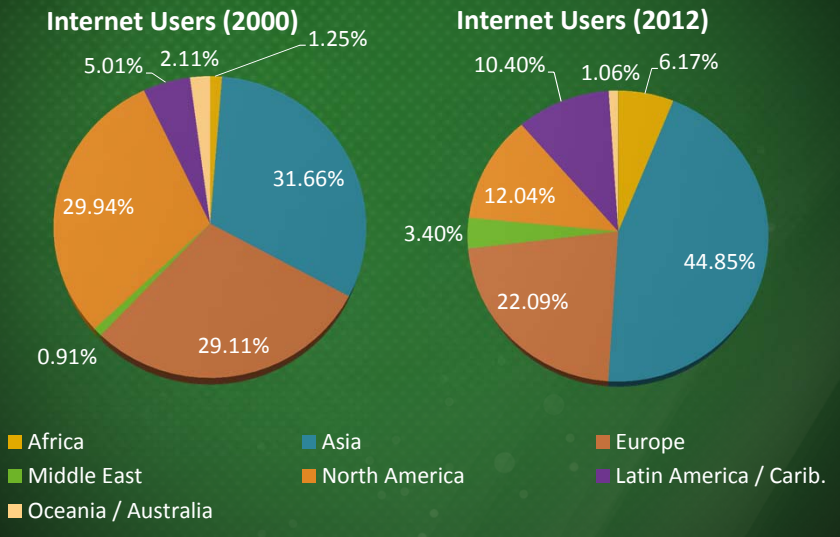
https://www.isc.org/solutions/survey/history

(Internet Systems Consortium, Inc)

Number of Internet Users



Internet Users Distribution



Internet Architecture

What is a Computer Network?

- A computer network is a system consisting of two or more computers *connected* together so that they can *exchange data (or communicate)* with each other.
- A small network can be connected with another to form a larger network.

Types of Layout

- Networks are classified according to the geographic layout and how they connect to other networks. (LAN vs MAN vs WAN)
- The largest network is the Internet, which is composed of many different networks, both large and small.

LAN vs MAN vs WAN

- LAN (local area network) – Connected within a building or complex
- MAN (metropolitan area network) – Generally covers a city or suburb
- WAN (wide area network) – Generally covers a state or country.

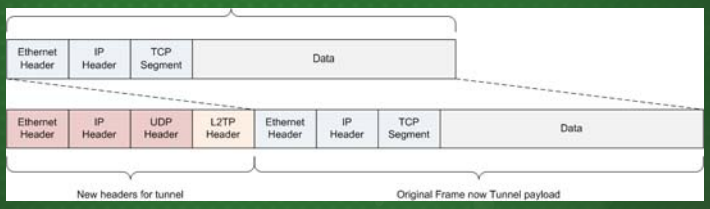
What is a Communication Protocol?

- Standard protocols allow computers from different manufacturers to communicate;
  - A set of rules for how computers will act when talking to each other.
  - The computers can use completely different software, providing that the programs running on both ends agree on what the data mean (protocols).

Remember Charlie?

Data Packets Protocol

- The protocol definitions range from how bits are placed on a wire (…to the format of an electronic mail message).



IP Address

- Every resource on the Internet has a unique 32-bit IP address.
- IP numbers include four address blocks (8 bits each) of numbers.
  - The highest IP address is 255.255.255.255
  - This allows about 4,294, 967,200 addresses
- IPv6 has a 128-bit address space.

Domain Names

- Domain names help human beings remember IP addresses as names instead of a bunch of numbers.
  - www.nyp.edu.sg -> xxxx.xxxx.xxxx.xxxx
  - Resources on the WWW are located with the Uniform Resource Locator (URL):

Protocol	Domain	Port	Subdirectory/filename
http://	www.nyp.edu.sg	80 (default)	sidm/sidm.html

How does data flow between these computers?

Switching Techniques

- Communication between computers is typically done over a network of switched nodes.
  - Data is transferred from node to node by switching
  - A node could be a network adaptor, a Switch, or a Router
- Switching techniques are used to establish a link between nodes and to transmit data across a shared channel.
- *Nodes do not bother about the content of data*.

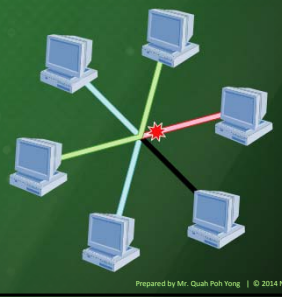
Circuit vs Packet Switching

- In simplified terms, there are 2 switching techniques
  - Circuit-switching network
  - Packet-switching network

Circuit-Switched Networks

- Everything is specified.
- Control is the essence of making signals move reliably, and everything is *designed for reliability*.
- Everything moves by permission.
- When connection breaks, transmission ends.
- Three phases
  - Establish
  - Transfer
  - Disconnect

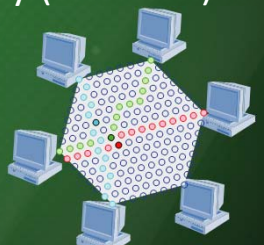
Eg Making a telephone call



Packet-Switched Networks

- A signal is broken down into packets.
- Each packet is individually addressed and routed across the network to its destination where the message is reassembled.
- Packets are received, stored briefly (buffered) and past on to the next node
- Packets that do not arrive at their destination are automatically retransmitted.

Eg Send large movie over the Internet.

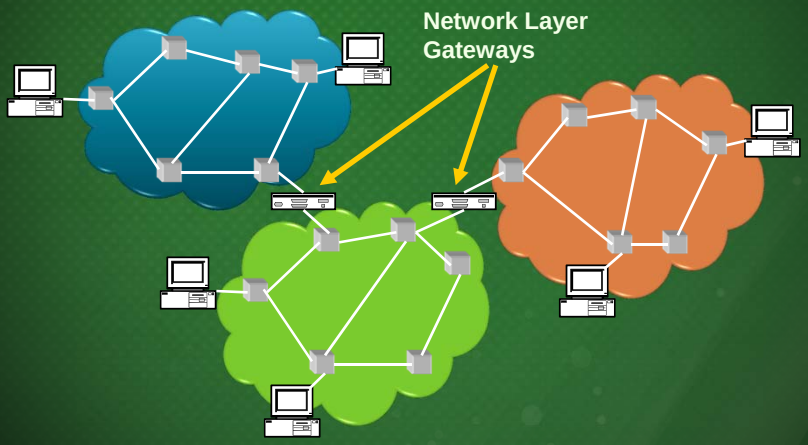


TCP/IP

Internet Technologies

- Before the Internet (before 1977), there were many different network styles and technologies:
  - Circuit-switched vs. packet-switched, etc
  - Wireless v.s wired vs. optical, etc
- Networks use different type of technology and implemented differently
  - Only nodes on the same type of network could communicate
  - Data could not be sent from one network to different one

Internet



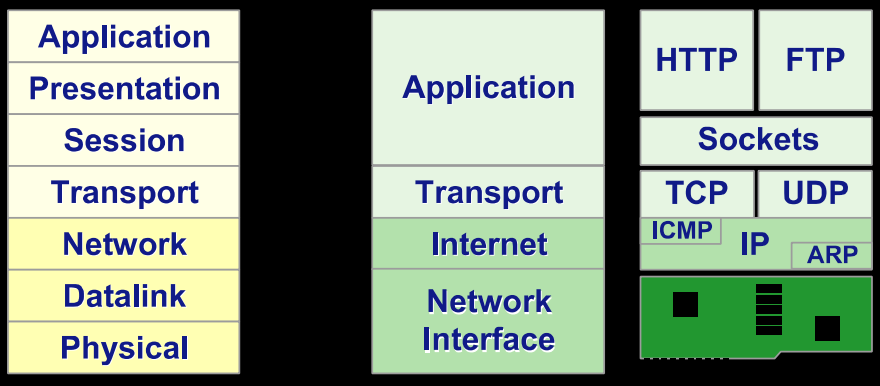
Communication Problems

- The many different network communication technologies meant that there were various communication problems:
  - How to interconnect a large number of disparate (i.e. separate) networks?
  - How to support a wide variety of network applications (e.g. FTP, e-mail, P2P, etc)?
  - How to handle data transfer from a large number of end-nodes and applications in an interconnected network?

The TCP/IP Protocol Suite

- Often called the Internet architecture
- The basic communication language or protocol of the Internet.
- TCP/IP consists of 4 layers, instead of the 7 layers of the ISO-OSI (International Organization for Standardization - Open System Interconnection) Architecture model.

The OSI Model vs. TCP/IP Protocol



TCP/IP Protocol Suite Layers

- Application Layer
  - defines TCP/IP application protocols and how host programs interface with Transport layer services to use the network.
  - Protocols included are FTP, HTTP and SMTP

TCP/IP Protocol Suite Layers

- Transport Layer (How to deliver the packets?)
  - Enable Communication between the source and destination computers
  - defines the level of service and status of the connection used when transporting data.
  - The main protocols are TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).

TCP/IP Transport Methods

- Transmission Control Protocol (TCP)
  - Is a reliable transport protocol.
  - TCP ensures that all data arrive accurately and intact at the other end.
  - TCP is "*connection oriented*" and requires a handshake before the session can begin.
- User Datagram Protocol (UDP)
  - Used in place of TCP when a reliable delivery is not required. There is less processing.
  - UDP is widely used for streaming audio and video, voice over IP (VoIP) and videoconferencing
  - UDP is "*connectionless*" and does not use a handshake to start a session. It just sends out packets

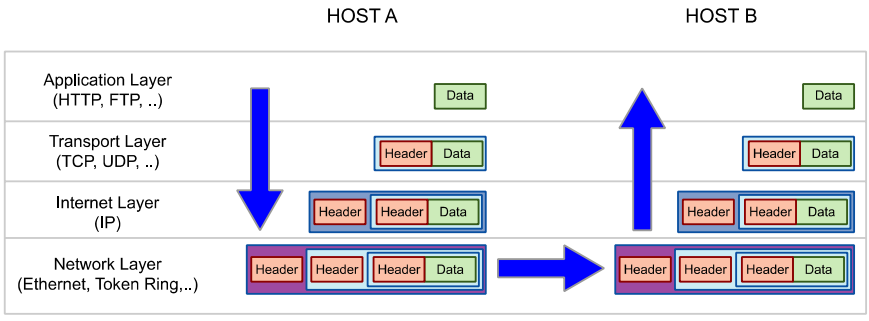
TCP/IP Protocol Suite Layers

- Internet Layer
  - pack data into data packets (include address)
    - Each gateway computer on the network checks this address to see where to forward the message.
  - Ensure the delivery of packets.
  - Protocols included are IP (Internet Protocol), ICMP (Internet Control Message Protocol), ARP (Address Resolution Protocol)

TCP/IP Protocol Suite Layers

- Network Interface
  - how data is physically sent through the network
  - The hardware and software involved in the interchange of frames between computers.
  - Protocols included are Ethernet, Token Ring

How Data is Transferred



World Wide Web (WWW)

- A massive collection of Web Pages (web sites) on the Internet.
- Based on
  - Hypertext Markup Language (HTML)
  - HyperText Transport Protocol (HTTP), File Transfer Protocol (FTP)
  - Web servers and Web browser

Web Servers

- A web server is a software program that serves web pages to requesting clients via HTTP.

Web Browsers

- A software program you use to view pages on and navigate the World Wide Web.
- When you request a page on a website, the browser makes a web connection to a web server.
- The web browser processes the web pages that it receives from a web server and displays the pages.
- Most browsers parse (i.e. display) web pages differently.

Web Applications

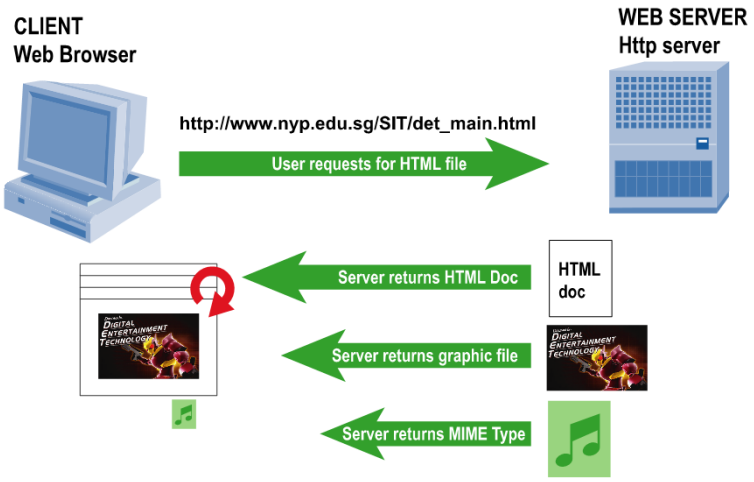
- Run in the web browsers allowing the users to interact with a web server
- Example
  - Gmail
    - Simple Mail Transfer Protocol (SMTP)
    - IMAP Internet Message Access Protocol

Web Development

Client or Browser Side Technologies

- Hypertext Markup Language (HTML)
- JavaScript
- VBScript
- Client Side Components
- Cookies
- Plug-ins

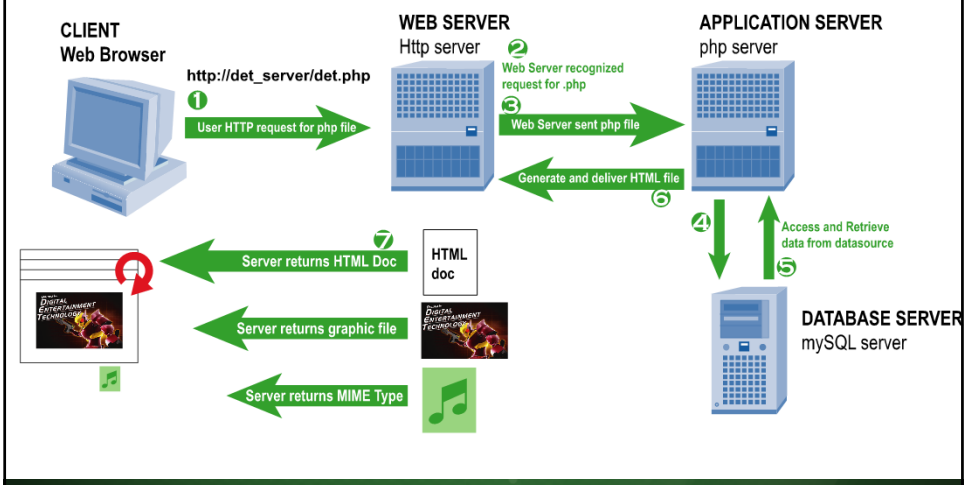
How a Web Page is Fetched?



Server Side Technologies

- Common Gateway Interface (CGI)
  - enables a client web browser to request data from a program executed on the web server. CGI specifies a standard for passing data between the client and the program.
- Servlet
- ASP.NET
- PHP – a server-side HTML-embedded scripting language.
- MySQL – a database management system using SQL

How a Dynamic Web Page is Fetched?



Static Or Dynamic Web Sites

Static Web Site

- A "static" site is one built out of *static HTML* pages.
  - Each page is individually coded in HTML

Dynamic Web Site

- Web Application?
- An individual page doesn't exist as a finished HTML document.
- When a user requests a page, the system *builds* it from three sets of data:
  - HTML templates (Presentation)
  - The content of the page is retrieved from a database (Model)
  - Any user input required to create the page (Control)

Advantages of Dynamic Sites

- It's easier to update and change content.
- The people who create and maintain the content don't need to know anything about HTML.
- Adding user interactivity is much easier.
- Compatibility problems can be resolved.
- It can cater to non-PC devices (e.g. palm, MMS etc)

Sisadvantages of Dynamic Sites

- More crash-prone than flat sites.
- They cost more to build and maintain.
- The reliance on either open source or proprietary technology (e.g. PHP vs. asp)
  - Reliance on bug fixes
  - Reliance on the software's current ability

Online Gaming

Online Games

- Install-able client application
  - This type of game usually generates a quite complicated sequence of animations. Virtually all true/full 3D online games are usually of this type.
  - e.g. Warcraft.
- Played using a web browser.
  - e.g. Internet Explorer

Web Browser Based Game

- plugin required.
  - Flash player
  - Java applet plugin
- plugin not required.
  - HTML and JavaScript
  - HTML5 <canvas>