CM0133
Internet Computing

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Room S 2.20, C/2.11

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The Web is a wonderful but Wired Place

A perfect example of the internet as a world wide forum (but not if your this kid... :-))

The Star Wars Kid was just goofing off at school. Now he finds his private performance downloaded by over 15 million Internet users across the world.

The Star Wars Kid is a 15-year-old from Quebec known only as Ghyslain -- his parents are keeping his last name secret to protect his identity. Back in November 2002, Ghyslain was goofing off at a school video studio and recorded himself fighting a mock battle with a golf ball retriever lightsaber. Over two minutes, the video shows the lone, overweight teenager twirling his mock lightsaber ever faster while making his own accompanying sound effects.

Yes, we've all had our dorky, private moments, but this poor kid is living the nightmare of having his private dorkiness projected across the world to giggling Web users. His friends found the tape, and uploaded it to KaZaA as a joke on April 19. Within two weeks, someone had added full *Star Wars* special effects and sound effects to the tape. Currently, new clone videos are being created at the rate of 1 per day!

Currently There Are 96 Clone Videos.
11 more in the making!

- The Original Movie
- A Different Version
- A Better Version
- There are now 96 Videos

The Web Page: http://www.jedimaster.net/

You Have to be Sane to Do Internet Computing

To Run: Click here or go this URL http://www.dave2k.com/

Course Information

Course Aims and Objectives

Students should be able to:

- Understand the relevance and underlying infrastructure of the Internet and the WWW.
- Design and produce user friendly WWW pages.
- Support a variety of Multimedia within WWW applications.
- Develop non-trivial WWW based applications.

Lecture Schedule

Standard Single Module

The course will consists of:

- 22 Lectures — Twice a Week
- 6 Tutorials — Approx. Every Two Weeks, and
- 11 weekly — 1 hour Lab Sessions each week

Lecture. Tutorial, Lab Timetable

Lecture Times:

white

Location: Room C/2.07,
Times: 9.00 AM Tues, 2.00 PM Tues

Tutorial Times:

Location: Room C/2.07,
Times: TBC

Lab Times:

Location: Room S/2.21a (Multimedia Lab),
Times: TBC.

Consult Year 1 Timetable/Noticeboard, Internet Course Web pages and Internet Lecture Announcements for times of Lectures **THIS YEAR**.

WWW Support

All course notes will be available on the COMMA information Server and will be accessible via any WWW browser.

URL: *http://www.cs.cf.ac.uk/Dave/Internet*

Note that links to extra reading and support material not covered in the lectures will be provided here. This extra material is examinable.

Exercise and general course information will also be provided.

Please note that the installation of material for this course is still an ongoing process. New material for any part of the course could be added at any time.

Examination + Assessment Information

Assessment

- Two Hour University written examination *60%*
- Coursework *40%*
  1. Internet Search Assignment (This Week) — Check Email
  2. FTP Assignment
  3. Web Site Assignment

  All Assignments at web site

Syllabus: Lecture by Lecture Description

Broadly the lectures will be broken down into the following:

Lecture 1 : Introduction

- History and Development of the Internet

Lecture 2 : Anatomy of the Internet

- Basic Internet Technologies and Components
- Tools of the Internet/WWW:

  E-mail, FTP, Telnet, WWW: HTTP/HTML, Web browsers, Web Servers

- Use of the Internet: What can the Internet do for you?
- The Internet and the World Wide Web (WWW)
- WWW Search engines etc.

Lecture 3-4 : How the Internet Works

- Network Topologies/Configuration
- Network Models
- Packets
- Network Protocols
- TCP/IP — How messages are transmitted.
- IP Addresses/Domain Names

Lecture 5 : Internet Tools and Resources

- What are they? How do they Work?
- E-mail Protocols
- FTP Protocols
- Telnet Protocols

Lecture 6-8 : The World Wide Web

- What is the WWW?
- Basic Introduction
- Introduction to HTML
- HTML Coding

Lecture 9 : WWW Programming: HTML Forms/CGI

- Forms
- CGI Scripts

Lectures 10-15 : WWW Programming: CGI/Perl

- CGI/Perl Programming

Lectures 16-18 : WWW Programming: JavaSript

Lectures 19-21 : WWW Programming: PHP

Lecture 22 : Multimedia:

- Forms of Multimedia
- WWW support for Multimedia
- WWW Design Issues
  - Graphic Design
  - Bandwidth and other problems

Computing Resources Used in this Course

Multimedia Lab Room S 2.21a

Macintosh G4 Power PC be used as the primary machines employed for practical work.

The Departments network of Sun Workstations will be required for storage and running of CGI Script. The setting up and programming required for advanced WWW pages can only be facilitated in this manner.

Students will therefore require access to file space etc on the Sun network.

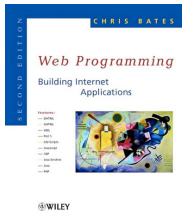
Students can access this network remotely

Books

Core Texts

Should be considered for purchase:

Web Programming: Building Internet Applications (2nd Edition),
Chris Bates,
J. Wiley and Sons.



Related Texts

- Not Essential Purchase
- BUT Highly recommend
- Books should be in Library
- Cover Parts of Module Well
- Many of these books also VERY useful for First Year Project

WWW, Internet in General

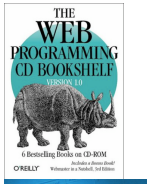
The Web Programming CD Bookshelf,
O'Reilly and Associates Inc, 2003.

Teach Yourself Web Publishing with with HTML & XHTML in 21 Days,
Laura Lemay,
Sams.Net Publishing.

Webmaster in a Nutshell,
S. Spainhour and V. Quercia,
O'Reilly and Associates Inc.
(Also available as part of *The Web Programming CD Bookshelf*)

Every Student's Guide to the World Wide Web,
K. Pitter and R. Minato,
McGraw Hill

Google Hacks – 100 Industrial-Strength Tips and Tricks,
TaraCalishain, RaelDornfest,
O'Reilly and Associates Inc, 2003.



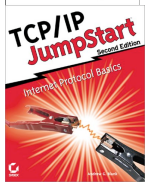
Internet — Protocols and Theory

TCP/IP JumpStart: Internet Protocol Basics,
A. G. Blank,
Sybex 2002

HTTP: the Definitive Guide,
B Totty, D Gourley, M Sayer, Aggarwal and S Reddy ,
O'Reilly and Associates Inc.

IP Routing,
R. Malhorta,
O'Reilly and Associates Inc.

Internet Email Protocol, *K. Johnson*,
Addison Wesley.

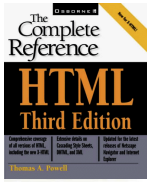


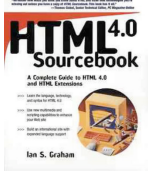
HTML BOOKS:

HTML: The Complete Reference, *Thomas A. Powell*, Osborne McGraw-Hill , 2000.

HTML Sourcebook, *I.S. Graham*, Wiley and Sons

HTML: The Definitive Guide, *C. Musciano and B. Kennedy*, O'Reilly and Associates Inc.





CGI Scripts / Perl Programming BOOKS:

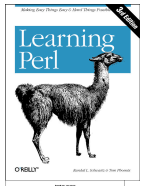
Learning Perl,
R.L. Schwartz,
O'Reilly and Associates Inc.

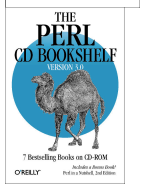
CGI Programming with Perl, 2nd Editionm
S.Guelich, S.Gundavaram, and G.Birznieks,
O'Reilly and Associates Inc.

Perl Cookbook,
T. Christiansen and N. Torkington,
O'Reilly and Associates Inc.

Programming Perl,
L. Wall, T. Christiansen and R.L. Schwartz,
O'Reilly and Associates Inc.

Perl 5 Desktop Reference,
J. Vromans,
O'Reilly and Associates Inc.





JavaScript BOOKS:

JavaScript: The Definitive Guide, 4th Edition,
D.Flanagan,
O'Reilly and Associates Inc.

JavaScript & DHTML Cookbook Solutions and Example for Web Programmers,
D.Goodman,
O'Reilly and Associates Inc

PHP BOOKS:

Programming PHP,
R,Lerdorf and K.Tatroe,
O'Reilly and Associates Inc.

Web Database Applications with PHP & MySQL,
H. E.Williams and D. Lane,
O'Reilly and Associates Inc.

PHP Cookbook ,
DavidSklar and AdamTrachtenberg,
O'Reilly and Associates Inc.

WWW Design Issues BOOKS:

Web Design n a Nutshell,
Jenifer Niederst,
O'Reilly and Associates Inc.

The Web Design CD Bookshelf ,
O'Reilly and Associates, Inc.

Designing with Style Sheets, Tables, and Frames,
M.E. Holzschlag,
Sams.Net

HTML Style Sheets Quick Reference,
R. Falla,
Que Press

10 Minute Guide to HTML Style Sheets,
C. Zacker,
Que Press

Teach Yourself Great Web Design in a Week,
A. Vasquez-Peterson and P. Chow,
Sams.Net

Introduction — Internet Computing

What is the Internet?

Any Defintions of the Internet?

Introduction — Internet Computing

What is the Internet?

Some common definitions given in the past include:

- a network of networks based on the TCP/IP protocols,
- a community of people who use and develop those networks,
- a collection of resources that can be reached from those networks.

Probably the broadest definition that defines the Internet today is:

The Internet is a global network of connected computer networks

Internet — A Network of Networks

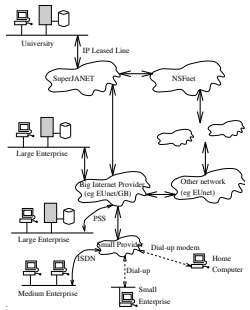


Figure 1: Internet - a large collection of networks

History of the Internet

How old is the Internet?

- Earliest trace in history?
- Formal specification?
- Public Awareness?

Brief History of the Internet

1836 — Telegraph. Cooke and Wheatstone patent it.

1858-1866 — Transatlantic cable.

1876 — Telephone. Alexander Graham Bell Exhibits.

1957 — USSR launches Sputnik, first artificial earth satellite.

1969 — Birth of Internet

1987 — Commercialisation of Internet

1991 — World-Wide Web (WWW)

What are the Key Internet Technologies?

Key Technologies of Internet

E-mail (1971) — a program to send messages across a distributed network.

Telnet (1972)— **Computers can connect more freely and easily**

FTP (1973) — computers send and receive data.

Newsgroups (1979) — News discussion Forrum

TCP/IP (1982) — defines future communication means

Domain Name servers (1983/4) — Internet gets bigger

World-Wide Web (1991) — developed released by CERN; within the UK academic network.

Mosaic/Netscape (1992-93) — User Friendly Graphical Front End to the World Wide Web.

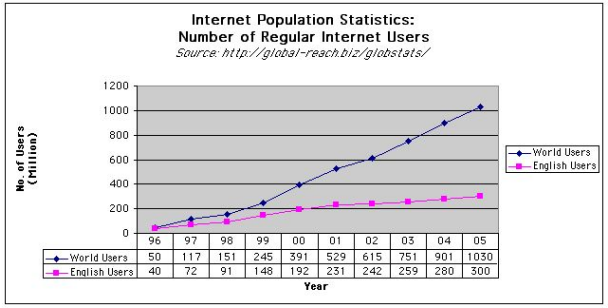
Internet Explorer [1996] — Microsoft enter *late*

Internet growth

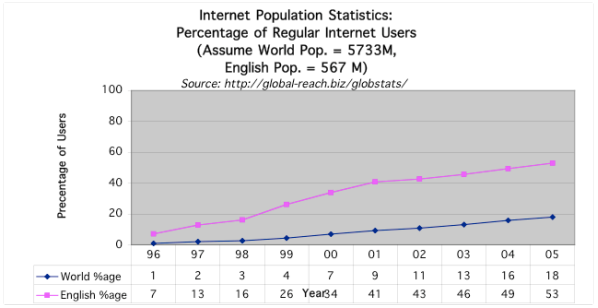
Currently (2003)

- 200 Million Hosts (Avg.), 150 Million WWW sites.
- 750 million people use the Internet.
- over 1 Billion home pages.
- 13% World Population Online, 46% English Speaking World
- 80% of the Web users are between the ages of 16 and 44.
- 57% of Web users have a college degree, 28% have graduate degrees.
- 80% business users surf the Web
- Browse the Internet from your Television Set and Mobile Telephone
- Broadband (fast) internet for all — affordable at last
- More than half of all email is spam (junk).
- Much More???

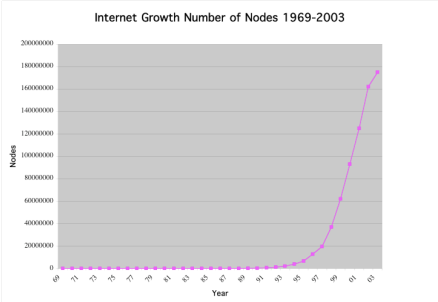
Internet Statistics

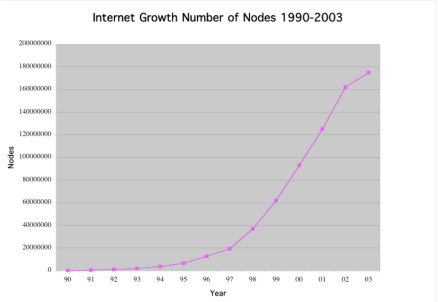


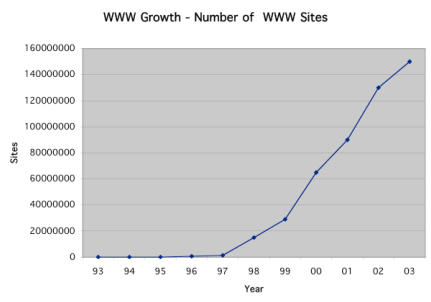
	96	97	98	99	00	01	02	03	04	05
World Users	50	117	151	245	391	529	615	751	901	1030
English Users	40	72	91	148	192	231	242	259	280	300

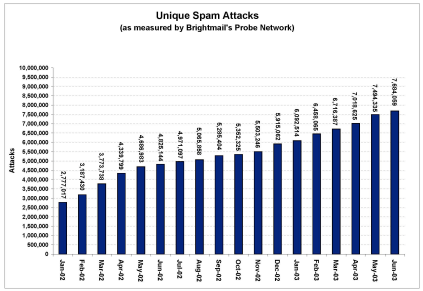


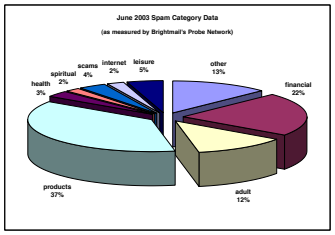
	96	97	98	99	00	01	02	03	04	05
World %age	1	2	3	4	7	9	11	13	16	18
English %age	7	13	16	26	34	41	43	46	49	53











The growth rate is staggering, and the number of users has been doubling approx. every 5 years.

Predicted Users

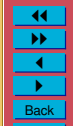
2004 901 Million (16% World Pop., 49% Eng. Pop.)
2005 1030 Million (18% World Pop., 53% Eng. Pop.)
2006 1200 Million (20% World Pop., 55% Eng. Pop.)

Interesting and Useful Uses of The Internet/WWW

Current day uses of the Internet/WWW include:

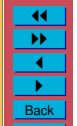
Personal usage

- Recreation — Hobbies, entertainment, sport, culture
- Shopping
- Personal finance and investment
- Travel planning
- Health, fitness
- Legal Advice



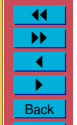
Business

- Advertising
- Telecommuting — working from home, mobile
- Transactions — selling items, buying.
- Information on competitors



Education

- Online Courses — support, distance learning
- Large source of information
- NASA Online: Schools project worldwide.
- University/School Information — advertise, attract students



Searching the WWW

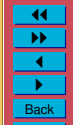
The WWW is vast

- need search tools to make senese/utilise the WWW

Powerful search engines developed:

- Macintosh OS X — Sherlock: Multiple Searches
- Macintosh OS X — Safari Web Browser: Built in Google Search
- Google — www.google.com
- Alta Vista —www.altavista.com
- Yahoo — www.yahoo.com
- Excite — www.excite.com
- Lycos — www.lycos.com
- Many More Ways to Search.

Tutorial Next Week



Anatomy of the Internet

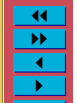
Internet Components and Technologies

What's It Made Up Of?

- Networks connected together
- In total (2003) 150 Million Computers connected to Internet.
- Different types of Networks (Local Area Networks (LAN), Wide Area Networks).
- Different types of connections to the Internet (Individual, Gateways *etc.*)
- See Lecture 3 for more detail on such matters.

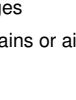
Who Pays for It?

- No one pays for "it" i.e. as a whole.
- Everybody pays for their part
  - Government pays for JANET and SUPERJANET.
  - NSF pays for NSFNET.
  - NASA pays for NASA Science Internet.
  - Businesses pay for connection to some regional network, which in turn pays a national provider for its access.
  - Individuals pay for connection through internet providers.



Internet Providers

- Universities
  - Joint Information Systems Committee (JISC)
  - Set up LAN (EtherNet)
  - Set up local DNS host
  - Attach via *router* to JANET/SuperJANET
- Large User
  - large-scale Internet Provider
  - Set up local net
  - Set up local DNS host (or use Provider's)
  - Attach via *router* or *gateway* to Provider's network
    - leased line
    - Integrated Services Digital Network (ISDN) or Asymmetric Digital Subscriber Line (ADSL) fast connections

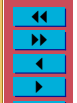


Examples of Internet Providers

- AOL (UK) —www.aol.co.uk
- BT — www.btopenworld.com, www.btbroadband.com
- Freeserve —www.freeserve.co.uk
- Demon — www.demon.net/
- Pipex — —www.pipex.com
- Many Others nowadays

Public Internet Access

- CyberCafes
- Libraries
- Airport Lounges
- Even some trains or airplanes (if you can afford it?)



Technologies/Tools of the Internet

There are four basic technologies on which the Internet is based:

E-mail — allows users to send messages to each other.

Telnet — allows users to connect and user computers directly on the Internet.

FTP (File Transfer Protocol) — allows users to connect to a remote computer for the *sole purpose* of uploading/downloading files.

World Wide Web (HTTP/HTML) — Binding of above technologies + a lot more.
Supports the user friendly (easy) access to all forms of media (text, graphics, sound, video *etc.* in a hypertext framework.
Special programs, *Browsers*, are required to access and use the WWW (*e.g.* Explorer,Safari, Netscape).

We concentrate on these four protocols in this course

Other tools developed to extend Internet functionality include:

Listserv — (E-mail list server) Discussion of common interests via E-mail.

USENET — News Groups. Discussion of common interests via a specialised medium.

Archie — search engine for FTP.

WAIS (Wide Area Information Server) — A popular way to search large bodies of electronic information. Key word search. Forerunner of WWW.

Gopher — the first user friendly interface for the Internet. Another important forerunner to the WWW and WWW browsers.

Archie, WAIS Gopher largely obselete now. USENET not as popular as Listserv these days?

Why is the Internet Important to Your Degree?

During your three years at Cardiff the Internet and its use will play a very important and ever increasing role in your education:

E-mail — The departments main means of communication between:

- Staff-Staff
- Staff-Student
- Tutor-Student
- Student-Student

Listserv/Newsgroups — Newsgroups contain a lot of technical detail and also discuss common problems, solutions etc.

Whilst not a major component of this course you are strongly advised to investigate email and news groups.

WWW — Extensive and increasing use of the WWW is made by the department. Some examples include:

- General Department and Course Information
  - General Information. (URL http://www.cs.cf.ac.uk)
  - Computer and Software documentation
  - Maps of Buildings.
- Student Information.
  (URL http://www.cs.cf.ac.uk/Department/student.html)
  - Staff lists,
  - E-mail lists, searchable E-mail addresses
  - Personal Tutor lists,
  - Laboratory timetables,

WWW (Cont)

- Lecture notes and Lecture support material.
  (URL http://www.cs.cf.ac.uk/Teaching)
  - Course information, reading lists, timetables.
  - Downloading of computer material, programs, printable lecture course notes, exercises, solutions *etc.*
  - For example the Intenet Computing Web Pages:
    http://www.cs.cf.ac.uk/Dave/Internet/
- Personal use for individual projects and coursework.
- Searching the WWW for all kinds of Information.
- Downloading files from all over the WWW.
  - Software
  - Software Updates
  - Web pages
  - Data Files — Text, Graphics, Spreadsheet ...
  - Multimedia Files – Audio, Video, Flash

WARNING University *Big Brother* is watching/monitoring you

Don't engage in *illegal* activities:

- Censored — Video, Picture or Text
- Copyright – MP3s, Pirate Software/Videos, Copyright Text/Graphics Material
- Abuse of University Resources
- Plagiarised Materials for courseworks – If material legitimately used of web then cite/reference in coursework.

Students have been caught and action taken against them

Why is the Internet Important to Your Degree? (Cont.)

FTP — an easy way to transmit files directly to another computer.

- In **this course** you may need to upload files/programs from the Macintosh computers or from Home Computer to University Web Space
- In **other courses** you may need to upload files/programs from Dept. PCs (or Home Computer) to a more permanent location on the Dept Unix machines.
  PC data may be lost after Computer Reboot. Unix files regularly backed up.
- FTP is still a very convenient way to do this although from University Macintoshes UNIX file system can be mounted directly on desktop
- From outside university Secure FTP (SFTP) MUST be used. Make sure your FTP client program supports SFTP.
- All common Web Browsers support some form of FTP but not always SFTP.

Why is the Internet Important to Your Degree? (Cont.)

Telnet

- Telnet is useful for direct (text only) contact to another machine.
- Whilst this is not as useful as it once was due to the WWW. There are still some uses for Telnet.
  - Some old systems/programs still exist.
  - Text access is a lot faster if that is all that is required. For example,
    - connecting to a computer over a slow internet connetion, perhaps just to read email.
    - configuring files preferences on web server (We need to do this in this course later)
  - Can be used a terminal window on a remote host. Many machines still have command line based windows (Unix, Mac OS X and MS-Dos terminal windows are still used).
  - If connecting from outside University to Dep, Machines (UNIX/Mac OS X) you need to use Secure Shell (SSH)

Clients.

Networks — How the Internet Works

"The Internet is a Network of Networks" — Thus in order to gain an understanding of the Internet we need to define:

- What a simple network is.
- How computers communicate over a network.
- The need for a variety of protocols to govern communication.
- How we connect networks together.

What is a Network?

A network can be:

- as simple as two computers connected together, or
- as complex as 150 Million connected together (The Internet).

Other devices can be connected to a network:
For example, printers, disk drives, terminal server and communication servers.
Computers can and will be of a different type

Thus, over a network, resources can be shared.

For a company (or university) this can

- maximise use of resources (share expensive computers, color printers), and
- all sorts of information (programs, data *etc*) can be easily exchanged or shared (over Email, Ftp, Telnet, Local network sharing — file servers).

Departmental Networks

Many computer networks exist in this department.
We have local networks of

- Unix/Linux Workstations (Research and Teaching Labs)
- Macintosh Power PCs (Multimedia Lab)
- IBM compatible PCs (Two Teaching Labs)
- Specialist machines (Parallel Computers, GRID computers, High performance Graphics).

Many of these computers (UNIX, PC, Mac Labs) all exist on a local (individual) network that share local printer resources.

However, they all connect to a large department layer of network and even to the Universities network before going onto the Internet.

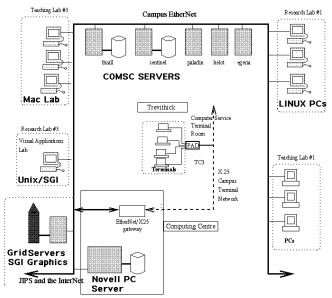


Figure 2: Department Local Networks and Internet Connectivity

(*This picture may be a little out of date w.r.t. computer resources but the network is still accurate)*

Communication — Protocol

The need for a protocol

A set of rules is needed for any means of communication:

- Human intercommunication (in pairs or larger groups) requires rules of conversation (do not speak if someone else is speaking) to function effectively.
- Computers are no different.
  Consider the following simplistic analogy:
  - Two computers connected via a single connection — Imagine two people talking via two tin cans connected via piece of string:
    If the two people talk at the same time then we get what is known (in networking terms) as *data collision*.

Protocols (Cont.)

- For any inter-computer communcation, we need regulations and rules to how we communicate over a computer network.
  For example to remote login (telnet), FTP, email, access web pages (HTTP, CGI)
- The set of rules and regulations is called a *Protocol*.

What exactly does an Internet (Network) Protocol do?

A network protocol has to define how:

- all the operations within a network, *and also*
- how entities outside the network must interact.

Typical network protocols define:

- How data gets from point A to Point B
- How computers and devices communicate, For example:
- How a file is printed on a printer
- How data is transmitted over a telephone line.

The Client Server Model — Another view of the Internet

We can to distinguish between computers that

- access information and
- provide information.

A computer can be either of both at the same time.

Client Server Definitions

The Internet is made up of **client** computers which can access information and **servers** which sort and distribute information.

- A program becomes a *client* when it sends a request to a server a awaits a response. The client runs on the computer you are using. It facilitates your access to information provided by the server.
- A *server* is a program that offers a service that can be obtained over the network.

Client Examples

Examples of Clients

- WWW Clients: Internet Explorer, Netscape, Safari, Opera.
- Email Clients: Mail (Mac OS X), Eudora, Pine, Elm, Outlook Express
- FTP Clients: Fetch, Interarchie, MacSFTP, Transmit (Mac SFTP) Anarchie, xftp, Unix FTP.
- Telnet Clients: Terminal (Mac OS X), Unix Telnet, NCSA Telnet.
- News: NewsWatcher, News Xpress, Free Agent

Server Examples

A server is typically a powerful computer capable of handling information requests from many clients simultaneously.

How requests per minute do heavy web servers require?

- Google
- BBC News Web Page
- Cardiff University Web Server
- Your own web server?

Clearly different computer requirements in terms of power required to deliver an effective web service.

Sending Data over the Internet

How is data send over the Internet?

- **The same basic mechanism is used for all internet communication.**
- Governed by *Low Level* TCP/IP (Transmission Control Protocol and Internet Protocol)
- Large Data broken into smaller packets
- Packets sent to destination not necessarily all through same route.
- Packets need to sent securely
- Packets need to be assembled at client.

Packets

Need for Security?:

- Recall: Historical Origins of Internet was Military (1960 Cold War)
- Military Needed to protect against enemy interception.
- Security Strategy:
  - Break Data up in small **packets** — send packets via different routes
    So if parts of message intercepted hopefully not all message is understood
  - Encode via some cryptography each message/each packet
    Enemy need to break to code as well as gather enough packets?

Packets (Cont.)

Public Internet No Longer Used for Military Purposes

Need for Security Today?:

- These days we are more concerned with commercial and personal security
  - protect our online credit card/financial details
  - protect commercially sensitive information
  - protect personal private information

Basic Packet Sending

- The information coming from one computer is broken up into **packets** — Small portions of the whole data.
- Each Packet marked with:
  - Source and destination addresses
  - Packet length
  - Packet position in whole data
  - Time to live
- The packets of information travel along the links and are guided to their eventual destination by **routers** which looks at the destination address and decides the best route to send them.
- Packets collected at the other and reassembled.

More on packet structure later when we know more about networks

Computer Networks

The Internet is a Network of Computer Networks.

So Let us briefly study how Computer Networks are configured and how they work.

Classifying Networks

There are two basic ways in which we can classify networks:

- How they operate — **type of connection**.
- How they are configured — **Topology**

Network Connections

Switched Networks

There are two types of networks

- **circuit switched**
- **packet switched**

Circuit Switched Networks

- Dedicated connection is established between two stations
- Advantage: guaranteed capacity - once a circuit is established, no other network activity will decrease the capacity of the circuit
- Disadvantage: cost - circuit costs are fixed, independent of traffic
- An example is the Telephone System
- If you dial into to an internet provider then you have a dedicated circuit switched initial connection to the internet
- Some business (e.g. International Recording Studios) create dedicated ISDN/ADSL links so that performers can record either side of the Atlantic, for example.

Packet Switched Networks

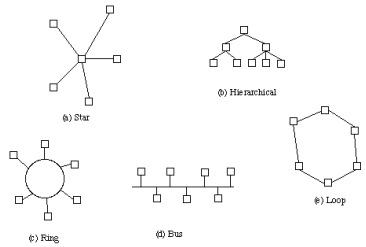
- Network traffic is divided into small *packets*, usually a few hundred bytes in size
- Advantage: concurrent connections among computers can exist
- Disadvantage: as activity increases, a given pair of communicating computers receives a smaller share of network capacity
- Another advantage: Since multiple machines can share a network, fewer interconnections are required
- **Internet is comprised predominantly of packet switched networks**

Network Topologies

Connecting two computers together is a straightforward task — Simple Point-toPoint

However, connecting several computers together is different.

- They can be connected in a variety of ways:



- Many of these topologies exist on Internet.

Advantages/disadvantages of each method of connection

- Star, Hierarchical and Loop configurations are all **point-to-point** topologies:
  - Each computer communicates directly with its neighbour.
  - Relies on Neighbour to rely data around network.
  - Problems if on computer fails.
  - Star extreme example as a central computer is present. If this fails ....
- Bus and Ring configurations are called **broadcast** topologies.
  - A message is placed on the bus or ring containing the name of the intended receiving computer.
  - All computers listen constantly.
  - If name identified by listener, message is captured.
  - Only one node can broadcast at a time: Needs a Protocol.
  - Bus and Ring Topologies very common.

Data Transmission

Having "wired" up our networks — How does data get sent down the "wires"

What considerations/implications of transmission medium?

- Interference — Electro-Magnetic Noise, Radio/Satellite Transmission
- Physical Limitation — Speed of Transmission through Wires, Optical Cables, Radio/Satellite
  - Governs Amount/size of Packets that can be send in given time
  - Governs amount of data that can be sent PERIOD — **Bandwidth** Limitation.

The Physical Design Layer — Wire, Optic Transmission

Using wire to transmit signals has been around since the telegram.

However, there are problems with this medium.

- A signal pair of wires can carry (send and receive) telephone conversation for some distance but suffer from
  - Electromagnetic interference (EMI) — noise *etc*
  - Crosstalk — interference of the two signals.
- Twisted pairs —- Twist wires together
  - reduces EMI and Crosstalk.
  - Used in telephones.
  - Can carry several simultaneous telephone conversations (100 voice channels).

- Coaxial cables — Place one wire inside another conductor separated by an insulator.
  - Superior rejection of EMI and Crosstalk.
  - Can support 10,000 analog voice channels
- Fibre-optic cables — one or more very thin (human hair thickness) glass rods.
  - Very little outside interference.
  - Can carry very large amounts of data (several gigahertz)
  - For example, laser light modulation carries data at 140 million bits per second. Best telephone rates 56,000 bits per second.

Bandwidth

As we shall see later in the course, the modern forms of media (digital audio and video, as well as fancy graphics) place a huge burden on the amount of data needed to be transmitted around the Internet (esp. World Wide Web).

Bandwidth is the amount of information or data that can be transmitted from one end of the medium to the other in a given time.

Clearly the design of the physical layer plays a fundamental role in the amount and hence speed of data transmission.

We will look at implications of this much later in the course.

Larger Networks of Computers

Local Area (LAN) and Wide Area (WAN) Networks

When we connect computers together they reside and communicate over some physical location(s).

- Many times a lab or office will be locally networked together
  - perhaps a single **gateway** to the outside Internet.
- Many times computers will connected together on a single network over a larger area.
  - For example the Cardiff University Campus Wide Network
  - Still a single **gateway** to the outside Internet.
- Clearly range and medium of connectivity affect Network Charateristics.

Recall this Picture

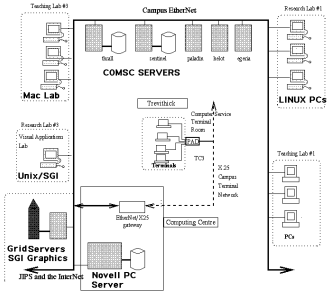


Figure 3: Department Local Networks and Internet Connectivity

Local Area Networks — LANs

- LANs can link several computers in a single building.
- The LAN can then itself be linked to other LAN's.
- The Internet is made up of thousands of LAN's.
- Provide the highest speed connections among computers
- Cannot span large distances
- Typical LAN spans small building and operates between 4 Mbps and 2 Gbps
- Usually bus based (Ethernet) networks.

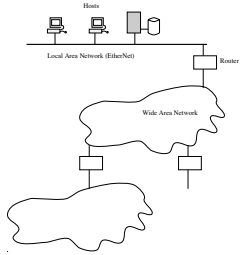


Figure 4: Local Area Connect to Wide Area Networks

Wide Area Networks — WANs

- Sometimes called long haul networks
- Allow endpoints arbitrarily far apart
- Intended for use over large distances
- Operate at speeds from 9.6 Kbps and 45 Mbps

A more formal look a Network protocols

A Model for all Protocols?

As we will shortly see there very many Networked and Internet Protocols:

- Each client application/server needs to communicate in a slightly different way.
- However, the basic transmission mechanism is same for all:
  - prepare data for transmission — encode, packetise etc.
  - send data — set destination and route to it
  - Server/Client recieves data and reassembles and prepares for viewing

Conceptualise these processes into a MODEL for all Network Communications

The OSI 7 Layer Model for Network Protocol

As we have pointed out already:

- There is a real need for a communication protocol to established for any process.
- There is clearly a need for a *standardised* protocol in the global context on networking — otherwise the Internet could not exist in its current form.

Therefore:
Networking protocols need to be established from the low level computer communication all the way up to how application programs communicate.

- There clearly several process or steps from low level computer communication to application programs
- Each step in this protocol is called a layer.

The OSI 7 Layer Model for Network Protocol (CONT.)

The International Standards Organisation (ISO) defines a 7 layer model for network communication protocol.

The model is more formally called the Open Systems Interconnection (OSI) model.

All Network Protocols should adhere to the Model:

- Not all levels always need to be supported
- depends on nature/level of application

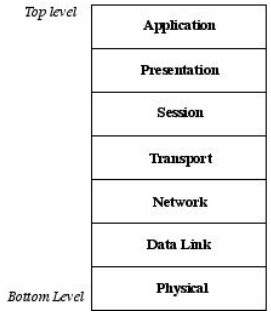
Advantages of the 7 Layer Model Design Approach?

The advantage of breaking down the protocol into layers is twofold:

- Each layer can be regarded as a *black box*.
  - Well defined inputs and outputs exist, **but**
  - The Inner workings of the layer can be regarded as being independent
  - **Thus**, New versions, updates or better methods can be written without affecting the whole system.
  - Network is *Future Proofed* to a great extent.
  - Benefits passed on to whole network.
- Communication need only take place at the layer appropriate for the task.

The 7 Layer s of the OSI Model

The 7 layers must be organised in the specified order:



The Bottom 3 Layers

The function of each layer (from bottom to top) is:

Physical — The interface between the medium and the device.
The layer transmits bits (ones and zeros) and defines how the data is transmitted over the network, what control signals are used and the mechanical properties of the network (Cable size and connector for example.)

Data Link — Provides low-level error detection and correction.
For example if a packet is corrupted this layer is responsible for retransmitting the packet.

Network — Responsible for routing packets of data across the network.
For example, a large email file will be divided up into packets, each packet addressed and sent out at this layer.

The Top 4 Layers

Transport — An intermediate layer that higher layers use to communicate to the network layer.
This layer hides the complexities of low-level networking communication from the higher levels.

Session — The User's (transparent) interface into the network.
The layer manages the "current" connection (or session) to the network. Note: In packet-switched network a full-time network connection does exist, even though it may seem so. The Session layer keeps the communication flowing.

Presentation — Ensures computers speak the same language.
They convert text to ASCII or EBCDIC form and also encode or decode binary data for transport.

Application — The programs you use directly may need to communicate.
E.g a file transfer, email program or web browser

Some Example (Local) Network Protocols

Token ring — low level network message passing protocol.

Media Access Control (MAC) — A protocol that defines the way workstations gain access to transmission media, most widely used in reference to LANs. For most LANs, the MAC layer is the lower sublayer of the data link layer protocol (Layer 2).

Carrier sense multiple access/collision detection (CSMA/CD) — In this protocol, stations listen to the bus and only transmit when the bus is free. If a collision occurs, the packet is retransmitted after a random time-out. CSMA/CD is used in Ethernet.

Network File System (NFS), External Data Representation (XDR) and **Remote Procedure Call (RPC)** — Work together to enable transparent access to remote network resources

X Windows — Serves as a distributed windowing and graphics system used for communication between X terminals and UNIX workstations (Sun, Dec, Linus, Mac OS X ..). Works across any network (incl. Internet).

Some More Example Network Protocols

Finger — Obtains information about a user from their profile.

Whois — Obtains information about domain registration.

Daytime - Network Time Protocol — The daytime protocol retrieves the current day and time.

Simple Network-Management Protocol (SNMP) —- Primarily reports anomalous network conditions and sets network threshold values

Some Example Low Level Internet Protocols

Transmission Control Protocol/Internet Protocol (TCP/IP) — The low level protocol: Basis of all Internet data transfer

Internet Control Message Protocol (ICMP) — a network-layer Internet protocol that provides message packets to report errors and other information regarding IP packet processing back to the source.

Common Gateway Interface (CGI) — How web forms and other means of web input communicate with special programs that process data on Web Servers.

Interior Gateway Protocols (IGPs) — How networks communicate with wider WWW.

Border Gateway Protocol (BGP) —How networks communicate with wider WWW.

Some More Example Low Level Internet Protocols

Internet Router-Discovery Protocol (IDRP) — Router Govern how packets will get delivered across the web

Point-to-Point Protocol (PPP) — Governs how "dial-up" connections communicate with WWW.

Serial Line IP (SLIP) — Older "dial-up" Protocol.

User Datagram Protocol (UDP) — Alternative to TCP.

Some Example Internet Protocols Application Layer Protocols

Telnet — Serves as a terminal emulation protocol

Domain Name System (DNS) — Translates the names of network nodes into network addresses

File Transfer Protocol (FTP) — Moves files between devices

Secure File Transfer Protocol (SFTP) — encrypted file data transfer

Simple Mail Transfer Protocol (SMTP)

Post-Office Protocol version 3 (POP3), IMAP — email protocols

Network News (Groups) Transfer Protocol (NNTP) — Govern how news group data is distributed.

Hypertext Transfer Protocol (HTTP) — Basis of Nearly all WWW Comms

HTTPS — encrypted Hypertext Transfer Protocol. Should used for all commercial and other secure Web transactions of data.

NOTE: We will meet and study many of these protocols in coming lectures

Summary: OSI Model and Internet Protocols