COMP1200 - Perspectives on Computing

These slides were based on those of C Johnson, E McCreath and W Liang.

Outline

- Networks
  - Classifications
  - Topologies
  - Protocols
- The Internet
  - Addressing
  - Applications
  - Protocols
  - Security

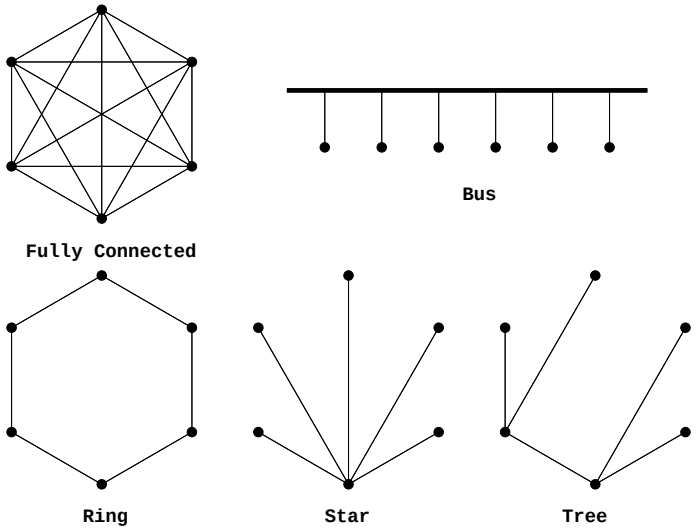
Networks

- A network is a number of computers linked together so that data can be transferred between machines
- Computers can exchange messages and share resources such as
  - printing capabilities
  - software packages
  - data storage
- The Internet (note the I) has become the most extensive network for computers to communicate across the world

Network Classification

- Local Area Network (LAN)
  - computers in a single building/institution e.g. ANU
- Metropolitan and Wide area Networks (MAN and WAN)
  - computer networks that span larger areas
- Open Network
  - internal operations based on designs that are in the public domain e.g. the Internet
- Closed/Proprietary Network
  - privately owned e.g. developed by IBM

Network Topologies



Network Protocols

- Protocols are the rules by which network activities are conducted
  - e.g. transmitting messages around a network
- Token Ring Protocol
  - transmit messages in one direction around the ring
  - when the message reaches its destination, a copy is taken and the message is forwarded on
  - when the message reaches its starting point, the message is removed from the ring

Token Ring Protocol

- The token ring protocol relies on inter-machine cooperation
- Machines are not permitted to send any message they want
- A unique bit pattern (token) is passed around the ring
- Possession of the token allows a machine to transmit its own messages
- Without the token only forwarding is allowed
- When the message completes its cycle the machine forwards the token to the next machine

Carrier Sense, Multiple Access with Collision Detection (CSMA/CD)

- Used in bus topology networks
- Each message is broadcast to all machines on the bus
- Machines monitor all messages but keep only their own
- To transmit a message, a machine waits for no activity
- If two machines transmit at once, they both wait for a random period of time before trying again

Ethernet

- Ethernet is a set of standards for implementing a LAN with a bus or star topology
- Ethernet has become one of the most popular standards for transmitting data between computers on a LAN
- Ethernet will transmit data at either 10 or 100Mbps

Combining Networks

- Sometimes it is necessary to combine networks into larger ones
- This is achieved by means of different devices
- Repeater
  - connects two buses
  - passes messages back and forth without considering their meaning

Combining Networks

- Bridge
  - connects two buses
  - passes messages across the connection only if that message is destined for a machine on the other side
- Switch
  - connects more than two buses
  - when connected they look like spokes on a wheel
  - passes messages only to the spoke that contains the machine that a message is destined for

Combining Networks

- Sometimes, networks that have incompatible characteristics must be connected
  - A ring network using the token ring protocol
  - A bus network using CSMA/CD
- Build a network of networks called an internet
- The individual networks maintain their individuality
- Connection is handled by a machine called a router
- It's task is more significant than a bridge or repeater

Interprocess Communication

- This is the communication between processes on a machine within a network in order to coordinate their actions and complete their tasks
  - Client/Server Model
    - a process that makes a request is a client
    - a process that satisfies the request is a server
    - e.g. a print server
    - e.g. a file server

Interprocess Communication

- Peer-to-Peer Model (P2P)
  - involves two processes communicating as equals
  - both processes execute on a temporary basis
  - e.g. instant messaging
  - e.g. computer chess

Distributed systems

- These consist of software units that execute as processes on different computers
  - global information retrieval systems
  - company-wide accounting and inventory systems
  - computer games
- The machines on which they reside are called hosts

The Internet

- Originated from research projects in the 1960's
- The aim was to develop the ability to connect a variety of networks
- The Internet can be viewed as a collection of domains
- A domain is a network or small internet operated by a single organisation

The Internet

- Establishment of domains is overseen by the Internet Corporation for Assigned Names and Numbers (ICANN)
- To establish a domain you need to register via a registrar
- Attach a registered domain to the Internet via a router
- A domain's router is called a gateway

Internet Addressing

- An internet must be associated with an internet-wide addressing system that assigns an address
- This is the Internet Protocol (IP) address
- An IP address has 32 bit and comes in 2 parts
  - The Network Identifier
    - identifies the domain in which it resides
  - The Host Address
    - identifies the particular computer within the domain

Internet Addressing

The string

10010110110001011011000110000100 0

is the same as

150.203.99.8

which is the same as

www.anu.edu.au

This unique mnemonic address is the domain name

Internet Applications

- Electronic Mail
  - All mail goes via a mail server
  - Email address is usually user@mailservername
- The File Transfer Protocol
  - FTP is a client/server protocol
  - transfers files across the Internet
- Telnet and SSH
  - Allows computer access from a great distance
  - Telnet is not encrypted - passwords are not secure
  - Secure Shell (SSH) fixes this problem

The World Wide Web

- Multimedia information is disseminated over the Internet using hypertext
- hypertext originally meant text documents that contain links to other documents
- Sometimes use hypermedia - to include video, audio, images etc.
- Portions of a document are linked to other documents forming an intertwined web of related information
- This web is the World Wide Web, WWW, W3, The Web, The Net, . . .

Web Implementation

- Software packages that allow access to hypertext are either browsers (clients) or web servers (servers)
- Documents are transferred between browsers and web servers using the Hypertext Transfer Protocol (HTTP)
- Each document is given a unique Uniform Resource Locator (URL)

http : //cs.anu.edu.au/students/comp1200/lectures/lectures.html

HTML

- Hypertext documents are written using Hypertext Markup Language (HTML)
- Files contain text and tags
- Tags are used to say
  - how text is to be displayed
  - which multimedia resources to include
  - which other documents there are links to
- The file encoded into HTML is called the source code

HTML

```
<HTML>
<HEAD>
<TITLE>My Title</TITLE>
</HEAD>
<BODY>
<CENTER><H1>My Heading</H1></CENTER>
This is some text<BR>This text appears on a new line<BR>
<A HREF="anotherpage.html">This text links to another page</A><BR>
<CENTER><IMG SRC="mypicture.jpg"></CENTER>
</BODY>
</HTML>
```

HTML

My Title

My Heading

This is some text
This text appears on a new line
This text links to another page

eXtensible Markup Language

- A standardised style for representing notational systems for representing data as text files
- Notational systems (called markup languages) have been developed for representing
  - Mathematics, Multimedia presentations, Music, ...
- HTML is based on the XML standard for representing web pages
- Since HTML was invented before XML we use XHTML to refer to HTML that conforms rigorously to XML standards

Internet Protocols

- A layered approach to Internet software
- Principal task of networking software is to provide an infrastructure for transferring messages
- Internet software has 4 layers of routines
  - Application layer
  - Transport layer
  - Network layer
  - Link layer

Internet Protocols

- Messages originate in the application layer
- They are passed through the transport layer and the network layer
- They are transmitted by the link layer
- The target machine receives the message via the link layer
- The message is then passed up though the network layer and the transport layer to the application layer

Internet Protocols

- Application layer
  - Software units that use Internet communication to carry out tasks
  - Responsible for providing an address for the message that is compatible with the transport layer

Internet Protocols

- Transport layer
  - Ensures messages are properly formatted for transport
  - Divides message into small segments
  - Adds sequence numbers to each segment (so that it can be re-assembled later)
  - Attaches addresses to each segment (packet)
  - Passes the packets to the network layer

Internet Protocols

- Network layer
  - Responsible for forwarding the packets it receives from one network to another
  - If the destination address is within the current network, it sends the packets to that address
  - Otherwise it sends them to a router in the network
  - Once it knows where to send the package, it appends this intermediate address to the packets and passes them to the link layer

Internet Protocols

- Link layer
  - sends the packets to the intermediate address
- The message is received by the link layer and passed to the network layer
- If the destination address is not local it is passed to the link layer with a new intermediate address
- If the packets have reached their final destination, they are passes to the transport layer
- The transport layer re-assembles the packets and passes the message to the application layer

TCP/IP

- The TCP/IP protocol suite is a collection of protocols used to implement the 4 level hierarchy
- TCP = Transmission Control Protocol
- IP = Internet Protocol
- There are many more
- TCP defines a version of the transport layer
- The User Datagram Protocol (UDP) also defines a version of the transport layer

TCP/IP

- Two basic differences
  - TCP sends its own message before sending packets
  - TCP transport layers at origin and destination communicate to ensure all packets have been sent correctly
- IP is the Internet's standard for the network layer
- A hop-count is appended to each packet
- This limits the number of times a packet can be forwarded
- 32 is usually enough

Security

- A computer connected to a network is subject to unauthorised attack
- Usually by malicious software (malware)
  - Virus
    - Software that insert itself into a program
    - Corrupts data or other programs
  - Worm
    - Transfers itself though a network
    - Forwards copies of itself to other computers
    - Can ultimately overload an entire network

Security

- Trojan Horse
  - Disguises itself as something useful and is willingly imported via email attachment
  - May lay dormant for a specific period
- Spyware
  - Collects information about a computer
  - Reports this back to the instigator
- Phishing
  - A way of obtaining information by asking for it
  - Usually via email

Security Protection

- Firewall
  - Installed at gateway
  - Blocks incoming messages with origin addresses within the domain
- Spam Filter
  - Firewall designed to block unsolicited email
- Proxy Server
  - Acts as an intermediary between client and server
  - Use for Ftp, Telnet, etc.

Security Protection

- Anti Virus software
  - Must be routinely updated
- Encryption
  - Passwords may be compromised
  - Examples of encryption include
    - FTPS
    - SSH
    - HTTPS
    - Public-key encryption

Reading and Self Assessment

- Required reading:
  - Chapter 4, sections 1, 2, 3, 4 and 5.
- Questions:
  - 4.1 : 1, 2, 3.
  - 4.2 : 1, 2, 3.
  - 4.3 : 1, 2, 3.
  - 4.4 : 1, 2, 3.
  - 4.5 : 1, 2, 3.

Algorithms

- "The study of algorithms is the cornerstone of computer science"
- An algorithm is a set of steps that define how a task is to be performed
  - e.g. consider the machine cycle
    - as long as the halt instruction has not been executed, continue to do the following steps:
      - fetch an instruction
      - decode the instruction
      - execute the instruction

Algorithms

- Formal Definition:
  - An algorithm is an ordered set of unambiguous, executable steps that defines a terminating process
- The set of steps must be ordered
- The steps must be executable
- The steps must be unambiguous
- The algorithm must define a terminating process
- The term 'algorithm' is often used to represent steps that don't necessarily define a terminating process

Algorithms

- An algorithm and its representation are distinct
- An algorithm is abstract from its representation - an algorithm may be represented in many ways
  - $F = \frac{9C}{5} + 32$
  - Multiply the temperature in Celsius by 9; divide this by 5; then add 32
- A program is a representation of an algorithm
- A process is the activity of executing an algorithm

Primitives

- The representation of an algorithm requires some form of language
- Problems are caused when
  - the language is not clearly defined
  - information is not given in adequate detail
- Computer Science establishes a well defined set of building blocks (primitives) from which algorithm representations can be constructed

Primitives

- Assigning precise definitions to primitives removes ambiguity
- Requiring algorithms to be described in terms of these primitives establishes a uniform level of detail
- A collection of primitives along with rules that state how they can be combined to construct more complex ideas constitutes a programming language

Primitives

- Primitives come in two parts
  - Syntax
    - refers to the primitive's symbolic representation
  - Semantics
    - refers to the primitive's meaning
- Algorithms are usually represented by a collection of "high level" primitives
- These are formed from the "low level" primitives in the machine's language
- The result is a formal programming language

Pseudocode

- Pseudocode is something less formal than a programming language
- Pseudocode is a notational system in which ideas can be expressed informally during the algorithmic process
- Need to develop a consistent, concise notation for representing recurring semantic structures

Pseudocode

- Saving a computed value
  - $name \leftarrow expression$
  - assign $name$ the value of $expression$
- Selecting one of two possible activities depending on the validity of of some condition (TRUE or FALSE)
  - if ($condition$) then ($activity1$) else ($activity2$)
  - If the $condition$ is TRUE then $activity1$ is performed
  - If the $condition$ is FALSE then $activity2$ is performed

Pseudocode

- The repeated execution of a statement
  - while ($condition$) do ($activity$)
  - Repeatedly do $activity$ as long as $condition$ is TRUE
- In order that the pseudocode may be used as abstract tools in other applications, we define a procedure
  - procedure $name$
- As procedures may be used in different situations we introduce parameters to procedures
  - procedure $sort(list)$

Pseudocode

- The development of a program consists of:
  - Discovering the underlying algorithm
  - Representing that algorithm as a program
- Algorithm discovery is usually the most difficult part
- We would like to reduce the process of problem solving to an algorithm itself
- This has been proven to be impossible as there exist problems that have no algorithmic solution

Problem Solving

- Basic Principles (Polya 1945)
  - Phase 1:
    - Understand the problem
  - Phase 2:
    - Devise a plan for solving the problem
  - Phase 3:
    - Carry out the plan
  - Phase 4:
    - Evaluate the solution (for accuracy and its potential)

Program Development

- Translated into the context of program development, these become
  - Phase 1: Understand the problem
  - Phase 2: Get an idea of how an algorithmic procedure might solve the problem
  - Phase 3: Formulate the algorithm and represent it as a program
  - Phase 4: Evaluate the program (for accuracy and its potential as a tool for solving other problems)

Program Development

- These are not necessarily steps to be *followed* when trying to solve a problem
- These are phases that will be completed sometime during the solution process
- Don't *follow* - Take the initiative and **lead!**
- Phases are not necessarily completed in sequence

How Do You Make A Start?

- Try working backwards
  - If you know what the output should be, maybe you can figure out the algorithm more easily
- Look for a related/easier problem
  - This problem may have been solved already
- Apply step-wise refinement
  - Treat as several sub-problems
  - Approach the overall solution in terms of steps
  - Top-down Methodologies versus Bottom-up Methodologies

How Do You Make A Start?

- You should find algorithms for all instances of a problem (not just one)
- Suppose we are asked to sort some integers into ascending order: 5, 7, 3, 6 for example
- One approach might be
  - Swap 3 with 5 (3, 7, 5, 6)
  - Swap 7 with 5 (3, 5, 7, 6)
  - Swap 7 with 6 (3, 5, 6, 7)
- This is too specific - needs to be more general

Reading and Self Assessment

- Required reading:
  - Chapter 5, sections 1, 2 and 3.
- Questions:
  - 5.1 : 1, 2.
  - 5.2 : 3.
  - 5.3 : 3.