Overview
- Protocol design
- Overview of TCP/IP
- IP addresses and domain names

Network Protocols
- Communication hardware transfers raw data (i.e. a stream of bits)
- Usually more sophisticated instructions need to be sent over networks
- This requires software which needs to follow standards for interoperability
- Protocols are the rules that govern communication on networks
- Protocols are implemented by protocol software

Stacks of Layers
- Protocols are designed according to a layered model
- The protocol software on each computer is divided into modules – each corresponding with a layer
- Each module only communicates with the modules corresponding to the layer above and the layer below
- All the protocol modules on a computer are collectively called a stack or suite
- Network communication requires that the same stack is installed on all computers (though the hardware and OS may be different)

The Layering Principle
- Layer N software on the destination computer must receive the exact message sent by layer N software on the sending computer

Examples of Protocol Stacks

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Stack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novell</td>
<td>Netware</td>
</tr>
<tr>
<td>Apple</td>
<td>Appletalk</td>
</tr>
<tr>
<td>IBM</td>
<td>SNA</td>
</tr>
<tr>
<td>Various (Internet)</td>
<td>TCP/IP</td>
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</tbody>
</table>
Internet Reference Model (TCP/IP)

- Application (LAYER 5)
- Transport (LAYER 4)
- Internet (LAYER 3)
- Network Interface (LAYER 2)
- Physical (LAYER 1)

TCP/IP

- Protocol stack used by the Internet
- Originally designed for DARPA (late 1960’s)
  - Major design features intended for military use
    - Multiple contractors
    - Simple (basic services)
    - Robust - automatic recovery from battlefield damage
  - These same features make the Internet possible
    - Multiple vendors
    - Simple (basic services)
    - Robust - the Internet is not centrally coordinated
- Since early 1980’s TCP/IP has been built into Unix
- Now available for, or as part of all major OS

The Internet

A vast network of networks

Virtual network

- TCP/IP gives illusion that there is a single universal network
- Universal service - any two computers should be able to communicate
  - Hardware: routers connect different networks
  - Internet protocols: provide universal service by creating a single virtual network

IP (Internet Protocol)

- Layer 3 protocol
  - A packet switching protocol
    - Packets of data are routed between nodes with no previously established path
    - Connectionless
  - IP is responsible for moving packet of data from machine to machine
    - IP forwards each packet based on a four-byte destination address (the IP number)
    - The Internet authorities assign ranges of numbers to different organisations
    - Organisations assign their own subsets of numbers to departments
    - IP operates on routers that move data from LANs to WANs and global WANs

TCP (Transport Control Protocol)

- Layer 4 protocol
- Connection-oriented
- Data may be sent in a continual stream between two hosts
- TCP is responsible for verifying the correct delivery of data between machines
  - Detection of errors or lost data
  - Management of retransmission until the data is correct and completely received
  - Assembles packets of data into the correct order without duplication
  - Handles multiplexing
TCP/IP Jargon (1)

- **Host** - any system that connects to an Internet and that runs applications
- **Router** - a device that connects independent networks together to form an internetwork
  - Forwards packets from one network to another
- **Both hosts and routers use TCP/IP protocol software**
- **Sockets** - the API for TCP/IP software (i.e. the library of functions that a program can use to access TCP/IP facilities)
  - For example the Winsock API on Windows

TCP/IP Jargon (2)

- **Host Name**
  - all hosts on a TCP/IP network must have a unique name
  - this may be a single word (on a small network) or follow a hierarchical convention
- **Internet Address (IP Number)**
  - all hosts on the Internet must have a unique identifying number
  - 32-bit number, usually written as 4 bytes separated by dots (e.g. 128.243.20.172)
- **Ethernet Address (Media Access Control, MAC)**
  - a unique number built into each Ethernet subsystem by the manufacturer
  - 6-byte numbers, usually written in hex separated by dashes (e.g. 02-Fe-87-4A-8C-A9)
  - if Ethernet is not used (e.g. over a phone line) then the software stack must provide a MAC

IPv4 Addresses

- **IP number is a unique identifier for TCP/IP**
  - Analogous to telephone number
- **IP numbers consist of 4 bytes (i.e. numbers from 0-255)**
  - This gives a maximum of 255^4 (4,294,967,296)
  - Dotted decimal notation for human readability
    - 128.242.22.17
- **Each 32 bit address is divided into two parts:**
  - prefix: physical network to which the host is attached - the network number
  - suffix: a host attached to a given physical network

IPv6 Addresses

- **New addressing system developed in 1995**
- **The IP version 4 address space is rapidly nearing exhaustion of available address blocks**
  - As of 27 January 2011 predictions of an exhaustion date converge to 1-Feb-2011
- **Uses 128 bits for the address**
  - provides the potential for a maximum of 2^128, or about 3.403×10^38 unique addresses
  - Hexadecimal notation

Special IP Numbers

- **Some IP numbers have special meanings, and so are not normally assigned to individual hosts**
- **Broadcast Address – 255**
  - Listened to by all machines on the network
- **Loopback Network – 127**
  - 127.0.0.1 - loopback address (localhost)
Host & Domain Names

- Domain names are alphanumeric labels assigned to IP numbers
- Each host name on a subnet must be unique
- There is a hierarchy of domain names
  - Top level
    - Country (if not US) – e.g. UK, FR, IE
    - Category - COM, MIL, GOV, EDU, ORG etc (or CO.UK, AC.UK, Gouv.UK, ORG.UK etc)
    - NB domain registration does not necessarily correspond to physical location!
  - Second level
    - Organisation (e.g. NOTT.AC.UK)
  - Third level
    - Subnet (e.g. CS.NOTT.AC.UK)
- Host names may be aliased
- Host names are obtained from databases called nameservers

Domain name conversion

- Fully qualified domain names must be converted to IP numbers before communication can take place over the Internet
  - DNS servers

Summary

- Protocol design
- TCP/IP overview
- IP addresses and domain names