

Lecture 3 TCP/IP & the Internet

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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)

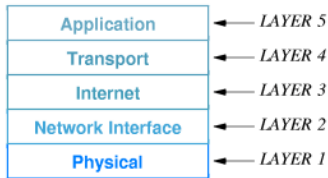
The Layering Principle

- 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

Vendor	Stack
Novell	Netware
Apple	Appletalk
IBM	SNA
Various (Internet)	TCP/IP

Internet Reference Model (TCP/IP)

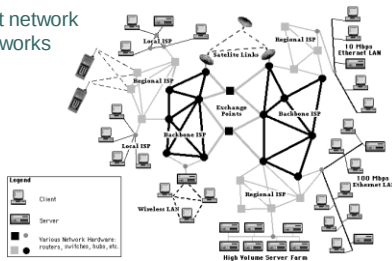


TCP/IP

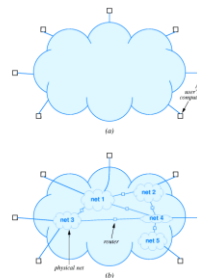
- Protocol stack used by the Internet
- Originally designed for DARPA (late 1960's)
- Major design features intended for military use
 - Multiple contractors
 - Simple (basic services)
 - Robust - automatic recovery from battlefield damage
- These same features make the Internet possible
 - Multiple 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

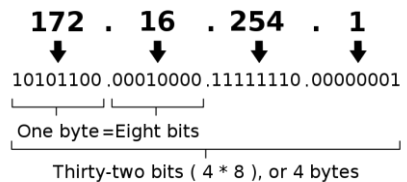
TCP/IP Jargon (2)

- **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

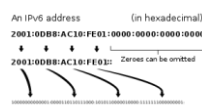
- IP number is a unique identifier for TCP/IP
 - Analogous to telephone number
- IP numbers consist of 4 bytes (i.e. numbers from 0-255)
 - This gives a maximum of 255^4 (4,294,967,296)
 - Dotted decimal notation for human readability
 - 128.242.22.17
- Each 32 bit address is divided into two parts: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

An IPv4 address (dotted-decimal notation)



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

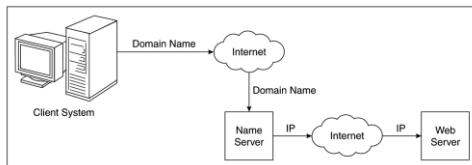
- Domain names are alphanumeric labels assigned to IP numbers
- Each host name on a subnet must be unique
- There is a hierarchy of domain names
 - Top level
 - Country (if not US) – e.g. UK, FR, IE
 - Category - COM, MIL, GOV, EDU, ORG etc (or CO.UK, AC.UK, GOV.UK, ORG.UK etc)
 - NB domain registration 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

IP Numbers and domain names – a Nottingham Example

- JANET (Joint Academic Network)
 - *.uk.ac
 - 128.*.*
- University of Nottingham
 - *.nott.ac.uk (also aliases – e.g. *.nottingham.ac.uk)
 - 128.243.*.*
- Computer Science
 - *.cs.nott.ac.uk
 - 128.243.20.* 128.243.21.* 128.243.22.*
- Marian (Unix server)
 - marian.cs.nott.ac.uk
 - 128.243.21.16

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