Introduction to the TCP/IP protocol suite

- TCP/IP has been around for longer than the ISO OSI 7 layer model
- the ISO OSI 7 layer model is useful as a reference model for explaining the function of data transmission
- practically TCP/IP has won but literature still uses the ISO OSI 7 layer model

ISO OSI 7 Layer model and the TCP/IP protocol stack

- there is not an exact match between the ISO OSI 7 layer reference model and the TCP/IP protocol stack

ISO OSI 7 Layer model and the TCP/IP protocol stack

- line from 5.250,7.250 to 6.500,7.250 line from 5.250,7.750 to 6.500,7.750 line from 5.250,8.250 to 6.500,8.250 line from 5.250,8.750 to 6.500,8.750 line from 5.250,9.250 to 6.500,9.250 line from 5.250,9.750 to 6.500,9.750 box with .sw at (5.250,6.750) width 1.250 height 3.500 dashwid = 0.050 line dashed from 4.750,7.250 to 5.250,6.750 line dashed from 4.750,7.750 to 5.000,7.750 to 5.250,7.750 line dashed from 4.750,8.250 to 5.000,8.250 to 5.250,8.250 line dashed from 4.750,8.750 to 5.000,8.750 to 5.250,8.750 line dashed from 5.250,9.250 to 4.750,8.750 line dashed from 5.250,9.250 to 4.750,9.250 line dashed from 5.250,9.750 to 4.750,9.250 line dashed from 5.250,10.250 to 4.750,9.250 "Application" at 5.500,10.033 ljust "Presentation" at 5.500,9.533 ljust "Session" at 5.500,9.033 ljust "Transport" at 5.500,8.533 ljust "Network" at 5.500,8.033 ljust "Data link" at 5.500,7.533 ljust "Physical" at 5.500,7.033 ljust "ISO OSI 7 Layer model" at 5.250,6.283 ljust "TCP/IP protocol stack" at 2.000,6.283 ljust "1" at 6.750,7.033 ljust "2" at 6.750,7.533 ljust "3" at 6.750,8.033 ljust "4" at 6.750,8.533 ljust "5" at 6.750,9.033 ljust "6" at 6.750,9.533 ljust "7" at 6.750,10.033 ljust line from 0.750,7.750 to 4.750,7.750 line from 0.750,8.250 to 4.750,8.250 line from 0.750,8.750 to 4.750,8.750 box with .sw at (0.750,7.250) width 4.000 height 2.000 line from 2.750,8.750 to 2.750,8.250 "Reliable Stream (TCP)" at 1.000,8.533 ljust "User Datagram (UDP)" at 3.000,8.533 ljust "Internet (IP)" at 2.375,8.033 ljust "Application" at 2.438,9.033 ljust "Network Interface (X25, Ethernet, FDDI)" at 1.438,7.596 ljust

Networking Glossary

- router
  - a special purpose, dedicated computer that attaches to two or more networks and routes IP datagrams from one to another
  - each router forwards a datagram to another router until the datagram reaches its destination

Networking Glossary

- hub
  - an electronic device that connects to several computers and serves as the centre of a LAN, often Ethernet using 100Base-T, 1000Base-T or 10000Base-T wiring

- firewall
  - a security mechanism placed between a company and the Internet to protect the company's computers from attack

Networking Glossary

- hostname
  - the name assigned to a computer

- domain name
  - the name assigned to a computer
  - a name might consist of several words separated by periods (sometime abbreviated to FQDN, fully qualified domain name)

Networking Glossary

- gateway
  - a device used to connect two different networks, especially a connection to the Internet

TCP/IP

- many excellent references on TCP/IP
  - *Internetworking with TCP/IP: principles, protocols and architecture by Douglas Comer* †
  - *UNIX Network Programming* by Richard Stevens, chapter 4

History of TCP/IP and Internet

- part of the excitement about the Internet is its size and growth rate line

from 0.250i,0.250i to 5.250i,0.250i line from 0.250i,0.250i to 0.250i,0.200i line from 0.607i,0.250i to 0.607i,0.225i line from

0.964i,0.250i to 0.964i,0.200i line from 1.321i,0.250i to 1.321i,0.225i line from 1.679i,0.250i to 1.679i,0.200i line from

2.036i,0.250i to 2.036i,0.225i line from 2.393i,0.250i to 2.393i,0.200i line from 2.750i,0.250i to 2.750i,0.225i line from

3.107i,0.250i to 3.107i,0.200i line from 3.464i,0.250i to 3.464i,0.225i line from 3.821i,0.250i to 3.821i,0.200i line from

4.179i,0.250i to 4.179i,0.225i line from 4.536i,0.250i to 4.536i,0.200i line from 4.893i,0.250i to 4.893i,0.225i line from

5.250i,0.250i to 5.250i,0.200i line from 0.250i,0.250i to 0.250i,3.250i line from 0.250i,0.250i to 0.200i,0.250i line from

0.250i,0.379i to 0.225i,0.379i line from 0.250i,0.454i to 0.225i,0.454i line from 0.250i,0.508i to 0.225i,0.508i line from

0.250i,0.550i to 0.225i,0.550i line from 0.250i,0.583i to 0.225i,0.583i line from 0.250i,0.612i to 0.225i,0.612i line from

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0.250i,1.312i to 0.225i,1.312i line from 0.250i,1.365i to 0.225i,1.365i line from 0.250i,1.407i to 0.225i,1.407i line from

0.250i,1.441i to 0.225i,1.441i line from 0.250i,1.469i to 0.225i,1.469i line from 0.250i,1.494i to 0.225i,1.494i line from

0.250i,1.516i to 0.225i,1.516i line from 0.250i,1.536i to 0.225i,1.536i line from 0.250i,1.536i to 0.200i,1.536i line from

0.250i,1.665i to 0.225i,1.665i line from 0.250i,1.740i to 0.225i,1.740i line from 0.250i,1.794i to 0.225i,1.794i line from

0.250i,1.835i to 0.225i,1.835i line from 0.250i,1.869i to 0.225i,1.869i line from 0.250i,1.898i to 0.225i,1.898i line from

0.250i,1.923i to 0.225i,1.923i line from 0.250i,1.945i to 0.225i,1.945i line from 0.250i,1.964i to 0.225i,1.964i line from

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0.250i,2.326i to 0.225i,2.326i line from 0.250i,2.351i to 0.225i,2.351i line from 0.250i,2.373i to 0.225i,2.373i line from

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0.250i,3.208i to 0.225i,3.208i line from 0.250i,3.230i to 0.225i,3.230i line from 0.250i,3.250i to 0.225i,3.250i line from

0.250i,3.250i to 0.200i,3.250i "198" at 0.250i,0.050i "200" at 0.964i,0.050i "202" at 1.679i,0.050i "204" at 2.393i,0.050i "206" at

3.107i,0.050i "208" at 3.821i,0.050i "210" at 4.536i,0.050i "212" at 5.250i,0.050i "10 Years" at 2.750i,-0.150i "1" at 0.112i,0.250i

"10" at 0.075i,0.679i "100" at 0.037i,1.107i "1000" at -0.000i,1.536i "10000" at -0.038i,1.964i "100000" at -0.075i,2.393i

"1000000" at -0.113i,2.821i "10000000" at -0.150i,3.250i "1" "0" "0" " " "h" "o" "s" "t" "s" " " at -0.800i,1.750i ljust "Internet

growth showing years vs. connected hosts" at 2.750i,3.650i line dashed from 0.250i,-0.550i to 0.550i,-0.550i "connected hosts" at

0.950i,-0.550i ljust "Key" at 0.250i,-0.350i ljust line dashed from 0.321i,0.391i to 0.393i,0.391i to 0.464i,0.421i to

0.536i,1.428i to 0.607i,1.585i to 0.679i,1.835i to 0.750i,1.964i to 0.786i,2.027i to 0.821i,2.231i to 0.929i,2.948i to

1.179i,3.121i to 5.107i,3.230i

History of TCP/IP and Internet (continued)

- DARPA was the main funding agency for packet-switched research in the USA DOD
  - began working on the Internet in the mid 1970s
  - design a protocol that would recover if various nodes disappeared
  - DOD had in mind a nuclear war!
  - wanted a nervous system to carry all military information in USA
- by 1980 TCP/IP protocol had been designed
- the physical network was called the ARPANET which consisted of
  - point to point connections
  - packet switching over radio networks
  - satellite communication channels

History of TCP/IP and Internet

- January 1983 DARPA demanded that all computer attach to ARPANET via TCP/IP
  - TCP/IP implementations were available at low cost
  - most (90%) Computer Science departments were running BSD Unix
  - TCP/IP available in source form for BSD systems

- growth
  - 1987 Internet growing at 15% per month (Comer p.6)
  - soon after that it began to double each year!

Moores Law

line from 0.250i,0.250i to 5.250i,0.250i line from 0.250i,0.250i to 0.250i,0.200i line from 0.875i,0.250i to 0.875i,0.225i line from 1.500i,0.250i to 1.500i,0.200i line from 2.125i,0.250i to 2.125i,0.225i line from 2.750i,0.250i to 2.750i,0.200i line from 3.375i,0.250i to 3.375i,0.225i line from 4.000i,0.250i to 4.000i,0.200i line from 4.625i,0.250i to 4.625i,0.225i line from 5.250i,0.250i to 5.250i,0.200i line from 0.250i,0.250i to 0.250i,3.250i line from 0.250i,0.250i to 0.200i,0.250i line from 0.250i,0.379i to 0.225i,0.379i line from 0.250i,0.454i to 0.225i,0.454i line from 0.250i,0.508i to 0.225i,0.508i line from 0.250i,0.550i to 0.225i,0.550i line from 0.250i,0.583i to 0.225i,0.583i line from 0.250i,0.612i to 0.225i,0.612i line from 0.250i,0.637i to 0.225i,0.637i line from 0.250i,0.659i to 0.225i,0.659i line from 0.250i,0.679i to 0.225i,0.679i line from 0.250i,0.679i to 0.200i,0.679i line from 0.250i,0.808i to 0.225i,0.808i line from 0.250i,0.883i to 0.225i,0.883i line from 0.250i,0.937i to 0.225i,0.937i line from 0.250i,0.978i to 0.225i,0.978i line from 0.250i,1.012i to 0.225i,1.012i line from 0.250i,1.041i to 0.225i,1.041i line from 0.250i,1.066i to 0.225i,1.066i line from 0.250i,1.088i to 0.225i,1.088i line from 0.250i,1.107i to 0.225i,1.107i line from 0.250i,1.107i to 0.200i,1.107i line from 0.250i,1.236i to 0.225i,1.236i line from 0.250i,1.312i to 0.225i,1.312i line from 0.250i,1.365i to 0.225i,1.365i line from 0.250i,1.407i to 0.225i,1.407i line from 0.250i,1.441i to 0.225i,1.441i line from 0.250i,1.469i to 0.225i,1.469i line from 0.250i,1.494i to 0.225i,1.494i line from 0.250i,1.516i to 0.225i,1.516i line from 0.250i,1.536i to 0.225i,1.536i line from 0.250i,1.536i to 0.200i,1.536i line from 0.250i,1.665i to 0.225i,1.665i line from 0.250i,1.740i to 0.225i,1.740i line from 0.250i,1.794i to 0.225i,1.794i line from 0.250i,1.835i to 0.225i,1.835i line from 0.250i,1.869i to 0.225i,1.869i line from 0.250i,1.898i to 0.225i,1.898i line from

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0.250i,2.326i to 0.225i,2.326i line from 0.250i,2.351i to 0.225i,2.351i line from 0.250i,2.373i to 0.225i,2.373i line from

0.250i,2.393i to 0.225i,2.393i line from 0.250i,2.393i to 0.200i,2.393i line from 0.250i,2.522i to 0.225i,2.522i line from

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0.250i,2.726i to 0.225i,2.726i line from 0.250i,2.755i to 0.225i,2.755i line from 0.250i,2.780i to 0.225i,2.780i line from

0.250i,2.802i to 0.225i,2.802i line from 0.250i,2.821i to 0.225i,2.821i line from 0.250i,2.821i to 0.200i,2.821i line from

0.250i,2.950i to 0.225i,2.950i line from 0.250i,3.026i to 0.225i,3.026i line from 0.250i,3.079i to 0.225i,3.079i line from

0.250i,3.121i to 0.225i,3.121i line from 0.250i,3.155i to 0.225i,3.155i line from 0.250i,3.184i to 0.225i,3.184i line from

0.250i,3.208i to 0.225i,3.208i line from 0.250i,3.230i to 0.225i,3.230i line from 0.250i,3.250i to 0.225i,3.250i line from

0.250i,3.250i to 0.200i,3.250i "1970" at 0.250i,0.050i "1982" at 1.500i,0.050i "1993" at 2.750i,0.050i "2005" at 4.000i,0.050i

"2016" at 5.250i,0.050i " year" at 2.750i,-0.150i "1" at 0.112i,0.250i "10" at 0.075i,0.679i "100" at 0.037i,1.107i "1000" at

-0.000i,1.536i "10000" at -0.038i,1.964i "100000" at -0.075i,2.393i "1000000" at -0.113i,2.821i "10000000" at -0.150i,3.250i " "

"1" "0" "0" "0" " " "t" "r" "a" "n" "s" "i" "s" "t" "o" "r" "s" " " at -0.800i,1.750i ljust "Processor transistor count vs time" at

2.750i,3.650i line dashed from 0.250i,-0.550i to 0.550i,-0.550i "Moore’s law" at 0.950i,-0.550i ljust "Key" at 0.250i,-0.350i ljust

line dashed from 0.359i,0.379i to 0.467i,0.454i to 0.685i,0.508i to 0.793i,0.454i to 1.228i,0.877i to 1.554i,1.162i to

1.880i,1.295i to 2.315i,1.567i to 2.750i,1.536i to 3.076i,1.807i to 3.185i,1.940i to 3.402i,2.111i to 3.511i,2.231i to

3.837i,2.540i to 3.946i,2.724i to 4.163i,2.592i to 4.272i,2.777i to 4.380i,2.941i to 4.489i,2.803i to 4.598i,2.976i to

4.707i,2.984i to 5.250i,3.250i

History of TCP/IP

- some reasons why
  - reference implementation of TCP/IP in BSD Unix (1983) 4.3 BSD and 4.4 BSD
  - inexpensive microprocessors (1983)
  - inexpensive wide area fiber optic cable - carrying a high throughput of data (1984)
  - deployment of DNS (Domain Name System) (dynamic ASCII to number lookup system)

Internet for the masses

- in early 1990's Tim Berner's Lee was working at CERN and as a bye product of high energy physics was working on document management system
- he created a hypertext markup language which was to become HTML
- HTTP is the protocol which WWW clients and servers obey
- people mistakenly think the HTTP is the Internet

Introduction to TCP/IP

- LANs have developed greatly over the last 20 years
  - there are a large variety of LANs
  - different LANs in different departments and countries
  - equipment can be bought on an incremental basis
  - evolution not revolution - cost savings

- can be really effective if applications can talk to one another across the different LANs
  - companies with different departments can share resources

Introduction to TCP/IP

- one solution is for an operating system to provide this multivendor integration
  - alternatively a standard network protocol could be designed

- Internet Protocol (IP) - so called because it allows communication between LANs

Problems/benefits of TCP/IP

- what problems exist if we want to link up many LANs?
  - unique addressing
  - hardware independent

- obvious benefits of the Internet

TCP/IP Protocol Overview

box with .sw at (0.312,6.875) width 0.688 height 0.438 box with .sw at (1.312,6.875) width 0.688 height 0.438 box with .sw at (2.250,6.875) width 0.688 height 0.438 box with .sw at (3.188,6.875) width 0.688 height 0.438 box with .sw at (1.438,5.938) width 0.688 height 0.438 box with .sw at (0.751,7.749) width 1.000 height 0.750 box with .sw at (2.438,7.749) width 1.000 height 0.750 box with .sw at (0.750,9.000) width 1.000 height 0.750 box with .sw at (2.438,8.999) width 1.000 height 0.750 line <-> from 1.250,9.000 to 1.250,8.500 line <-> from 3.000,9.000 to 3.000,8.500 line <-> from 1.250,7.750 to 1.688,7.312 line <-> from 1.688,7.312 to 2.938,7.750 line <-> from 1.688,6.875 to 1.750,6.375 line <-> from 1.750,6.375 to 2.562,6.875 line <-> from 1.812,6.375 to 3.500,6.875 line <-> from 1.000,7.062 to 1.312,7.062 dashwid = 0.050 box dashed with .sw at (0.625,8.875) width 3.000 height 1.000 box dashed with .sw at (0.688,7.625) width 2.938 height 1.000 box dashed with .sw at (0.188,6.750) width 3.812 height 0.688 box dashed with .sw at (1.250,5.750) width 1.250 height 0.750 "ICMP" at 0.500,7.033 ljust "IP" at 1.500,7.033 ljust "ARP" at 2.438,7.033 ljust "RARP" at 3.250,7.033 ljust "hardware" at 1.500,6.283 ljust "interface" at 1.500,6.033 ljust "user" at 1.000,9.533 ljust "process" at 1.000,9.283 ljust "user" at 2.688,9.533 ljust "process" at 2.688,9.283 ljust "TCP" at 1.125,8.096 ljust "UDP" at 2.750,8.158 ljust "OSI Layers 5..7" at 3.812,9.283 ljust "OSI Layer 4" at 3.750,8.033 ljust "OSI Layer 3" at 4.188,7.033 ljust "OSI Layer 1..2" at 2.750,6.033 ljust

TCP/IP Protocol Summary

- Internet Prococol
  - provides the packet delivery service for TCP, UDP and ICMP
  - user processes do not normally explicitly generate IP datagrams

- an IP address is a virtual address, it was not constructed with a preconceived piece of hardware in mind

TCP/IP Protocol Summary

- Address Resolution Protocol
  - maps an Internet address into a hardware address

- Reverse Address Resolution Protocol
  - maps a hardware address into an Internet address.

TCP and UDP

- primarily there are two transport protocols used with IP: TCP and UDP
  - remember that IP may provide an unreliable service

- **Transmission Control Protocol (TCP)**
  - provides a flexible two-way byte stream protocol (byte stream allows addressing *within* a host - to user, process or service)
  - *provides a bidirectional pipe*
  - the source and destination address are called a *Port*
  - TCP is the most popular transport protocol on top of IP
  - it uses sliding window technique to provide a reliable service
  - it uses a three way handshake to establish a connection
  - and a two way handshake to disconnect

User Datagram Protocol (UDP)

- is an unreliable datagram protocol and is deliberately simple
  - it does not ensure that packets arrive in order, un duplicated, or even at all!

- it sends discrete datagrams, and delivers messages that arrive to the appropriate *Port* (same addressing schema as TCP)
  - a *port* may belong to a user, process or service
  - the standard Internet name service, DNS, uses UDP
  - it can be regarded as multiplexing many users, processes and services through one IP address

- UDP has no standard connection procedure and no disconnect procedure

IP technical introduction

- IP centerpiece of the TCP/IP protocol stack. It hides the differences between data link protocols from the transport protocols that the end user applications use
  - can replace old data link technologies with new faster technologies
  - application independent

- IP defines a virtual network address space
  - if you are connected to the Internet then your network has a unique IP address
  - within that network address your machine has a unique host id.

IP technical introduction

- IP provides a connectionless packet delivery service
  - it routes small messages from one machine to another on the addressed within that message
  - connectionless service routes each packet separately and therefore does not guarantee reliable delivery
  - having connectionless packet delivery as the basis for all Internet services makes it adaptable to a wide range of hardware
  - connectionless packet delivery is often termed *datagram*

IP (continued)

- the IP protocol works as follows:
  - transport layer split up a message into datagrams of <=64k bytes
- transport layer gives a datagram to the IP layer
  - datagram is transmitted through the Internet
  - a hop at a time (gateway to gateway)
  - a datagram maybe divided into smaller units at any hop
- datagram is reassembled at the destination machine
  - original message is constructed
  - delivered to the corresponding transport layer

TCP/IP Support Protocols

- are another reason TCP/IPs popularity

TCP/IP Support Protocols

box with .sw at (0.312,6.875) width 0.688 height 0.438 box with .sw at (1.312,6.875) width 0.688 height 0.438 box with .sw at (2.250,6.875) width 0.688 height 0.438 box with .sw at (3.188,6.875) width 0.688 height 0.438 box with .sw at (1.438,5.938) width 0.688 height 0.438 box with .sw at (0.751,7.749) width 1.000 height 0.750 box with .sw at (2.438,7.749) width 1.000 height 0.750 box with .sw at (0.750,9.000) width 1.000 height 0.750 box with .sw at (2.438,8.999) width 1.000 height 0.750 line <-> from 1.250,9.000 to 1.250,8.500 line <-> from 3.000,9.000 to 3.000,8.500 line <-> from 1.250,7.750 to 1.688,7.312 line <-> from 1.688,7.312 to 2.938,7.750 line <-> from 1.688,6.875 to 1.750,6.375 line <-> from 1.750,6.375 to 2.562,6.875 line <-> from 1.812,6.375 to 3.500,6.875 line <-> from 1.000,7.062 to 1.312,7.062 dashwid = 0.050 box dashed with .sw at (0.625,8.875) width 3.000 height 1.000 box dashed with .sw at (0.688,7.625) width 2.938 height 1.000 box dashed with .sw at (0.188,6.750) width 3.812 height 0.688 box dashed with .sw at (1.250,5.750) width 1.250 height 0.750 "ICMP" at 0.500,7.033 ljust "IP" at 1.500,7.033 ljust "ARP" at 2.438,7.033 ljust "RARP" at 3.250,7.033 ljust "hardware" at 1.500,6.283 ljust "interface" at 1.500,6.033 ljust "user" at 1.000,9.533 ljust "process" at 1.000,9.283 ljust "user" at 2.688,9.533 ljust "process" at 2.688,9.283 ljust "TCP" at 1.125,8.096 ljust "UDP" at 2.750,8.158 ljust "OSI Layers 5..7" at 3.812,9.283 ljust "OSI Layer 4" at 3.750,8.033 ljust "OSI Layer 3" at 4.188,7.033 ljust "OSI Layer 1..2" at 2.750,6.033 ljust

TCP/IP Protocol Summary

- Transmission Control Protocol
  - connection-oriented protocol
  - reliable, full duplex, byte stream for user processes
- User Data Protocol
  - connectionless protocol for user processes
  - unreliable
- Internet Control Message Protocol
  - handles error and control information between gateways and hosts
  - *normally* generated by TCP/IP networking software itself, not the user processes

TCP/IP Protocol Summary

- Internet Protocol
  - provides the packet delivery service for TCP, UDP and ICMP
  - user processes do not normally explicitly generate IP datagrams
- Address Resolution Protocol maps an Internet address into a hardware address
- Reverse Address Resolution Protocol
  - maps a hardware address into an Internet address.

IP Classes

- line from 4.987,7.513 to 4.987,7.013 line from 2.737,7.513 to 2.737,7.013 line from 2.487,7.513 to 2.487,7.013 line from 2.237,7.513 to 2.237,7.013 line from 3.987,8.512 to 3.987,8.012 line from 2.487,8.512 to 2.487,8.012 line from 2.237,8.512 to 2.237,8.012 line from 2.987,9.512 to 2.987,9.012 line from 2.237,9.512 to 2.237,9.012 box with .sw at (1.988,7.013) width 4.000 height 0.500 box with .sw at (1.988,8.012) width 4.000 height 0.500 box with .sw at (1.988,9.012) width 4.000 height 0.500 "1" at 2.050,8.233 ljust "0" at 2.550,7.233 ljust "1" at 2.300,7.233 ljust "1" at 2.050,7.233 ljust "0" at 2.300,8.233 ljust "0" at 2.050,9.233 ljust "Class C" at 1.175,7.296 ljust "Class B" at 1.175,8.296 ljust "Class A" at 1.175,9.296 ljust "8" at 5.425,7.608 ljust "21" at 3.675,7.608 ljust "16" at 4.862,8.608 ljust "14" at 2.987,8.608 ljust "24" at 4.300,9.608 ljust "7" at 2.612,9.608 ljust "1" at 2.550,7.608 ljust "1" at 2.300,7.608 ljust "1" at 2.050,7.608 ljust "1" at 2.300,8.608 ljust "1" at 2.050,8.608 ljust "1" at 2.050,9.608 ljust

- for example `193.63.129.1` is a class C address as we convert the first byte of the address `193` into binary and examine the top 3 bits of a byte

IP Classes

- there are 127 class A networks
  - each can have 16,777,216 hosts
- there are 16,384 class B networks
  - each can have 65,336 hosts
- there are 2,097,152 class C networks
  - each of which have 256 hosts
- note that in practice the host byte values 0 and 255 are reserved for network and broadcast respectively

Private addresses in class A, B and C

- in addition each class A, B and C have a private network address
- class A
  - reserves the range 10.0.0.0 - 10.255.255.255 (16,777,216 hosts)
- class B
  - 172.16.0.0 - 172.31.255.255 (1,048,576 hosts)
- class C
  - 192.168.0.0 - 192.168.255.255 (65,536 hosts)

Example IP Static Configuration

- Case study - adding a machine onto the Computer Science network

- the IP network in Computer Studies connects:
  - Apple computers
  - Windows computers
  - Raspberry Pi machines
  - Debian and Mint GNU/Linux clients and servers
  - routers and various print services, etc

Example IP Static Configuration

- each machine may run a different protocol above the IP layer if they wish
  - but most machines will run the IP protocol

- the Computer Studies IP network is connected (via a gateway) to the University of Southwales IP network
  - in turn is connected to the world IP network via another gateway (through the University of Southwales 1M bit line)

Example IP Static Configuration

- *every* IP address actually refers to the interface card and **NOT** the machine!

- thus a gateway machine will have at least two interface cards

- to add a new machine `floppsie` onto the Computer Studies network
  - floppsie's interface card has to be assigned a unique IP address
  - first three numbers the same as the Computer Science network (193.63.130)
  - class C network - means first 3 bytes are always the same
  - last number is the interface card number (hostid) 52
  - 193.63.130.52

Example IP Static Configuration

- software on the new machine needs to know:
  - the gateway on the Computer Studies network to other networks
  - its own interface card IP address
  - the *nameserver* IP address. The *nameserver* translates all ASCII names to IP numerical addresses.
  - hop metric given with each gateway

IP Configuration

dashwid = 0.050 box dashed with .sw at (1.575,7.941) width 1.850 height 1.772 box with .sw at (5.512,5.776) width 1.772 height 3.150 box dashed with .sw at (1.378,5.579) width 6.102 height 1.575 box dashed with .sw at (4.134,7.941) width 3.346 height 1.772 "DNS (Nameserver)" at 6.063,9.549 ljust "Dept of Computer Science" at 3.346,6.793 ljust box with .sw at (5.722,6.091) width 1.312 height 0.262 box with .sw at (5.761,8.295) width 1.312 height 0.262 box with .sw at (1.929,5.776) width 1.312 height 0.262 line from 3.031,6.169 to 3.163,6.169 line from 3.031,6.235 to 3.163,6.235 line from 3.031,6.301 to 3.163,6.301 line from 1.982,6.169 to 2.507,6.169 line from 1.916,6.235 to 2.769,6.235 line from 1.850,6.301 to 2.900,6.301 box with .sw at (1.785,6.038) width 1.575 height 0.328 box with .sw at (2.113,6.497) width 0.787 height 0.394 box with .sw at (2.047,6.432) width 1.050 height 0.525 dashwid = 0.038 line dotted <-> from 3.412,8.925 to 4.199,8.925 box with .sw at (6.050,9.175) width 1.312 height 0.262 "193.63.130.254" at 5.853,6.190 ljust "Gateway" at 5.984,6.452 ljust "193.63.134.x" at 5.827,8.394 ljust "Gateway" at 5.958,8.657 ljust "193.63.130.52" at 2.087,5.848 ljust "World IP network" at 1.640,8.959 ljust "193.63.130.0" at 3.937,6.596 ljust "Somemachine" at 5.906,7.541 ljust "Floppsie" at 1.457,6.596 ljust "193.63.134.00" at 4.291,8.959 ljust "University of Southwales" at 4.173,9.195 ljust "193.63.134.2" at 6.299,9.273 ljust