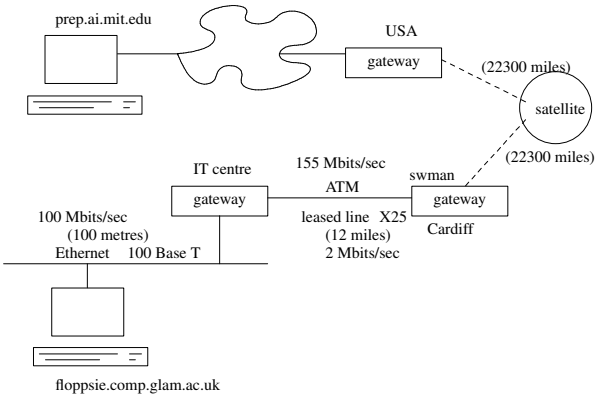
Recommended books

- Comer, D.E, (2001) Computer Networks and Internets, Prentice-Hall; ISBN 0-13-091449-5.
- Hodson, P. (2002) Local Area Networks (4th ed), Continuum; ISBN 1 85805 230 0.
- Stevens, W.R. (1990), UNIX Network Programming, Chapter 4 & 5, Prentice-Hall; ISBN 0-13-9 49876-1.
- Lutz M., Programming Python, O'Reilly, 2nd Edition, ISBN 0-596-00085-5.

Networking standards (The OSI model)

- the need for a standard



Networks: why should we study them?

- *"The network is the computer"* **SUN Microsystems**"
  - all computer interconnections are achieved through a network
  - processor, memory, disks, keyboard
  - Ethernet, Internet etc.
- data communications technology and physical communication means are competing
  - each trying to make the other obsolete!
  - Internet is still in its infancy - it will be as revolutionary as the industrial revolution

Taxonomy of networks

interproc distance	location	data speed throughput (bits/sec)	example latency	
0.1 m	circuit board	2G	.5 ns	memory & processor
1 m	system	1G	5 ns	Gigabit Ethernet
10 m	room	1G	5 ns	Gigabit Ethernet
100 m	building	155M	50 ns	LAN
1 km	campus	2-155M	1 ms	LAN/WAN
10-100 km	city/country	155M (ATM)	20 ms	WAN
1000-10 km	continent	274M (T4)	0.27 sec	WAN

The need for standards

- the communications industry has accepted that standards are essential
- different vendors, different countries need to communicate
- standards now permeate all areas of computer communications and networking

Advantages

- productivity and efficiency may be increased because of large scale, low cost production runs
- smaller firms can compete
- technology transfer and the dissemination of information is facilitated
- international trade can expand
- simplification
  - resources are conserved as only one item of equipment is needed where before many might have been required
- the worldwide exchange of information is increased

Disadvantages

- standards tend to freeze technology. Standards take a long time to be 'certified'
  - thus the technology may be out-of-date before it is adopted
- there are many different standards bodies producing many different standards for the same piece of equipment
  - manufacturers tend to supply the standard plus a little bit more ...
- many different committee tasked with producing standards

Standards bodies - ISO

- an international agency for the development of standards in many areas
  - currently 89 member countries including: Britain, France, USA
  - consists of national standard bodies
  - British Standards Institute and American National Standards Institute

Whos who in standards

- International Telegraph and Telephone Consultative Committee
- CCITT is part of an agency within the United Nations which deals with telephone and data communication systems
  - historically, computer communications evolved through telecommunications and as such comes within the scope of CCITT
  - CCITT - a French abbreviation

Institute of Electrical and Electronic Engineers

- IEEE is the largest professional society in the world
- it is also a member of ANSI
- a standardization group that develops standards for computing
- the IEEE standards for local area networks have subsequently been used by ISO as the basis for its standards on LANs

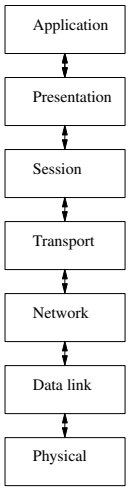
ISO OSI 7 Layer Reference Model

- connecting computers together might be difficult (why?)
  - the computers might be produced by different companies
  - different data representations
  - different voltage levels for encoding 1 and 0
- users prefer connectivity
  - thus there is a drive towards establishing standard for computer networks
  - as computers are worldwide these standards must be international
- the central idea is that any computer in the world should be able to connect to any other
- there should be an *open system*.

ISO OSI 7 Layer Reference Model

- the first step along this goal was
  - the concept of an abstract model for computer communication by the International Standards Organization
- full name is the International Standards Organization Open Systems Interconnection 7 Layer Reference Model
  - provides a framework for the development of Open Systems protocol standards

ISO OSI 7 Layer Reference Model



Physical layer

- concerned with the description of the physical circuits and the transmission of bits
- it ensure that when one side sends a 1, the other side receives a 1
  - voltages used to represent a 1 and a 0 must be determined
  - the length of time a bit may occupy (usually in microseconds) must also be agreed
- standards in this layer cover the shape and connections of the plug to be used
  - the speed of transmission
  - the handshaking required for transmission to take place

Data link layer

- turns the raw (possibly errorant) transmission facility into an error free digital link
- how does it do this?
  - the data link layer breaks data into frames
  - provides error detection and correction mechanisms upon these frames
- the Data link needs to:
  - recognize the boundaries of each frame
  - determine the correct sequence of frames
  - and regulate how many frames arrive over a specific period

Network layer

- network layer is very complex
- it provides the transfer of data between two hosts without the transport layers on the machines knowing about the mechanism
- eg. the simplest connection may be a direct link between two stations
  - alternatively, at the other extreme, the connection may be over many different networks which are linked together via gateways
- the network layer must therefore be responsible for
  - the establishment, maintenance and termination of the connection between two hosts across any intervening communications facility
  - it must deal with problems of addressing, routing and prevention of bottlenecks
  - some accounting - to detect bottlenecks before they arise!

The Transport Layer

- primary task is to hide all the network dependent characteristics from the layers above it
  - provides transparent data transfer
  - so all the protocols defined for the transport layer will only need to be implemented on the host computers and not on any intermediate computers in the network
- system programmers interface to the network
- the transport layer
  - establishes and maintains a logical connection with the corresponding transport layer on a remote host
  - uses this connection to transfer data

Session layer

- the period of time for which two users remain logically connected (even though not transmitting data continuously) is known as a session
- purpose of the session layer is to provide a *user-oriented* connection service
  - a session protocol may provide a user interface by adding to the basic connection service
  - possibly by imposing a structure on the dialogue between the users

Presentation Layer

- presentation layer is concerned with the format of the data being exchanged
  - it provides a set of data transformation services, typically including formatting and data translation
  - eg. if one user might use ASCII codes for character representation whereas another user might use EBCDIC
- the presentation layer provides the code conversion
- additionally
  - the presentation layer may provide sophisticated text compression techniques
  - or may perform a data encryption operation on data to be transmitted

Application Layer

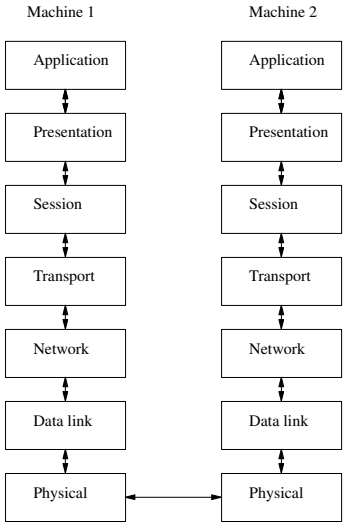
- the highest layer in the reference model and is the environment in which user's programs operate and communicate
- this layer therefore contains management functions and generally useful mechanisms to support distributed applications
- protocols are provided for functions such as file transfer and electronic mail
  - ftp
  - mail
  - telnet

Concepts

- the communications functions are partitioned into a vertical set of *layers*
  - the composition of the layers provide the total functionality required by communicating applications on remote computers
- each layer is assigned a specific set of functions
- each layer was designed to perform its tasks in such a way that minimizes information flow across the boundaries
- thus functionality is not evenly distributed
  - resulting in some layers being more complex than others
- eg the network layer is particularly full, while the session layer is almost empty

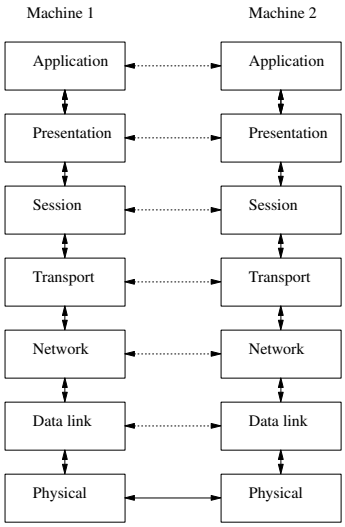
Concepts (continued)

- each layer provides *services* to the next higher layer
  - described in terms of *primitives* (basic functions) and associated data
- each layer relies on the next lower layer
  - no layer may interact with a layer which is not its direct neighbour



Concepts (continued)

- the same set of layered functions must exist in both the systems wishing to communicate
- the corresponding (*peer*) layers in the two systems communicate by means of a set of rules
  - which form a *protocol*
  - and dictates data format, control information for coordination and timing



Advantages of layering

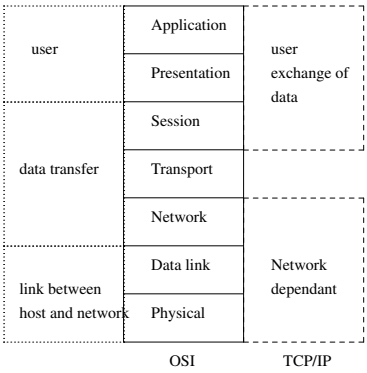
- divide and conquer
- standard interfaces between layers allow internal developments within layers
- easy to allow substitute layers for different options (connection oriented vs. datagram)
- data/code hiding
- layers can be substituted with ultra thin layers if not required

Disadvantage of layering

- standards do not define how data is to be passed between layers
- bottom 3 ISO OSI Layers are often implemented as processes, making implementation complex
- layer N needs to simultaneously
  - retrieve data from layer N+1 and layer N-1
  - give data to layer N+1 and layer N-1
- layer N-1 might be doing exactly the same
  - hence data exchange is *very* complex!

Concepts

- note that the only layer at which there is direct communication between the peer layers is the physical layer
- it is possible to view the seven layers in three parts by grouping together some of the layers
  - eg you could view the lower two layers as dealing with the link between the host and the network
  - while the next three deal with the actual data transfer
  - the upper two layers are regarded as being oriented towards the users



Tutorial questions

- which of the following ISO OSI 7 layers handles each of the following:
  - breaking the transmitted bit stream into frames?
  - determining which route the subnet to use?
  - providing synchronization?
- list two advantages and two disadvantages of having international standards for network protocols
- which of the 7 layers are essential to LANs, why are the remaining layers necessary for WANs? Justify your answers.

General question

- It is a Saturday morning and you wish to install the latest GNU/Linux debian SID release onto your computer. The release is 4 CDs of 500 Mbyte each. You have a 32 Kbits/sec Internet link and live 30 miles from work. At work you have a copy of the 4 CD's on the harddisk of the main server. Given that the cost of traveling is 50p a mile, the cost of Internet access is 1p a minute, time to burn 4 CDs at work will take 4 hours.
  - Work out the cost of traveling to work and burning the CDs
  - Work out the cost of downloading SID release
  - Work out the total round trip time to go to work and collect the 4 CDs
  - Work out the downloading time?
  - Which would you choose!