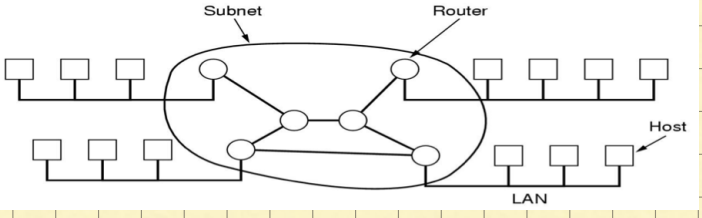
Network Architecture

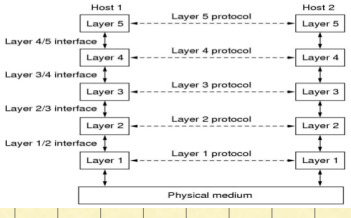
- Network Architecture: framework for designing and implementing Networks
- Components:
  - Software
    - Protocols
    - Services
  - Hardware
    - Transmission technology, media and devices
    - Scale: LANs, MANs, and WANs
    - Topology

Subnet



Layered Architecture

- The purpose of each layer is to offer a communication services to higher level layers
- Each layer has two interfaces
  - peer-to-peer interface
    - defines the form and types of messages exchanged between peers (indirect communication)
  - service interface
    - defines the primitives (operations) that a layer provides to the layer above it
- Layering is non-linear



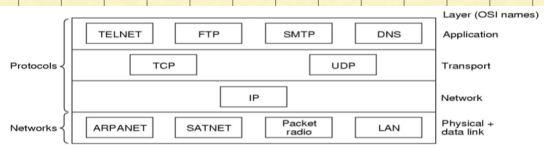
Protocols

- The functionality encapsulated within each layer is called *Protocol*
- The Protocol refers to both
  - the abstract peer-to-peer & service interfaces and
  - the objects that implement those interfaces
- Protocol vs. Service
  - Service is the set of primitives provided to the higher layer
  - Protocol defines the implementation of these primitives
- Protocol stack

ISO OSI Architecture

- International Standards Organisation (ISO)
- *Physical*: transmission of raw bits onto the communications medium
- *Data link*: reliable transmission of frames, flow control, arbitration
- *Network*: packet switching, routing congestion control
- *Transport*: process-to-process channel, node-to-node connection, provides user services, flow control, multiplexing
- *Session*
- *Presentation*
- *Application*

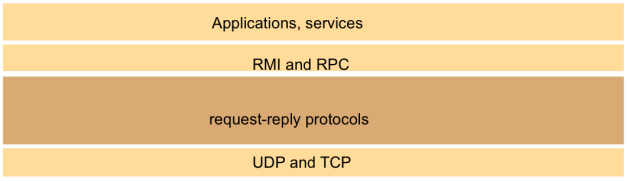
Internet Architecture



- Host-to-Network Layer (OSI Physical and Data link layers)
- Internet Layer (OSI Network layer - Internet Protocol/IP)
- **Transport Layer**
  - **Transmission Control Protocol - TCP**
  - **User Datagram Protocol - UDP)**
- Application Layer

Accessing Transport Layer

- How application programs use protocol software (invoke the services) of transport layer to communicate across networks

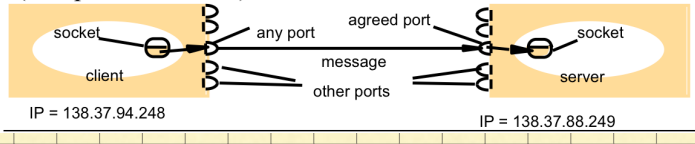


Inter-process Communication

- Message passing model: send - receive
- Synchronous communications : blocking
- Asynchronous communications
  - Blocking (receive) vs non blocking (send, receive)
- Reliability
  - Validity: messages are guaranteed to be delivered despite of packets being lost
  - Integrity: messages must arrive uncorrupted and without duplication
- Ordering: message send and delivery

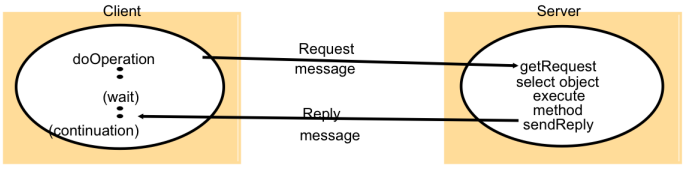
Sockets and ports

- Sockets provide an abstract endpoint for inter-process communication (UDP, TCP)
- Destination:
  - internet address, port, process id
- Port: message destination within a computer (integer) –Internet addresses: names rather than numbers (2^{16})
- A socket must be bound to a local port and an internet address
- A process may use multiple ports but cannot share ports (exception: multicast)



The Request-Reply Protocol

- Processes communicate using a protocol



public byte[] doOperation (RemoteObjectRef o, int methodId, byte[] arguments)
sends a request message to the remote object and returns the reply.
The arguments specify the remote object, the method to be invoked and the arguments of that method.

public byte[] getRequest ();
acquires a client request via the server port.

public void sendReply (byte[] reply, InetAddress clientHost, int clientPort);
sends the reply message reply to the client at its Internet address and port.

Issues

- Message identifiers (sequence+sender id)
- Failure Model
- Timeouts
- Duplicate request messages
- Lost reply messages
- History for retransmissions

UDP Sockets

- Receive method returns the IP address+port of sender so that a reply can be sent
- Message size: receiving process specifies a byte-array in which to receive the message (IP: 2^{16} bytes, usually 8kB)
- Non-blocking send & blocking receive (timeouts and threads for deadlocks)
- Receive *from any*

Java API

- *DatagramPacket* class provides
  - a constructor that makes an instance of a message: [message byte array, length,IP address,post no]
  - A constructor for use when receiving a message
  - Methods: *getData, getPort, getAddress*
- *DatagramSocket* class provides
  - A constructor that takes a port as an argument for use by processes that need to use a port
  - A no-argument constructor that allows the system to choose a free local port
  - *SocketException* if problem with port
  - Methods:
    - *send:* argument an instance of DatagramPacket
    - *Receive:* argument an empty DatagramPacket
    - *setSoTimeout: InterruptedIOExpception* when expire
    - *connect:* connect a socket to a particular remote port and IP address, the socket is abe to send to and receive from that address

TCP Sockets

- API provides an abstraction of a stream of bytes to which data may be written and from which data may be read. The abstraction hides the following:
  - Message sizes. The application can choose how much data data it writes to a stream. TCP may fragment it to smaller packets
  - Lost messages
  - Flow control
  - Message duplication and ordering
  - Message destinations: once a connection is established, processes simply read from and write to a stream (no need for IP addresses and ports)
- Client-server model during connection:
  - client creates a stream socket bound to a port and asks for a connection to a server port
  - server creates a listening socket bound a a port and waits to *accept* connect requests
- During operation each socket is both for input and output
- Close a socket when no more data to write

Java API

- *ServerSocket* class: create a socket at a server port for listening for connect requests
  - Method *accept*: wait until there is a *connect* request in the queue, then create an instance of *Socket*
- *Socket* class: client uses a constructor which creates a socket (specifying the DNS hostname and port of a server) and connects it to the specified remote server (*UknownHostException*, *IOException*)
  - Methods: *getInputStream* and *getOutputStream*
    - *R*eturn types are abstract classes that define methods for reading (*InputStream)* and writing (*OutputStream)* bytes
    - Return values can be used as the arguments of constructors for suitable input and output streams.

Group Communication

- Multicast: an operation that sends a single message from one process to each of the members of a group of processes
- Fault tolerance based on replicated services
- Finding the discovery servers in spontaneous networking
- Better performance through replicated data
- Propagation of event notifications

IP Multicast

- multicast group is specified by a class D Internet address
  - membership is dynamic, to join make a socket
  - programs using multicast use UDP and send datagrams to mutlicast addresses and (ordinary) port
  - (For example of Java code see book)