System Models and Networking Chapter 2,3

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Fundamental Issues

- There is no global time.
- All communications are by means of messages.
- Message communication may be affected by network delays and can suffer from a variety of failures and security attacks.
- How does one express a solution/process for handling an issue? One of the ways is to establish a model.

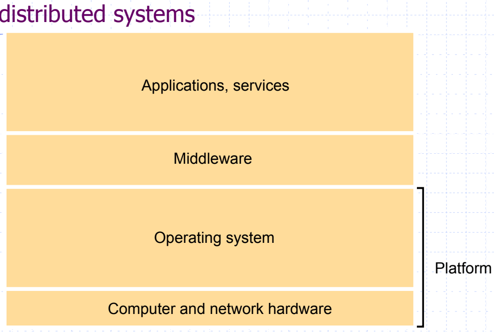
System Models

- **Interaction model** deals with performance and setting time limits in a distributed system, say, for message delivery.
- **Failure model** gives specification of faults and defines reliable communication and correct processes.
- **Security model** specifies possible threats and defines the concept of secure channels.
- **Architectural model** defines the way in which the components of the system interact with one another and the way in which they are mapped onto the underlying network of computers.
- **Application Model**: Defines how a certain concept can be used solve problems.

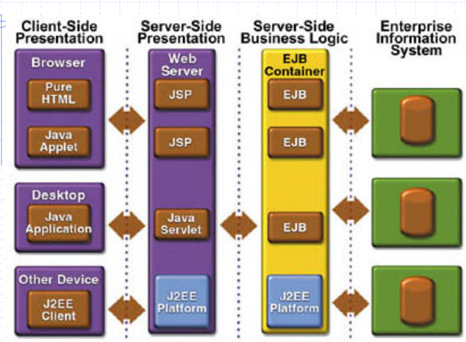
Architectural Model

- Abstracts the functions of the individual components.
- Defines patterns for distribution of data and workload.
- Defines patterns of communication among the components.
- Example: Definition of server process, client process and peer process and protocols for communication among processes; definition client/server model and its variations.

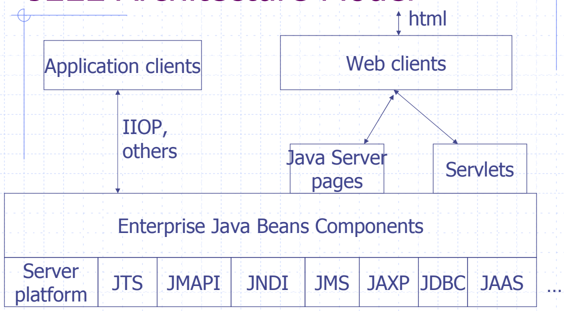
Software and hardware service layers in distributed systems



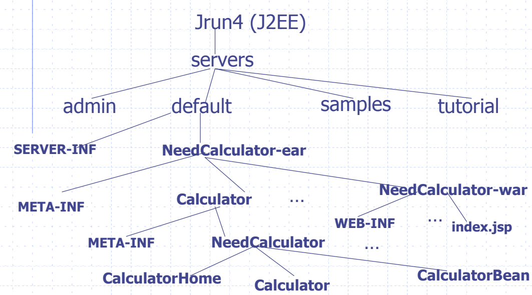
Enterprise(J2EE) Application Model



J2EE Architecture Model



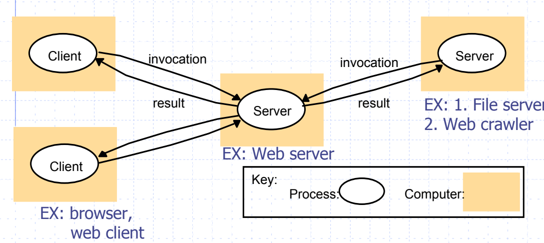
Programming Model for J2EE Application



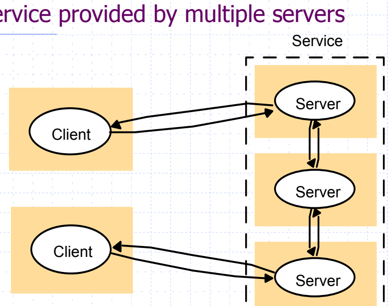
Middleware

- Layer of software whose purpose is to mask the heterogeneity and to provide a convenient programming model for application programmers.
- Middleware supports such abstractions as remote method invocation, group communications, event notification, replication of shared data, real-time data streaming.
- Examples: CORBA spec by OMG, Java RMI, MS's DCOM.

Clients invoke individual servers

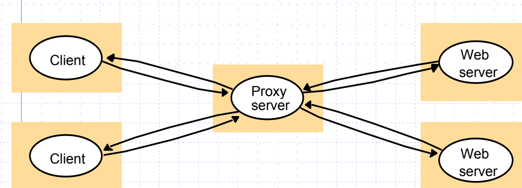


A service provided by multiple servers



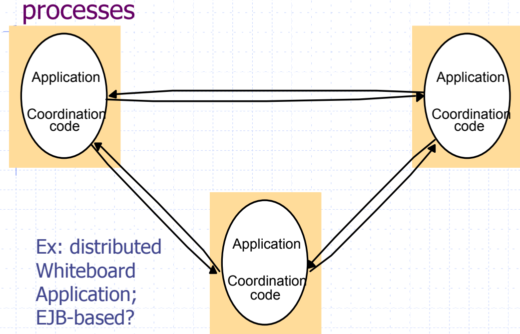
EX: akamai, altavista, Sun's NIS (data replication)

Web proxy server and caches



Proxy servers + cache are used to provide increased Availability and performance. They also play a major role Firewall based security. http://www.interhack.net/pubs/fwfaq/

A distributed application based on peer processes



Ex: distributed Whiteboard Application; EJB-based?

Networking (Chapter 3)

- Distributed systems use local area networks, wide area networks and internet for communication.
- Performance, reliability, scalability, mobility, and quality of service (qos) impact the design.
- Changes in user requirements have resulted in emergence of wireless and qos guarantees.
- Principles: protocol layering, packet switching, routing, data and behavior streaming.
- Coverage: Ethernet, Asynchronous Transfer Mode (ATM), IEEE 802.11 wireless network standard.

Networking Issues

- Performance:
  - Latency: delays at the switches and routers.
  - Data transfer rate (bits/sec) : raw data
  - Bandwidth: total volume of traffic that can be transferred across the network in a given time.
- Scalability:
  - How does a system handle increase in the number of users? Increase in the size of the system? Increase in load and traffic?

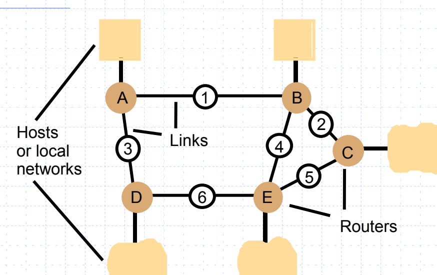
Networking Issues (contd.)

- Security: requirements and techniques for achieving security. Firewall, Virtual Private Network (VPN).
- Mobility: Support for moving devices. Not necessarily wireless.
- QoS: Bandwidth and latency bounds.

Figure 3.5 OSI protocol summary

Layer	*Description*	*Examples*
Application	Protocols that are designed to meet the communication requirements of specific applications, often defining the interface to a service.	HTTP,FTP, SMTP, CORBA IIOP
Presentation	Protocols at this level transmit data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption is also performed in this layer, if required.	Secure Sockets (SSL),CORBA Data Rep.
Session	At this level reliability and adaptation are performed, such as detection of failures and automatic recovery.	
Transport	This is the lowest level at which messages (rather than packets) are handled. Messages are addressed to communication ports attached to processes, Protocols in this layer may be connection-oriented or connectionless.	TCP, UDP
Network	Transfers data packets between computers in a specific network. In a WAN or an internetwork this involves the generation of a route passing through routers. In a single LAN no routing is required.	IP, ATM virtual circuits
Data link	Responsible for transmission of packets between nodes that are directly connected by a physical link. In a WAN transmission is between pairs of routers or between routers and hosts. In a LAN it is between any pair of hosts.	Ethernet MAC, ATM cell transfer, PPP
Physical	The circuits and hardware that drive the network. It transmits sequences of binary data by analogue signalling, using amplitude or frequency modulation of electrical signals (on cable circuits), light signals (on fibre optic circuits) or other electromagnetic signals (on radio and microwave circuits).	Ethernet base- band signalling, ISDN

Routing in a wide area network



Routing tables for the network in Figure 3.7

Routings from A		
To	*Link*	*Cost*
A	local	0
B	1	1
C	1	2
D	3	1
E	1	2

Routings from B		
To	*Link*	*Cost*
A	1	1
B	local	0
C	2	1
D	1	2
E	4	1

Routings from C		
To	*Link*	*Cost*
A	2	2
B	2	1
C	local	0
D	5	2
E	5	1

Routings from D		
To	*Link*	*Cost*
A	3	1
B	3	2
C	6	2
D	local	0
E	6	1

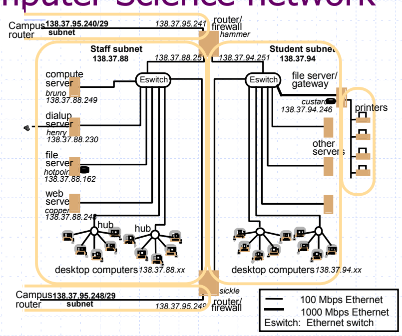
Routings from E		
To	*Link*	*Cost*
A	4	2
B	4	1
C	5	1
D	6	1
E	local	0

Pseudo-code for RIP routing algorithm

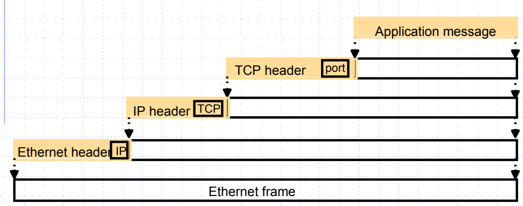
Send: Each *t* seconds or when *Tl* changes, send *Tl* on each non-faulty outgoing link.
Receive: Whenever a routing table *Tr* is received on link *n*:

```
for all rows Rr in Tr {
    if (Rr.link | n) {
        Rr.cost = Rr.cost + 1;
        Rr.link = n;
        if (Rr.destination is not in Tl) add Rr to Tl;
         // add new destination to Tl
        else for all rows Rl in Tl {
            if (Rr.destination = Rl.destination and
                    (Rr.cost < Rl.cost or Rl.link = n)) Rl = Rr;
            // Rr.cost < Rl.cost : remote node has better route
            // Rl.link = n : remote node is more authoritative
        }
    }
}
```

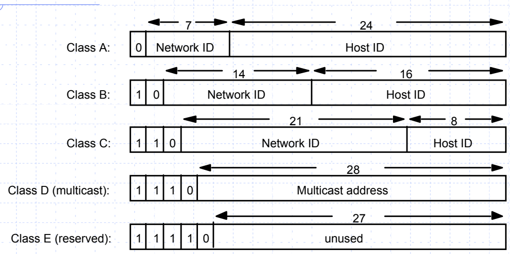

Simplified view of the QMW Computer Science network



Encapsulation in a message transmitted via TCP over an Ethernet



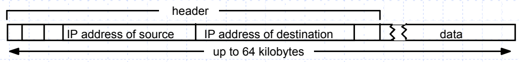
Internet address structure, showing field sizes in bits



Decimal representation of Internet addresses

	octet 1	octet 2	octet 3		Range of addresses
Class A:	Network ID: 1 to 127	Host ID: 0 to 255	0 to 255	0 to 255	1.0.0.0 to 127.255.255.255
Class B:	Network ID: 128 to 191	0 to 255	Host ID: 0 to 255	0 to 255	128.0.0.0 to 191.255.255.255
Class C:	Network ID: 192 to 223	0 to 255	0 to 255	Host ID: 1 to 254	192.0.0.0 to 223.255.255.255
Class D (multicast):	Multicast address: 224 to 239	0 to 255	0 to 255	1 to 254	224.0.0.0 to 239.255.255.255
Class E (reserved):	240 to 255	0 to 255	0 to 255	1 to 254	128.0.0.0 to 247.255.255.255

IP packet layout and IPV4 Issues



- Address limitations
- Scarcity of Class B addresses
- Managing entries in routing tables
- Ad hoc measures such as allocation Class C to Class B address ranges (CIDR – classless interdomain routing).

Issues in IPV4

- Address limitations
- Scarcity of Class B addresses
- Managing entries in routing tables
- Ad hoc measures such as allocation Class C to Class B address ranges (CIDR – classless interdomain routing).

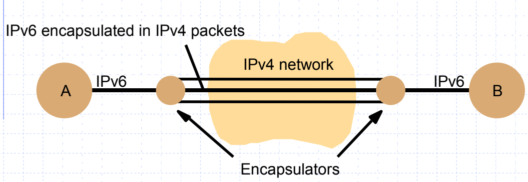
IPV6 Features

- Addresses are 128 bits (double that of IPV4)
- Address space is partitioned
- Routing speed improved by removing some operations such as checksum.
- Accommodates real-time and special services. (streams and devices)
- Future evolution possible (next header field).
- IPV6 support "anycast" (message delivered to at least one of the hosts).
- Built-in security.

IPv6 header layout

Version (4 bits)	Priority (4 bits)	Flow label (24 bits)	
Payload length (16 bits)		Next header (8 bits)	Hop limit (8 bits)
Source address (128 bits)			
Destination address (128 bits)			

Tunnelling for IPv6 migration



Summary

- We looked several models of the distributed systems.
- We also studied some important issues in networking.
- Distributed system models and networking concepts are fundamental to topics such as Web Services and Grid services we will be discussing in future.