Processes

Overview

- Threads vs Processes
- Clients
- Servers
- Virtualization
- Code Migration

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- Light-Weight Processes (LWP): Hybrid model. Multiple LWP/threads run inside a single (heavy-weight) process. In addition, the system offers a user-level threads package.

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- Characteristics of server implementations.

Model	**Characteristics**
Single-threaded	No parallelism, blocking system calls
Multi-threaded	Parallelism, blocking system calls
Finite state machine	Parallelism, nonblocking system calls

- See example LargerHttpd.java in folder `sockets` in package `tcp.largerhttpd`.

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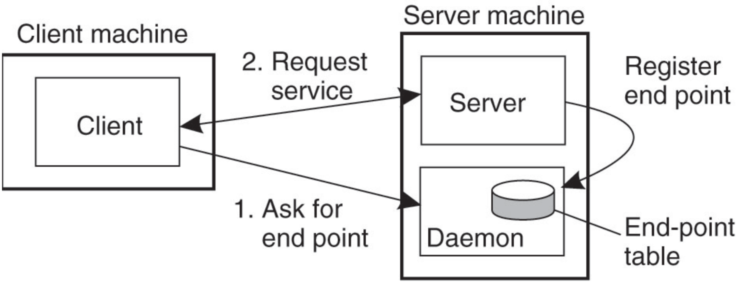
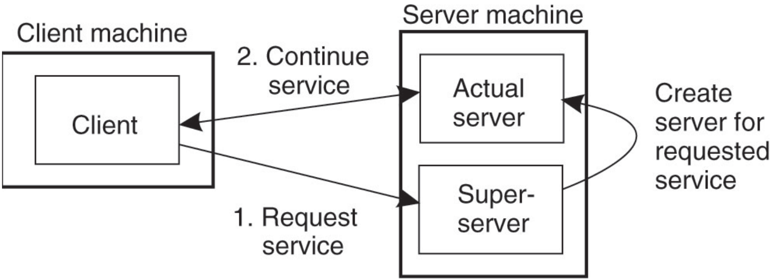
  - Look-up service provided by a special directory/registry server.
  - Using a superserver that selects on multiple ports and forks off the appropriate server when a request comes in.

Directory/Registry Server Setup



SuperServer Setup



`xinetd` is an example of a superserver

Design Issues for Servers (3)

- Stateless server: A stateless server does not remember anything from one request to another. For example, a HTTP server is stateless. Cookies can be used to transmit information specific to a client with a stateless server. Easy to recover from a crash.

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- Soft State servers: The server promises to maintain state on behalf of the client, but only for a limited time.

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- How to handle communication interrupts? Use out-of-band data. Example: to cancel the upload of a huge file.
  - Server listens to separate endpoint, which has higher priority, while also listening to the normal endpoint (with lower priority).
  - Send urgent data on the same connection. Can be done with TCP, where the server gets a signal (`SIGURG`) on receiving urgent data.

In-class Exercises

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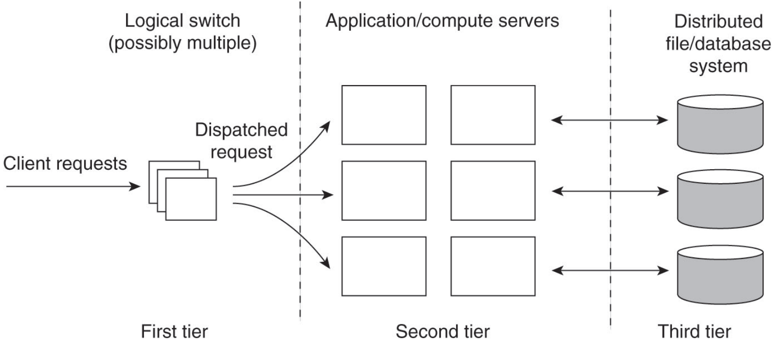
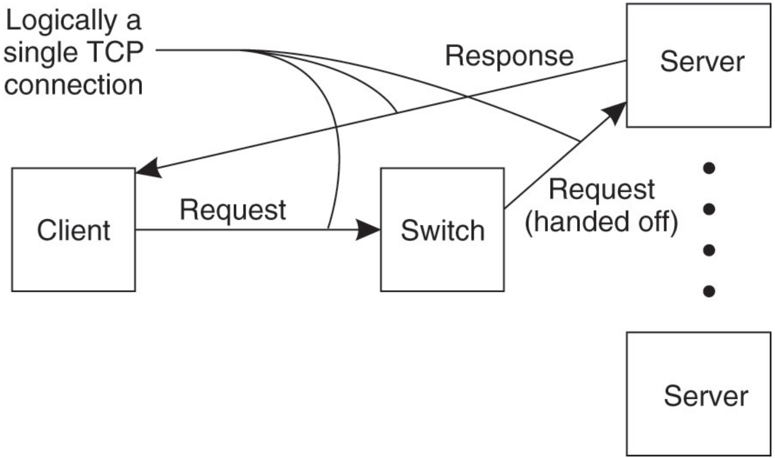
- Is a server that maintains a TCP/IP connection to a client stateful or stateless?
- Imagine a web server that maintains a table in which client IP addresses are mapped to the most recently accessed web pages. When a client connects to the webserver, the server looks up the client in its table, and if found, returns the registered page. Is the server stateful or stateless?

Server Clusters (1)



Design of a Three-tiered Server Cluster

Server Clusters (2)



TCP Handoff (uses IP forwarding and IP spoofing)

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- Single point of access can be made better using DNS to map one hostname to several servers. But the client still has to try multiple servers in case some are down.

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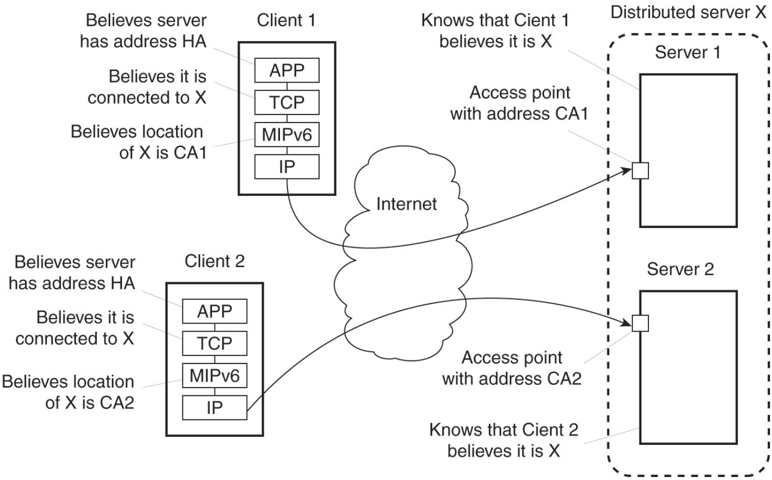
  - route optimization from MPIv6 is used to make different clients believe they are communicating with a single server where, in fact, each is communicating with a different member node of the distributed server

Route Optimization in Distributed Servers



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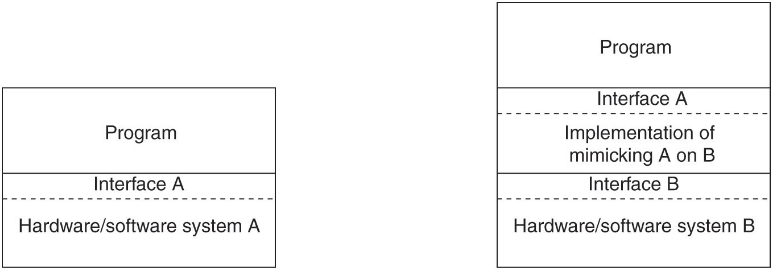

(a) (b)

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- The main driver behind the growth in cloud computing and utility computing.

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- An interface consisting of library calls generally forming what is known as an application programming interface (API). In many cases, the aforementioned system calls are hidden by an API.

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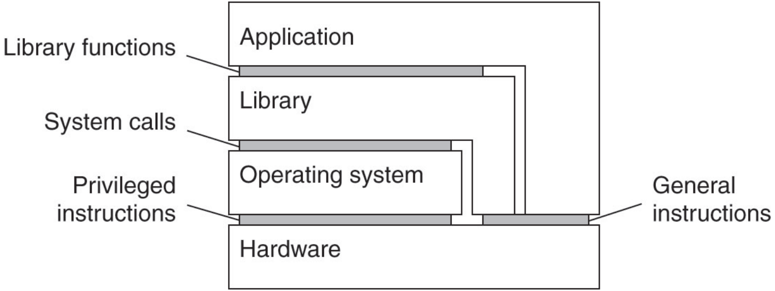

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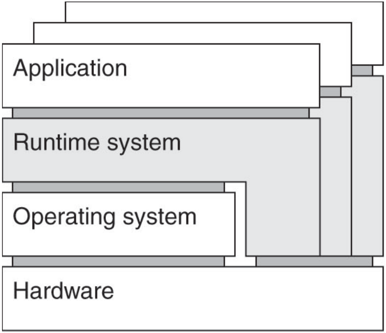

- Process Virtual Machine: An abstract instruction set that is to be used for executing applications. For example: Java Virtual Machine.

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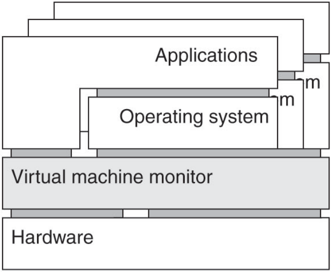

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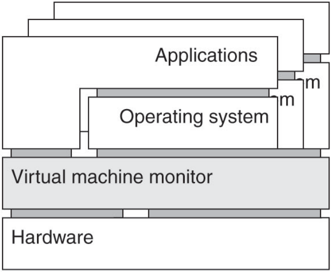

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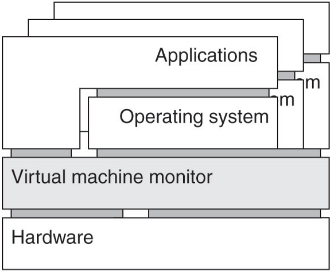

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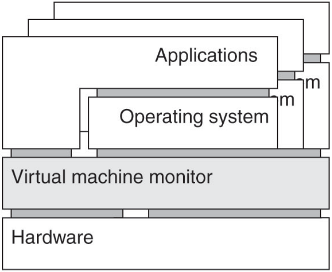

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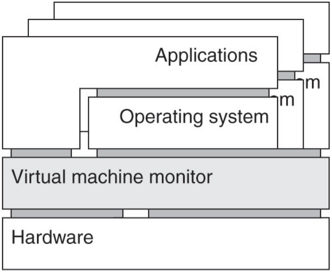

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- *Microkernel Examples*: Hyper-V, VMWare ESX/ESXi, Xen, z/VM.

Architectures for Virtual Machines (5)

- Sandbox (Application-level). Examples: Citrix XenApp, ZeroVM.

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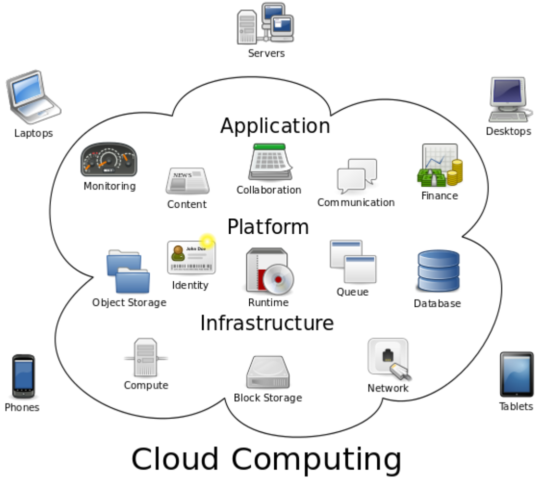
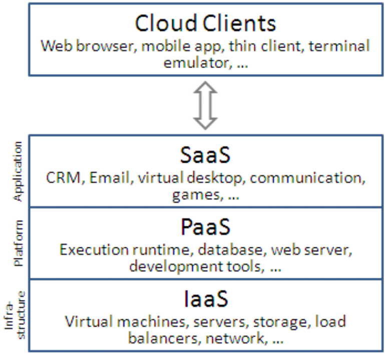
- Containers (Environment-level). Examples: *cgroups*-based Docker and LXC (Linux Containers). Lighter weight compared to Virtual Machine Monitors.

Cloud Computing



Cloud Computing Layers



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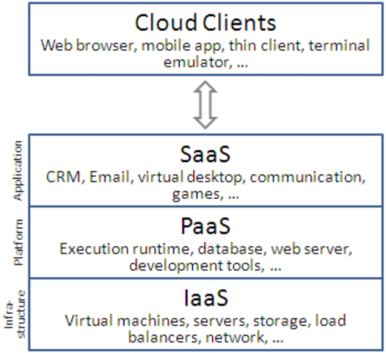

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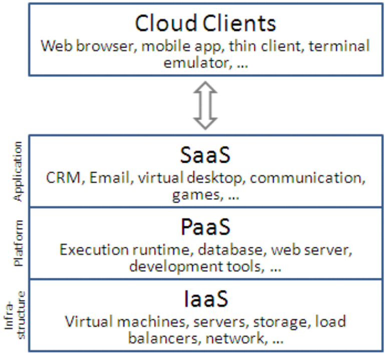

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PaaS: Google App Engine, Microsoft Azure

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- *Flexibility to dynamically configure distributed systems*. E.g. a server can provide interface code to a client dynamically. This does require that the protocol for downloading and initializing the code is standardized. Allows the interface to be changed as often as desired without having to rebuild applications or servers.

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Recall that a process consists of three segments: *code segment*, *resource segment*, *execution segment*.

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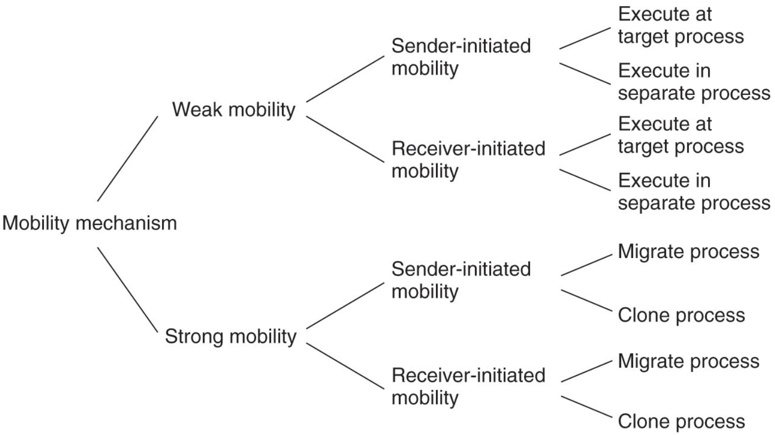
- Strong mobility: Code and execution segments can both be transferred.
- Sender-initiated versus receiver-initiated: Uploading code to a server versus downloading code from a server by a client.

Code Migration Models (2)



Process to Resource Binding

Three ways to handle migration (which can be combined)

- Binding by identifier: A process requires precisely the referenced resource. For example using a URL for a web site or a FTP server.
- Binding by value: The process can continue to execute if it gets the same value from another resource. E.g. A standard library.
- Binding by type: The process only needs a resource of specific type. E.g. a printer.

Resource to Machine Binding

Three ways to handle migration (which can be combined)

- Unattached resources: can be easily moved between machines. E.g. Data files.
- Fastened resource: Can only be moved at a high cost. E.g. a local database, a web site.
- Fixed resource: Intimately bound to a specific machine and environment and cannot be moved. E.g. Local devices, local communication end point (a socket bound to an address and port).

Migration and Local Resources

Process-to-resource binding		Unattached	Fastened	Fixed
	By identifier	MV (or GR)	GR (or MV)	GR
	By value	CP (or MV,GR)	GR (or CP)	GR
	By type	RB (or MV,CP)	RB (or GR,CP)	RB (or GR)

Resource-to-machine binding

GR	Establish a global systemwide reference
MV	Move the resource
CP	Copy the value of the resource
RB	Rebind process to locally-available resource

Exercises

- Consider a process P that requires access to file F, which is locally available on the machine that P is currently available. When P moves to another machine, it still requires access to F. If the file-to-machine binding is fixed, how could the systemwide reference to F be implemented.
- Is your chat server implementation *stateless* or *stateful*? Discuss.
- Is your filesync server implementation *stateless* or *stateful*? Discuss.