# Processes

# Overview

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

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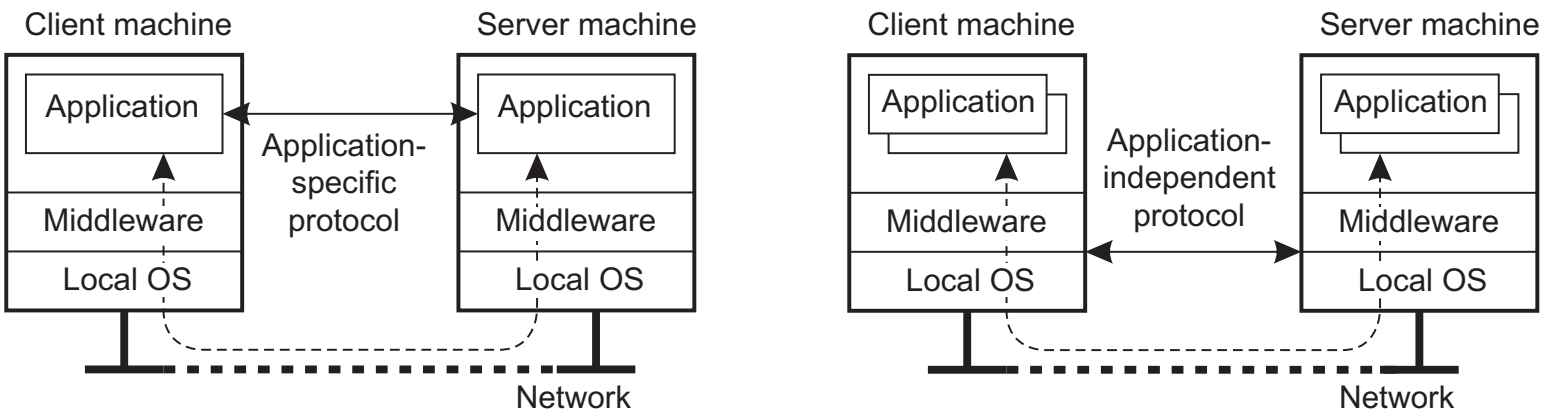
- Light-Weight Processes (LWP): Hybrid model. Multiple LWP/threads run inside a single (heavy-weight) process. In addition, the system offers a user-level threads package.

# Clients

- A networked client with its own protocol
- A middleware-based client



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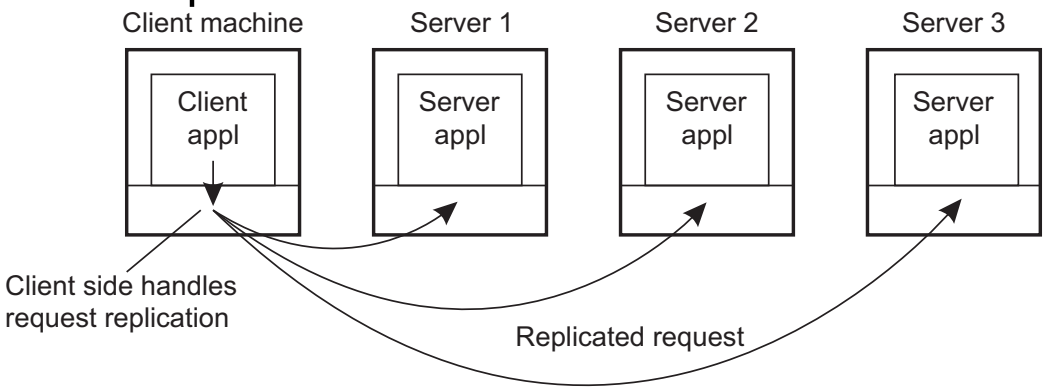

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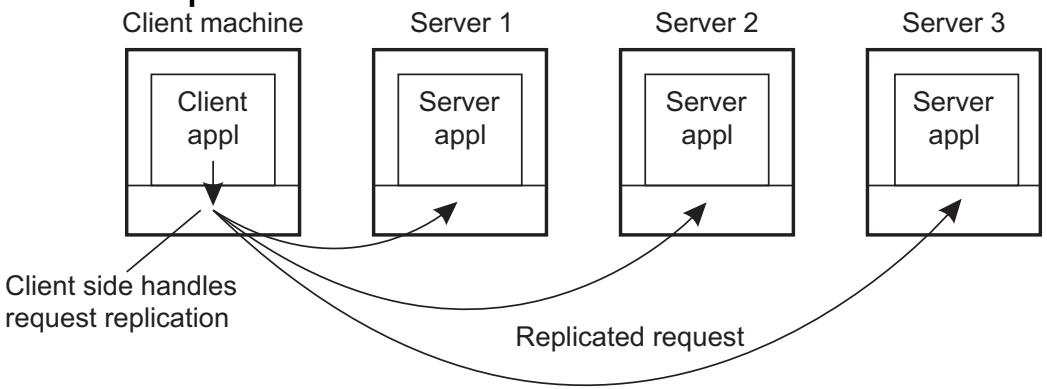


- The client-side middleware can provide failure transparency by repeating attempts to connect to a server, or contacting another server. Or even provide data cached from the past in some cases.

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- Characteristics of server implementations.

| **Model** | **Characteristics** |
|---|---|
| Singlethreaded | No parallelism, blocking system calls, single data space |
| Multithreaded | Parallelism, blocking system calls, shared data space |
| Multiprocess | Parallelism, blocking system calls, separate data space |
| Finite state machine | Parallelism, nonblocking system calls, single data space |

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

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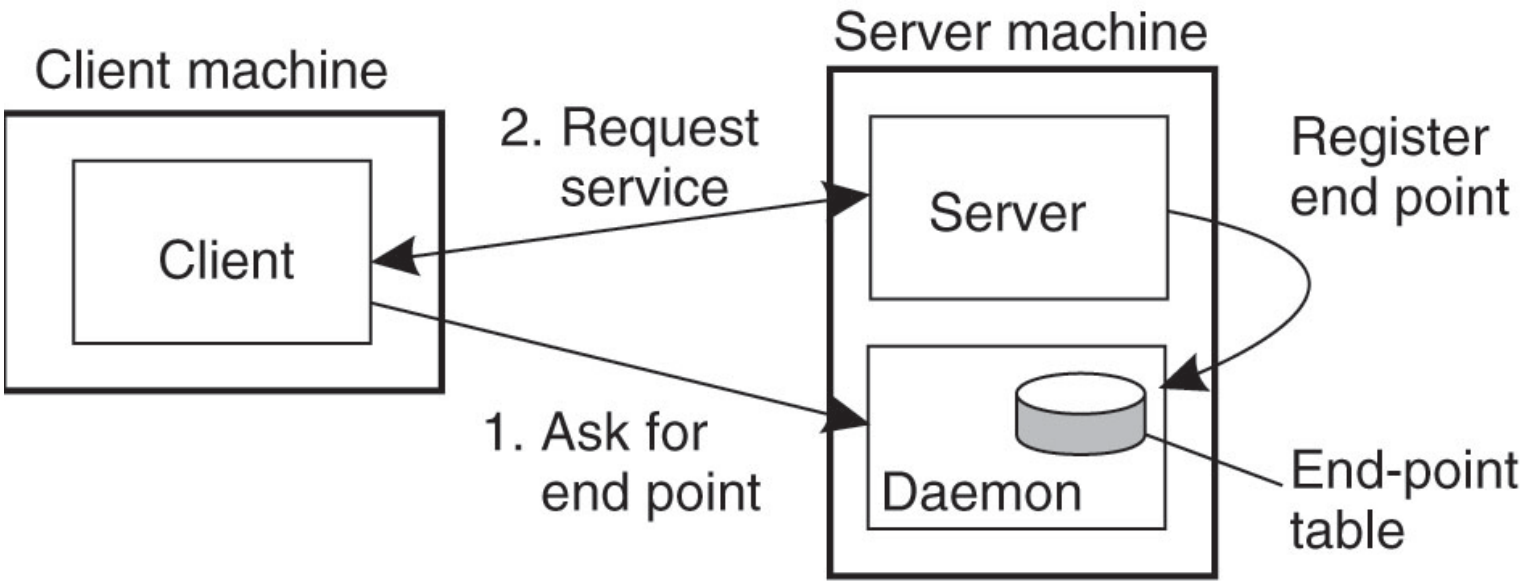
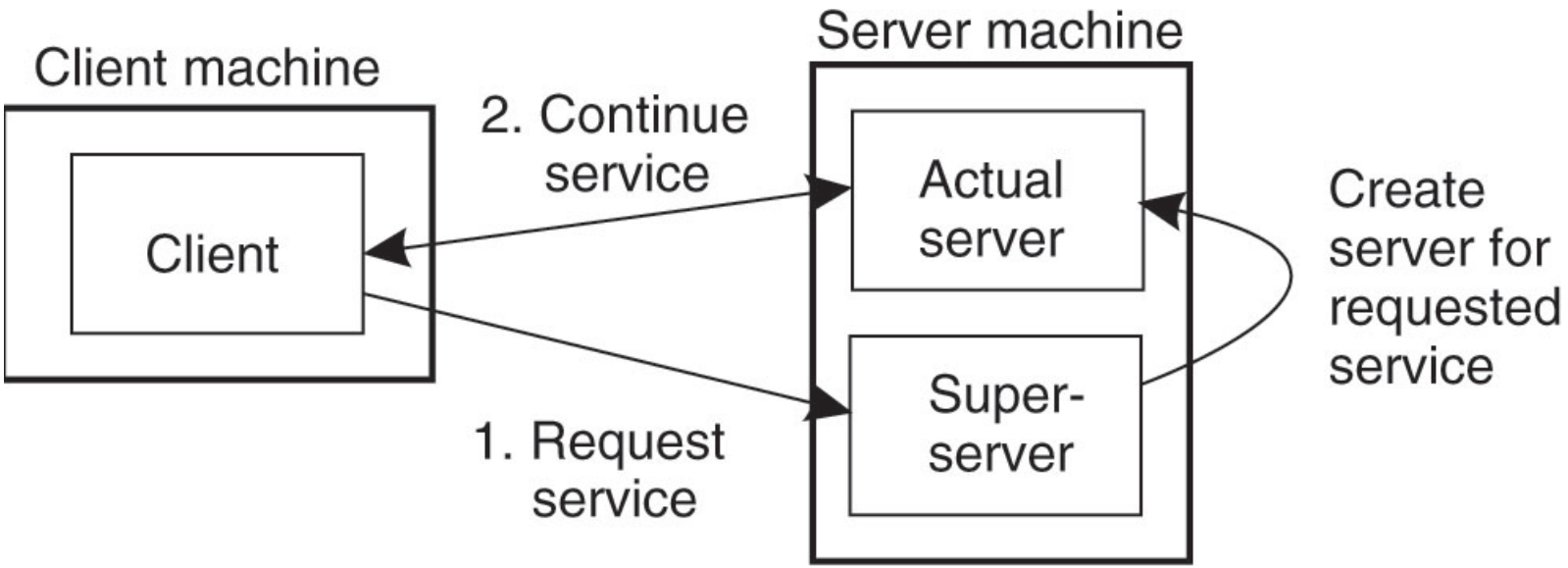
  - Using a superserver that selects on multiple ports and forks off the appropriate server when a request comes in.

# Directory/Registry Server Setup



# SuperServer Setup




`xinetd` is an example of a superserver

# Design Issues for Servers (3)

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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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  - Use a thread pool to prevent denial-of-service attacks.

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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. However, this isn't portable as not all socket implementations provide this feature.

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- 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?

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- Sketch the design of a multithreaded server that supports multiple protocols using sockets.

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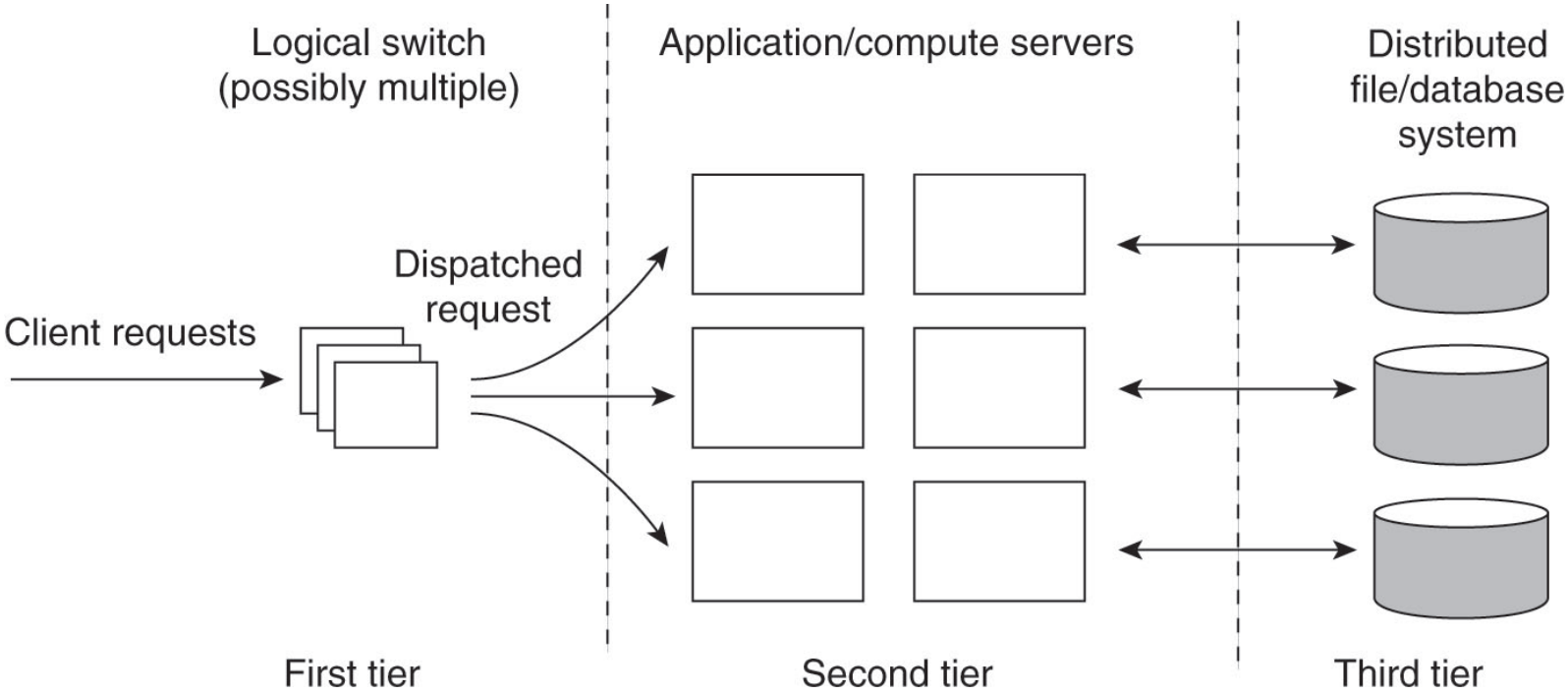


Design of a Three-tiered Server Cluster

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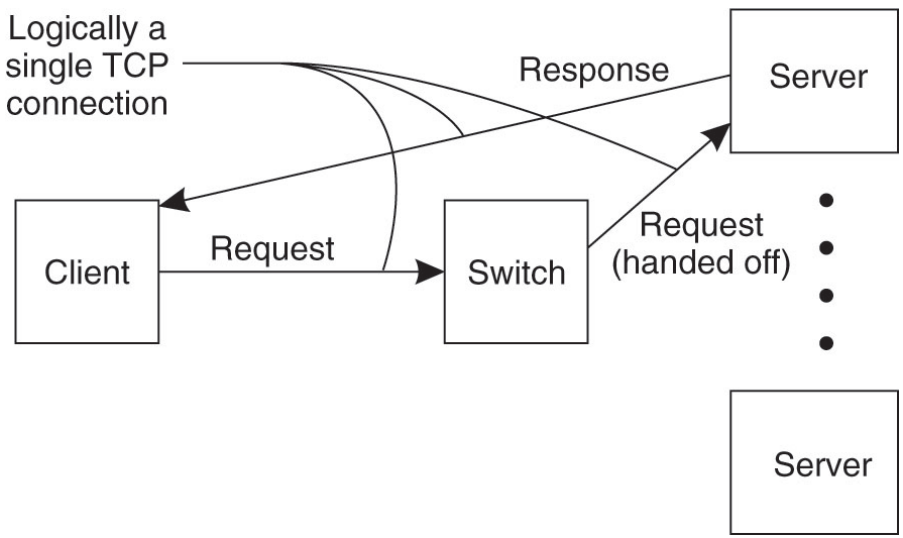
- The switch can hand off the connection to a selected server such that all responses are directly communicated to the client from that server. This is known as a TCP handoff, which uses IP forwarding and IP spoofing.



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- Switch can handoff request by being aware of the content
- 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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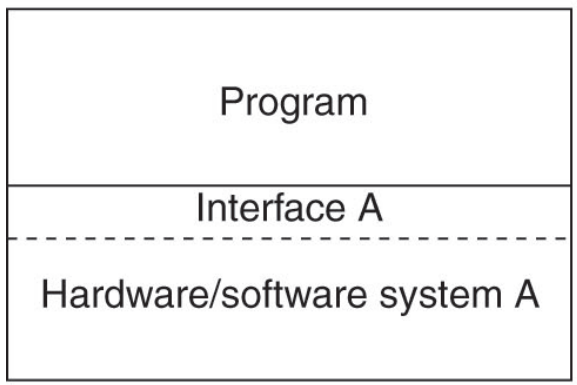
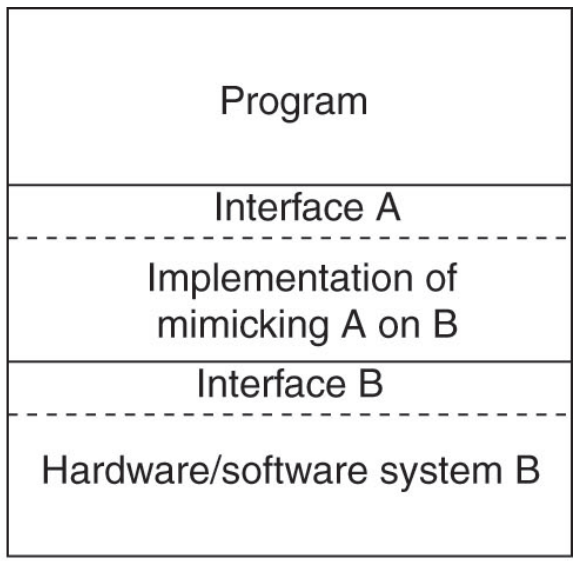



(a)




(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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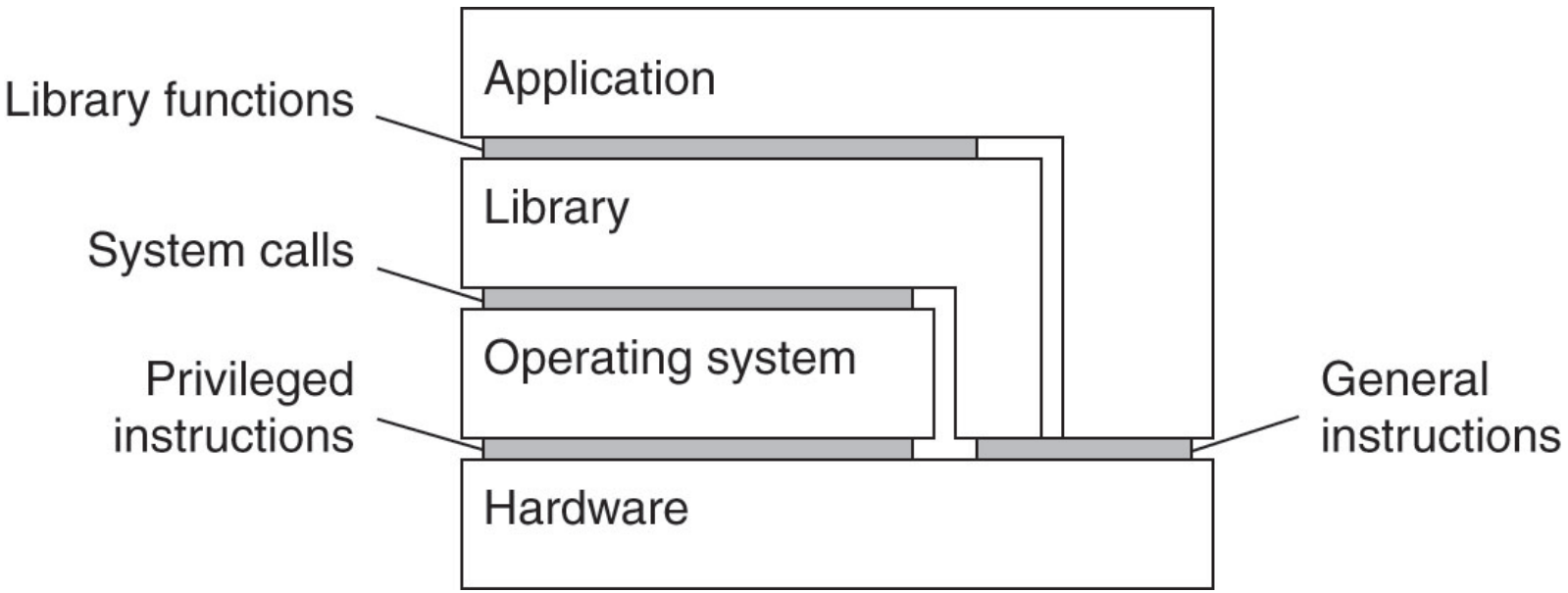

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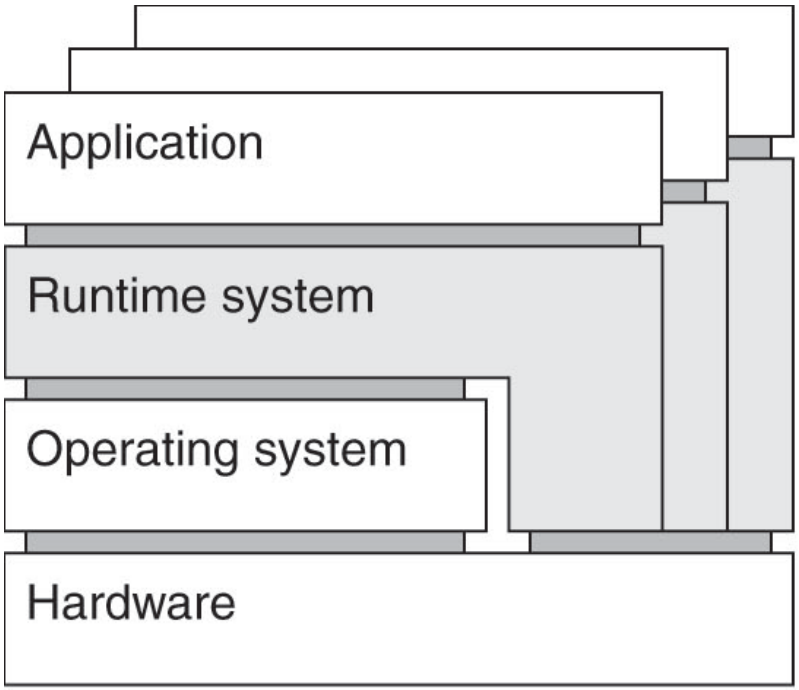


- Process Virtual Machine: An abstract instruction set that is to be used for executing applications. For example: Java Virtual Machine.

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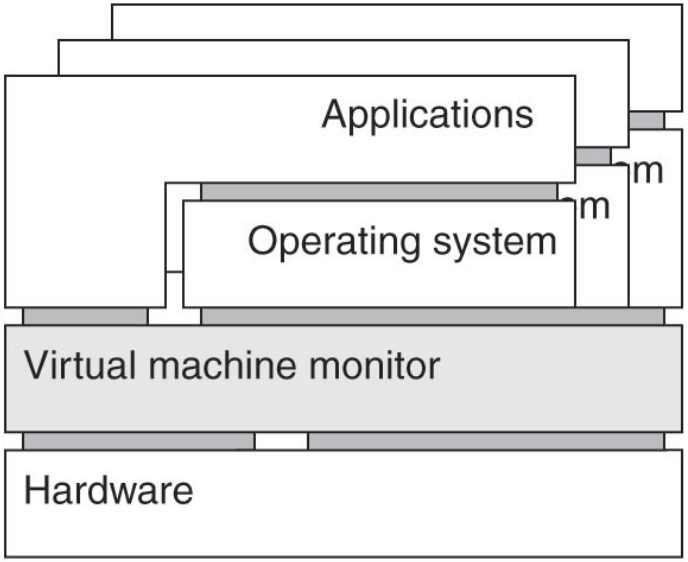

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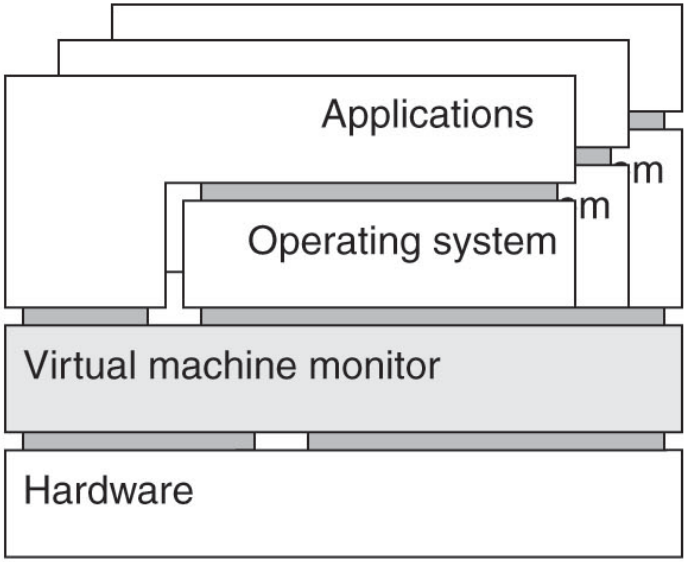


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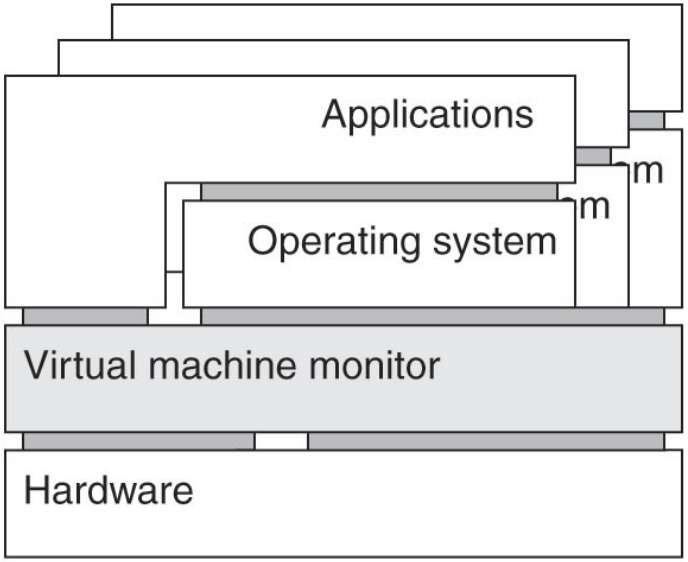


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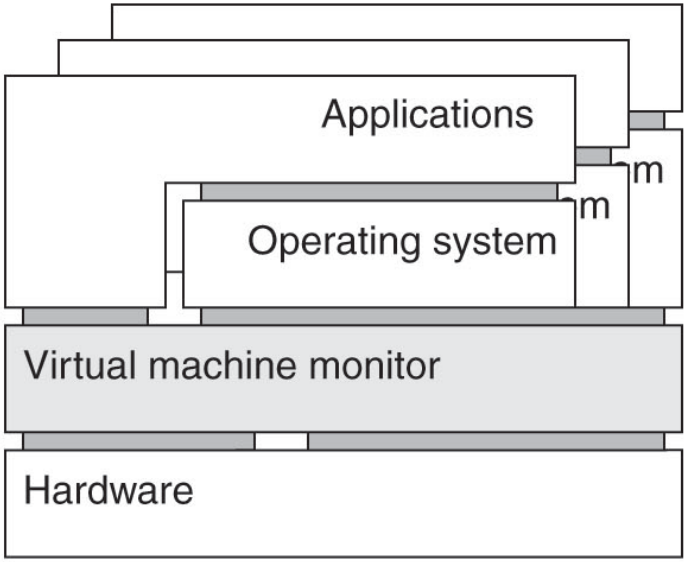


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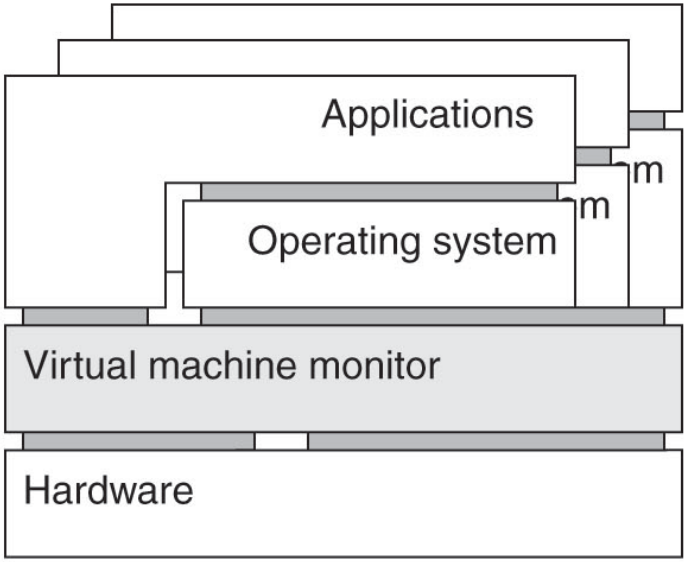


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- *Microkernel Examples*: Hyper-V, VMware ESX/ESXi, Xen, z/VM.

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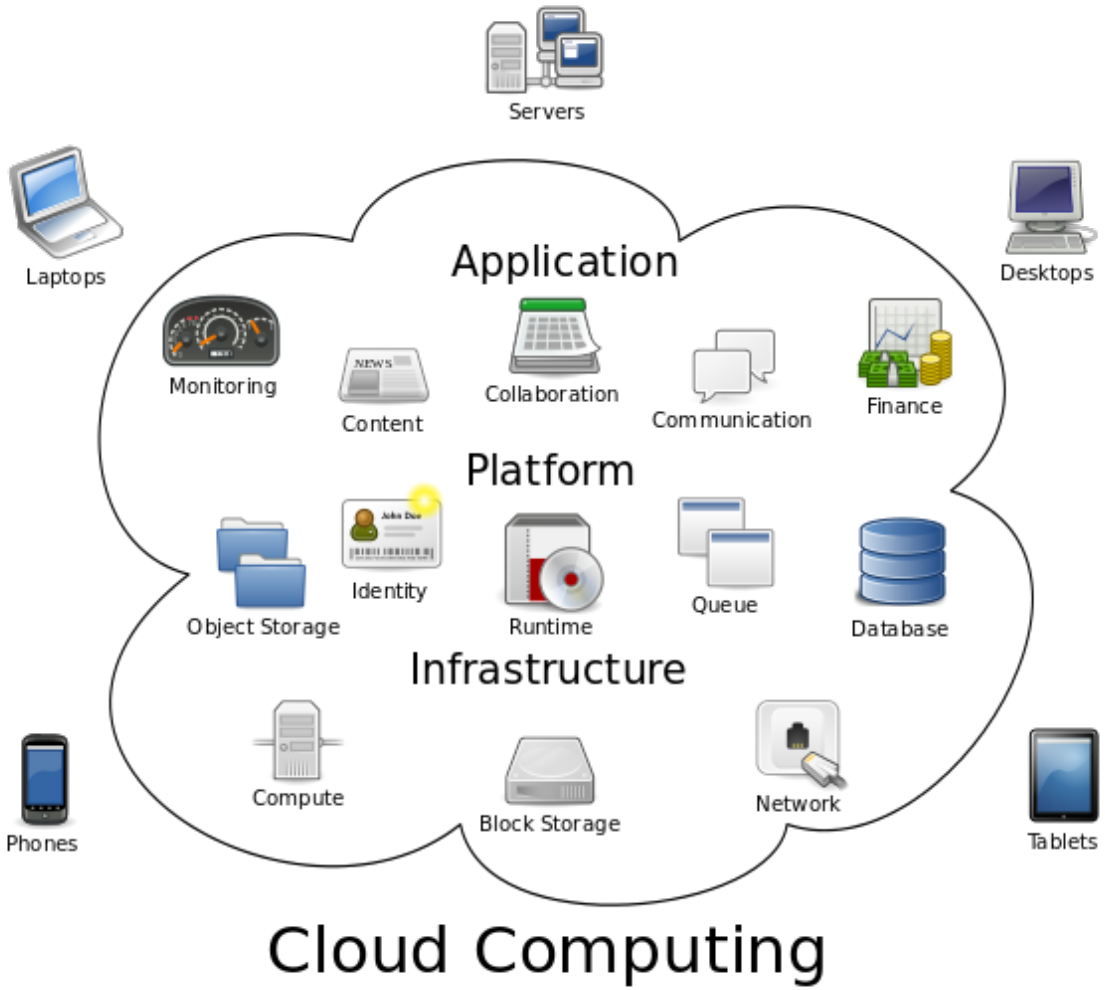
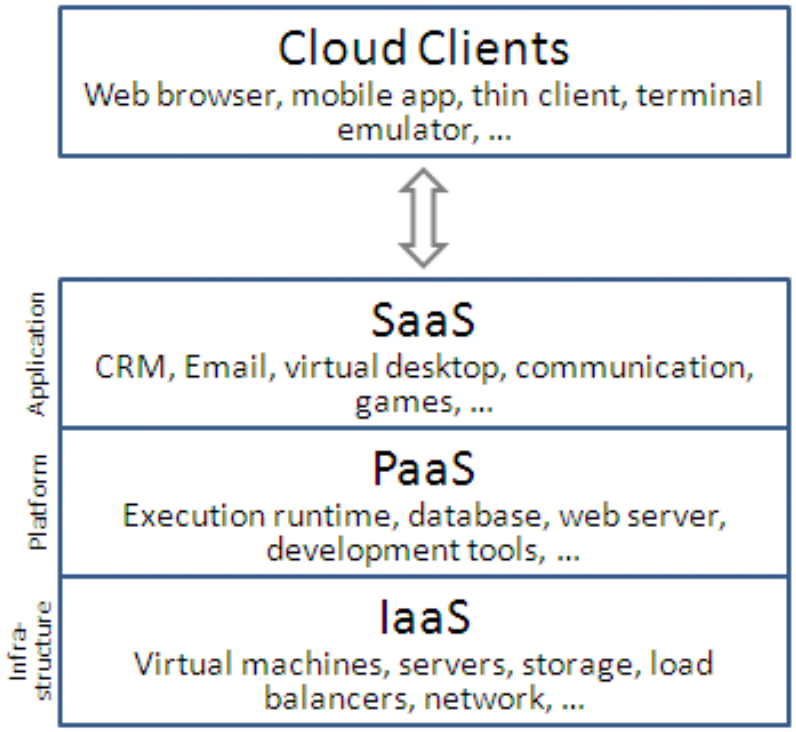
- Sandbox (Application-level). Examples: Citrix XenApp, ZeroVM.
- Containers (Environment-level). Examples: *cgroups*-based Docker and LXC (Linux Containers). Lighter weight compared to Virtual Machine Monitors.

# Cloud Computing



# Cloud Computing Layers



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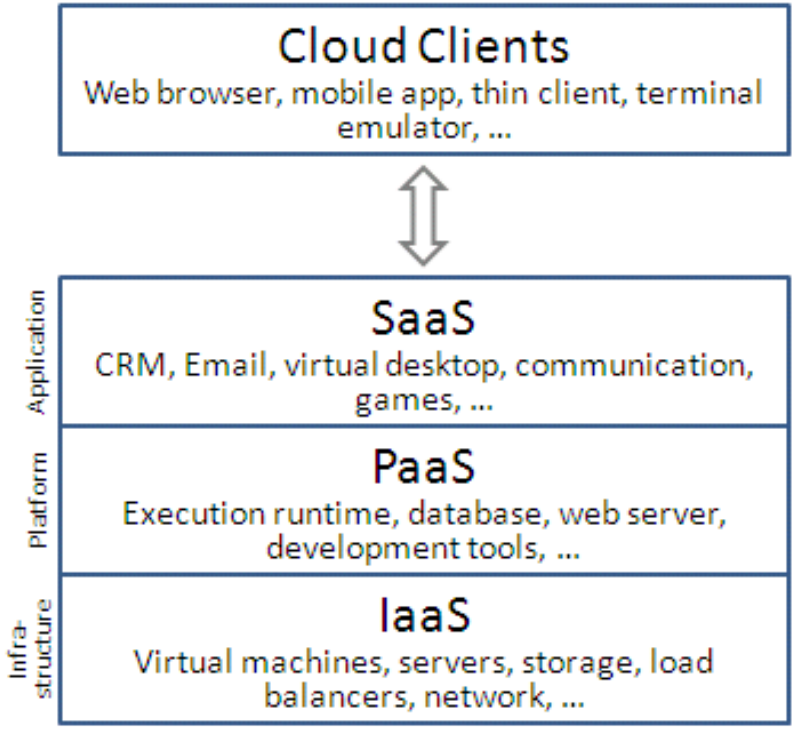


**IaaS**: Amazon Web Services, Microsoft Azure.

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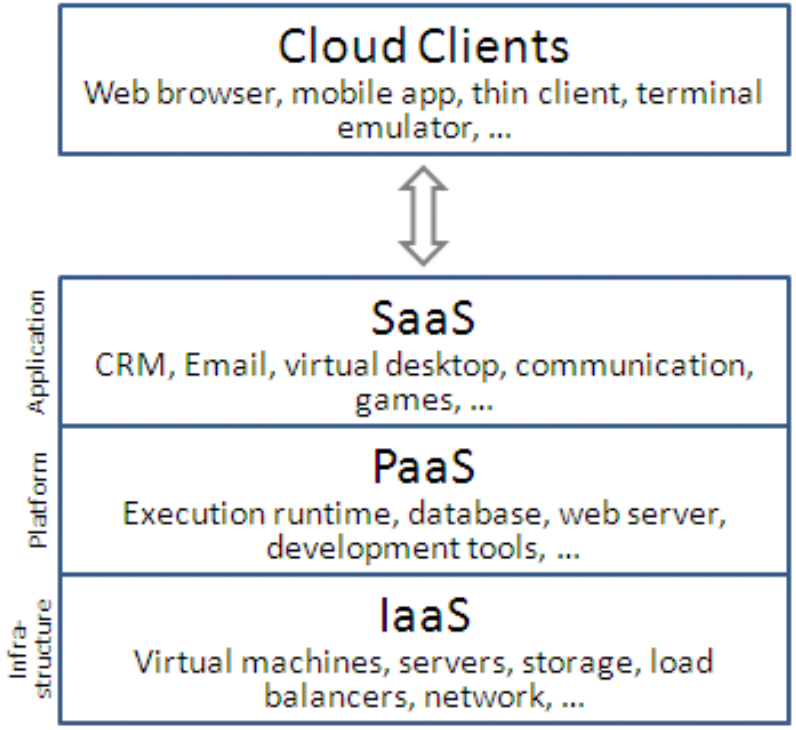


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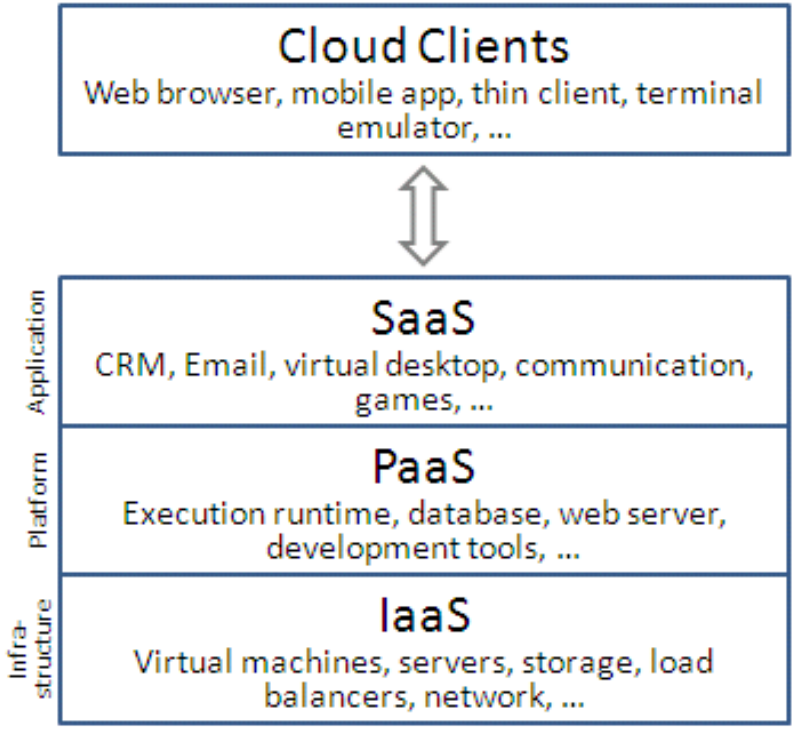
**PaaS**: Google App Engine, Microsoft Azure, Salesforce.

# Cloud Computing Layers




**IaaS**: Amazon Web Services, Microsoft Azure.

**PaaS**: Google App Engine, Microsoft Azure, Salesforce.

**SaaS**: Many companies!

# Case Study: Amazon Elastic Compute Cloud

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- Data stored in an EC2 instance is transient, that is, the data is lost when the instance stops. To persist the data, we have to use the S3 (*Simple Storage Service*) or the EBS (*Elastic Block Store*) service or EFS (*Elastic File Storage*).

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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.

# Code Migration Models (1)

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

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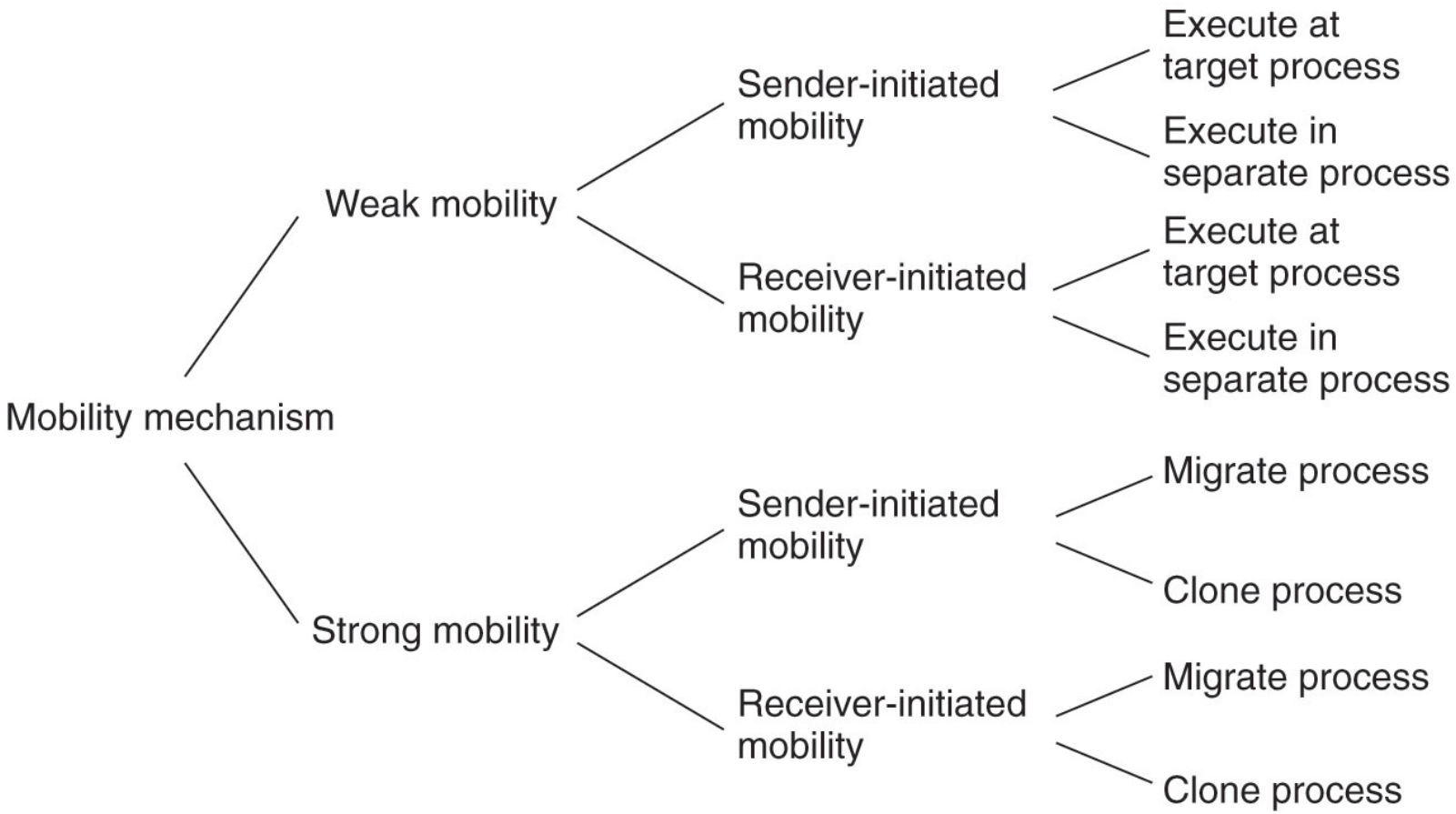
- Strong mobility: Code and execution segments can both be transferred.
- Sender-initiated versus receiver-initiated: Uploading code to a server versus downloading code from a server by a client.

# 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

| | | Resource-to-machine binding | | |
|---|---|---|---|---|
| | | Unattached | Fastened | Fixed |
| **Process-to-resource binding** | 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) |

| | |
|---|---|
| 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 running on. When $P$ moves to another machine, it still requires access to $F$. If the file-to-machine binding is fixed, how could the system wide reference to $F$ be implemented?
- Is your chat server implementation *stateless* or *stateful*? Discuss.
- Read the Wikipedia article on cloud computing.
- Read the Wikipedia article on proxy server.