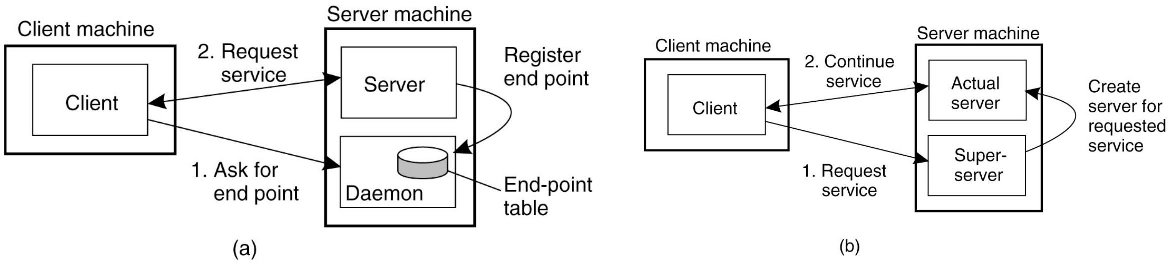
Server Design Issues

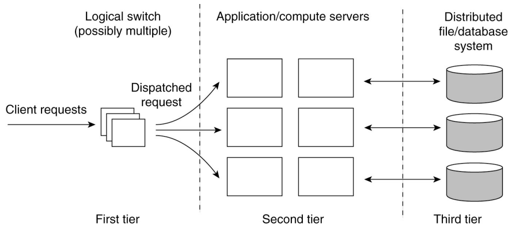


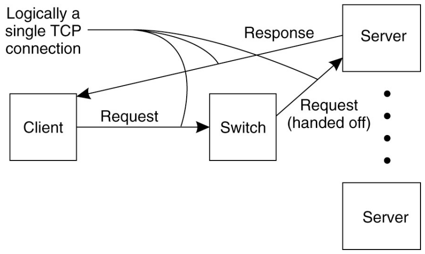
- Server Design
  - Iterative versus concurrent
- How to locate an end-point (port #)?
  - Well known port #
  - Directory service (port mapper in Unix)
  - Super server (inetd in Unix)

Stateful or Stateless?

- Stateful server
  - Maintain state of connected clients
  - Sessions in web servers
- Stateless server
  - No state for clients
- Soft state
  - Maintain state for a limited time; discarding state does not impact correctness

Server Clusters


Logical switch (possibly multiple)
Application/compute servers
Distributed file/database system
Dispatched request
Client requests
First tier
Second tier
Third tier



- Web applications use tiered architecture
  - Each tier may be optionally replicated; uses a dispatcher
  - Use TCP splicing or handoffs

Server Architecture

- Sequential
  - Serve one request at a time
  - Can service multiple requests by employing events and asynchronous communication
- Concurrent
  - Server spawns a process or thread to service each request
  - Can also use a pre-spawned pool of threads/processes (apache)
- Thus servers could be
  - Pure-sequential, event-based, thread-based, process-based
- Discussion: which architecture is most efficient?

Scalability

- *Question:*How can you scale the server capacity?
- Buy bigger machine!
- Replicate
- Distribute data and/or algorithms
- Ship code instead of data
- Cache

Code and Process Migration

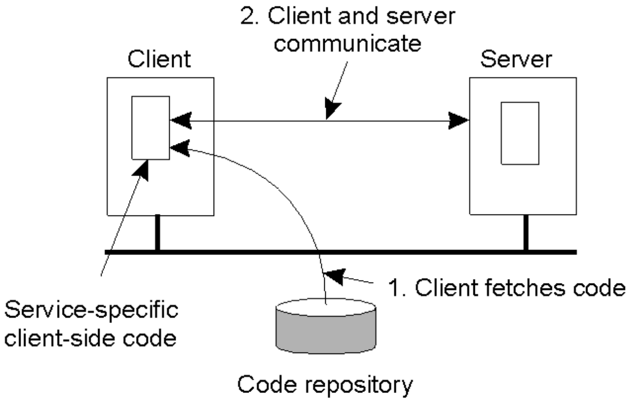
- Motivation
- How does migration occur?
- Resource migration
- Agent-based system
- Details of process migration

Motivation

- Key reasons: performance and flexibility
- Process migration (aka *strong mobility*)
  - Improved system-wide performance – better utilization of system-wide resources
  - Examples: Condor, DQS
- Code migration (aka *weak mobility)*
  - Shipment of server code to client – filling forms (reduce communication, no need to pre-link stubs with client)
  - Ship parts of client application to server instead of data from server to client (e.g., databases)
  - Improve parallelism – agent-based web searches

Motivation

- Flexibility
  - Dynamic configuration of distributed system
  - Clients don't need preinstalled software – download on demand


2. Client and server communicate
Client
Server
1. Client fetches code
Service-specific client-side code
Code repository

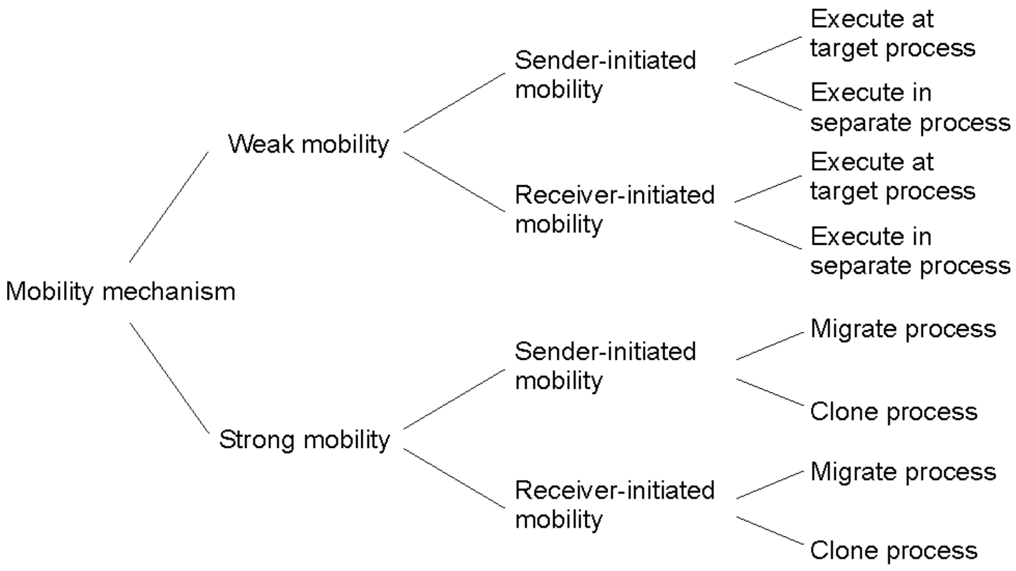
Migration models

- Process = code seg + resource seg + execution seg
- Weak versus strong mobility
  - Weak => transferred program starts from initial state
- Sender-initiated versus receiver-initiated
- Sender-initiated
  - migration initiated by machine where code resides
    - Client sending a query to database server
      - Client should be pre-registered
- Receiver-initiated
  - Migration initiated by machine that receives code
  - Java applets
  - Receiver can be anonymous

Who executes migrated entity?

- Code migration:
  - Execute in a separate process
  - [Applets] Execute in target process
- Process migration
  - Remote cloning
  - Migrate the process

Models for Code Migration


Mobility mechanism
Weak mobility
Strong mobility
Sender-initiated mobility
Receiver-initiated mobility
Sender-initiated mobility
Receiver-initiated mobility
Execute at target process
Execute in separate process
Execute at target process
Execute in separate process
Migrate process
Clone process
Migrate process
Clone process

Do Resources Migrate?

- Depends on resource to process binding
  - By identifier: specific web site, ftp server
  - By value: Java libraries
  - By type: printers, local devices
- Depends on type of “attachments”
  - Unattached to any node: data files
  - Fastened resources (can be moved only at high cost)
    - Database, web sites
  - Fixed resources
    - Local devices, **communication end points**

Resource Migration Actions

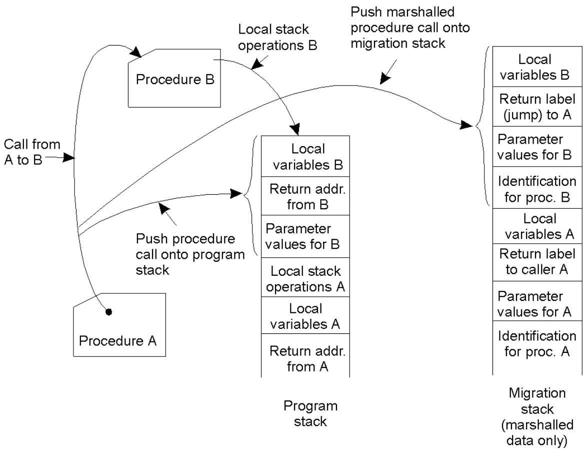
Resource-to machine binding

		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 GR, CP)	RB (or GR, CP)	RB (or GR)

- Actions to be taken with respect to the references to local resources when migrating code to another machine.
- GR: establish global system-wide reference
- MV: move the resources
- CP: copy the resource
- RB: rebind process to locally available resource

Migration in Heterogeneous Systems

- Systems can be heterogeneous (different architecture, OS)
  - Support only weak mobility: recompile code, no run time information
  - Strong mobility: recompile code segment, transfer execution segment [migration stack]
  - Virtual machines - interpret source (scripts) or intermediate code [Java]



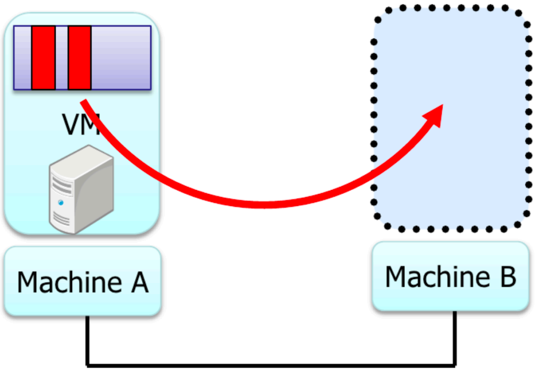
Virtual Machine Migration

- VMs can be migrates from one physical machine to another
- Migration can be live - no application downtime
- Iterative copying of memory state
- How are network connections handled?

- Inherently migrates the OS and all its processes

Pre-Copy VM Migration

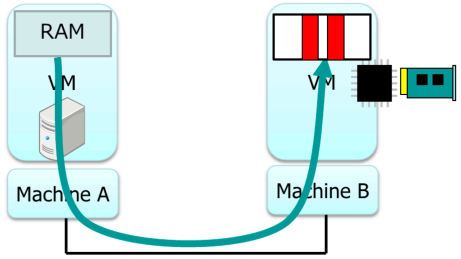
- 1. Enable dirty page tracking
- 2. Copy all memory pages to destination
- 3. Copy memory pages dirtied during the previous copy again
- 4. Repeat 3rd step until the rest of memory pages is small.
- 5. Stop VM
- 6. Copy the rest of memory pages and
- non-memory VM states
- 7. Resume VM at destination



Figures Courtesy: Isaku Yamahata, LinuxCon Japan 2012

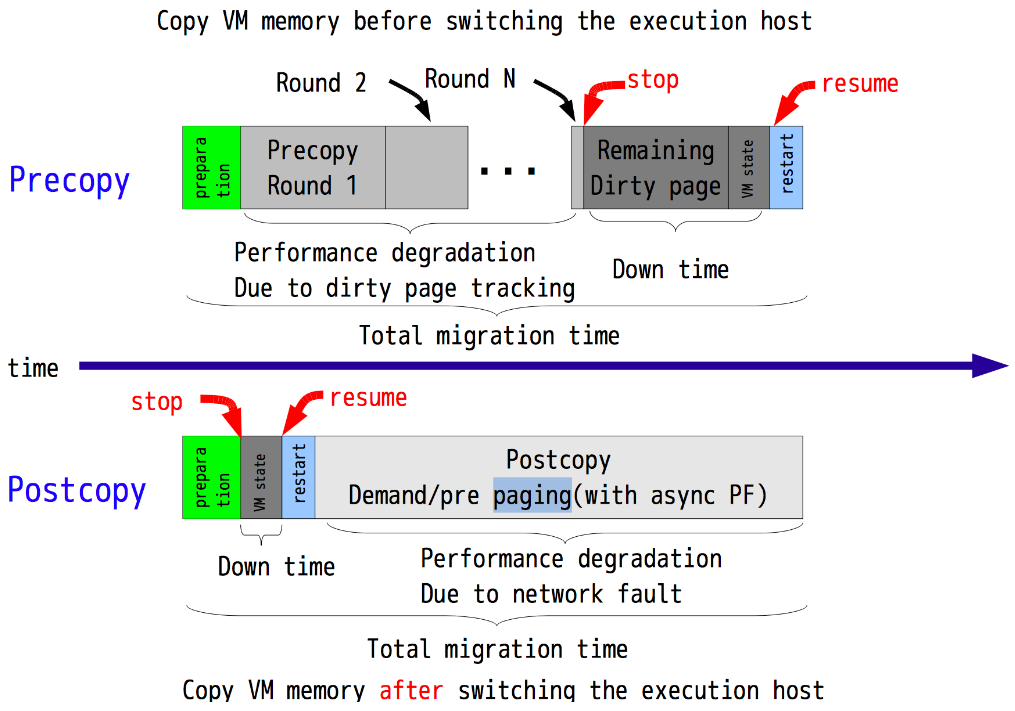
Post-Copy VM Migration

- 1. Stop VM
- 2. Copy non-memory VM states to destination
- 3. Resume VM at destination
- 4. Copy memory pages on-demand/background
  - Async page fault can be utilized



Copy memory pages
•On-demand(network fault)
•background(precache)

VM Migration Time



Copy VM memory before switching the execution host

Round 2 Round N stop resume

Precopy

preparation | Precopy Round 1 | ... | Remaining Dirty page | VM state | restart

Performance degradation
Due to dirty page tracking

Down time

Total migration time

time

stop resume

Postcopy

preparation | VM state | restart | Postcopy Demand/pre paging(with async PF)

Down time

Performance degradation
Due to network fault

Total migration time

Copy VM memory after switching the execution host

Figure Courtesy: Isaku Yamahata, LinuxCon Japan 2012

Case Study: Viruses and Malware

- Viruses and malware are examples of mobile code
  - Malicious code spreads from one machine to another
- Sender-initiated:
  - proactive viruses that look for machines to infect
    - Autonomous code
- Receiver-initiated
  - User (receiver) clicks on infected web URL or opens an infected email attachment