CSE 4/521 Introduction to Operating Systems

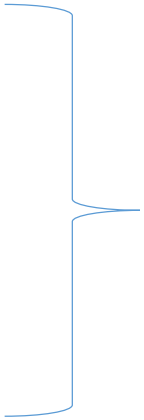
Lecture 2 – Introduction 2

(Storage Management, Protection and Security, Kernel Data Structures, Computing Environments, Open-Source Operating Systems)

Summer 2018

Overview

- What Operating Systems Do
- Computer-System Architecture
- Operating-System Structure
- Operating-System Operations
- Process Management
- Memory Management
- Storage Management
- Protection and Security
- Kernel Data Structures
- Computing Environments
- Open-Source Operating Systems



Previous Lecture

Recap

- What Operating Systems Do
  - Definition and goals of an Operating System.
- Computer-System Architecture
  - Single processor and multi-processor system.
- Operating-System Structure
  - Multiprogramming and timesharing system.
- Operating-System Operations
  - Interrupt driven and dual-mode.
- Process Management
  - What is a process? Single-threaded and multi-threaded process.
- Memory Management
  - Determines what instructions and data needs to be in memory.

Questions

1. What are the 3 goals of the operating system? (Easy)

2. Under what circumstances would a user be better off using a time-sharing system than a multi-programming workstation. (Medium)

3. Some CPUs provide for more than two modes of operation. What are two possible uses of these multiple modes? (Hard)

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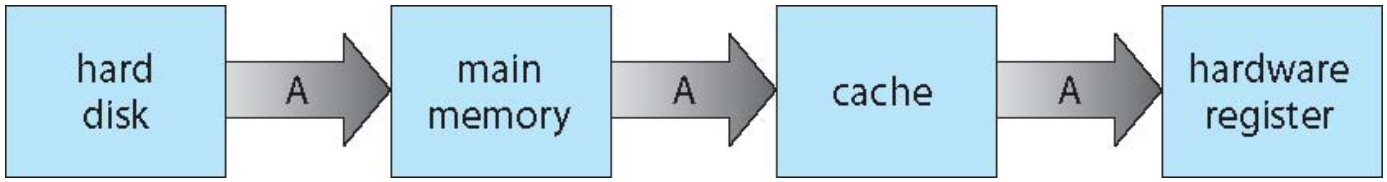
Storage Management

- Migration of data ‘A’ from Disk to Register



- Multitasking environments must be careful to use most recent value, no matter where it is stored in the storage hierarchy
- Multiprocessor environment must provide cache coherency in hardware such that all CPUs have the most recent value in their cache

Storage Management

Level	1	2	3	4	5
Name	registers	cache	main memory	solid state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25 - 0.5	0.5 - 25	80 - 250	25,000 - 50,000	5,000,000
Bandwidth (MB/sec)	20,000 - 100,000	5,000 - 10,000	1,000 - 5,000	500	20 - 150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

Movement between levels of storage hierarchy can be explicit or implicit

OS activities

- Free-space management
- Storage allocation
- Disk scheduling

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Protection and Security

- Protection – any mechanism for controlling access of processes or users to resources defined by the OS
- Security – defense of the system against internal and external attacks
  - Denial-of-service, worms, viruses, identity theft, theft of service
- Systems generally first distinguish among users, to determine who can do what
  - User identities (user IDs, security IDs) include name and associated number, one per user
  - Group identifier (group ID) allows set of users to be defined and controls managed, then also associated with each process, file
  - Privilege escalation allows user to change to effective ID with more rights

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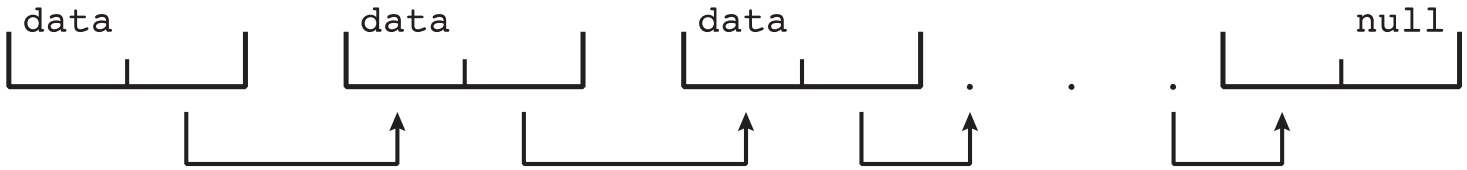
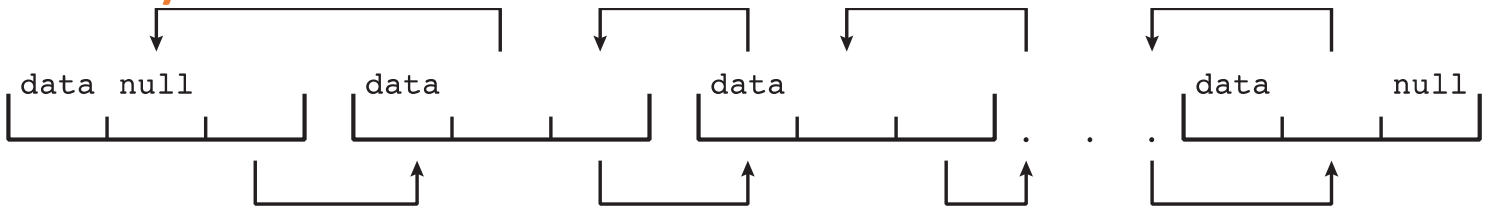
Kernel Data Structures

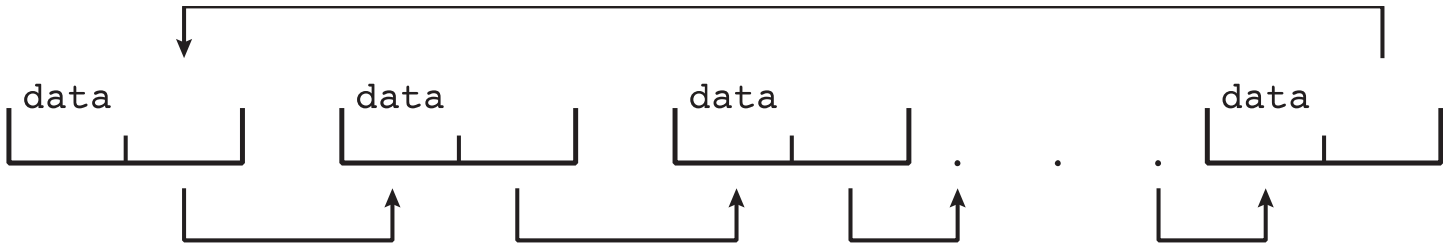
- Singly linked list



- Doubly linked list

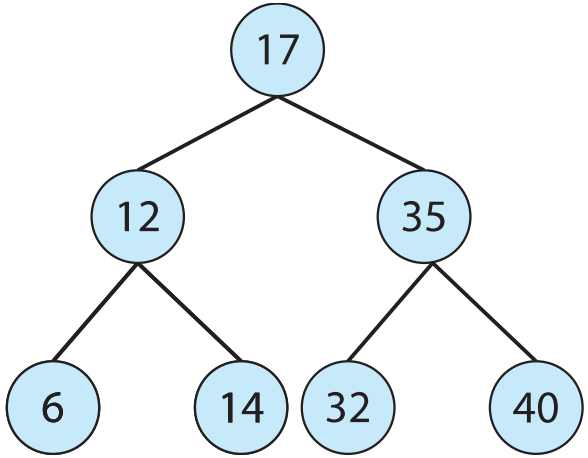


- Circular linked list



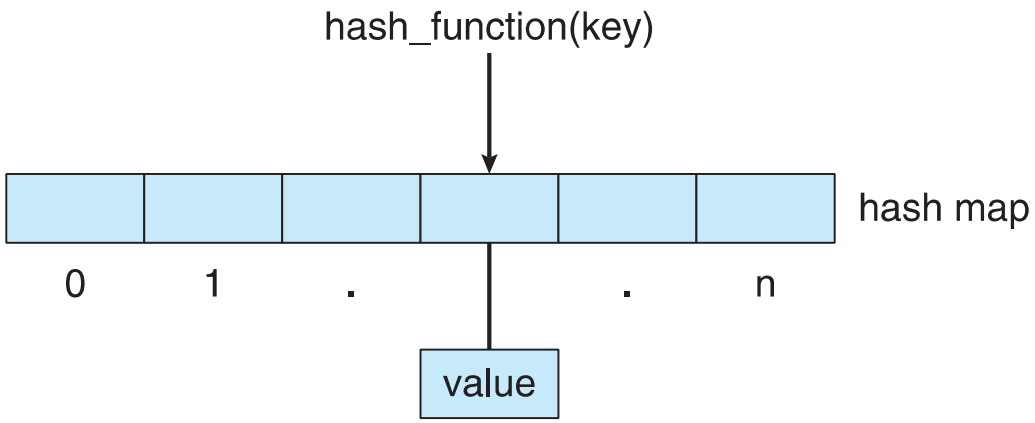
Kernel Data Structures

- Binary search tree
  left <= right
  - Search performance is *O(n)*
  - Comparisons in Balanced binary search tree is *O(lg n)*



Kernel Data Structures

- **Hash function** can create a **hash map**



- **Bitmap** – string of *n* binary digits representing the status of *n* items
- Linux data structures defined in

  include files `<linux/list.h>, <linux/kfifo.h>, <linux/rbtree.h>`

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Computing Environments

1. Traditional
2. Mobile
3. Distributed
   - Client-Server
   - Peer-to-Peer
4. Virtualization
5. Cloud Computing

Computing Environments - Traditional

- Stand-alone general purpose machines
- But blurred as most systems interconnect with others (i.e., the Internet)
- Portals provide web access to internal systems
- Networking becoming ubiquitous – even home systems use firewalls to protect home computers from Internet attacks

Computing Environments - Mobile

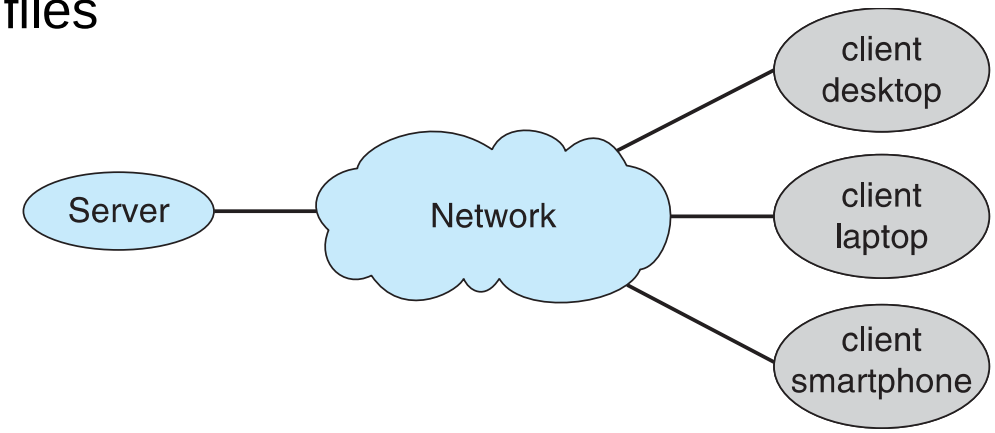
- Handheld smartphones, tablets, etc
- Extra feature – more OS features (GPS, gyroscope)
- Allows new types of apps like augmented reality
- Use IEEE 802.11 wireless, or cellular data networks for connectivity
- Leaders are Apple iOS and Google Android

Computing Environments - Distributed

- Collection of separate, possibly heterogeneous, systems networked together
  - Network is a communications path, TCP/IP most common
    - Local Area Network (LAN)
    - Wide Area Network (WAN)
    - Metropolitan Area Network (MAN)
    - Personal Area Network (PAN)
- Network Operating System provides features between systems across network
  - Communication scheme allows systems to exchange messages
  - Illusion of a single system

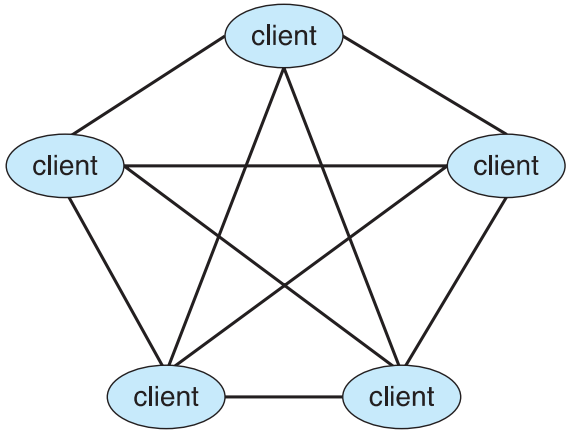
Computing Environments – Distributed Client-Server

- Dumb terminals supplanted by smart PCs
- Many systems now servers, responding to requests generated by clients
  - Compute-server system provides an interface to client to request services (i.e., database)
  - File-server system provides interface for clients to store and retrieve files



Computing Environments – Distributed Peer-to-Peer

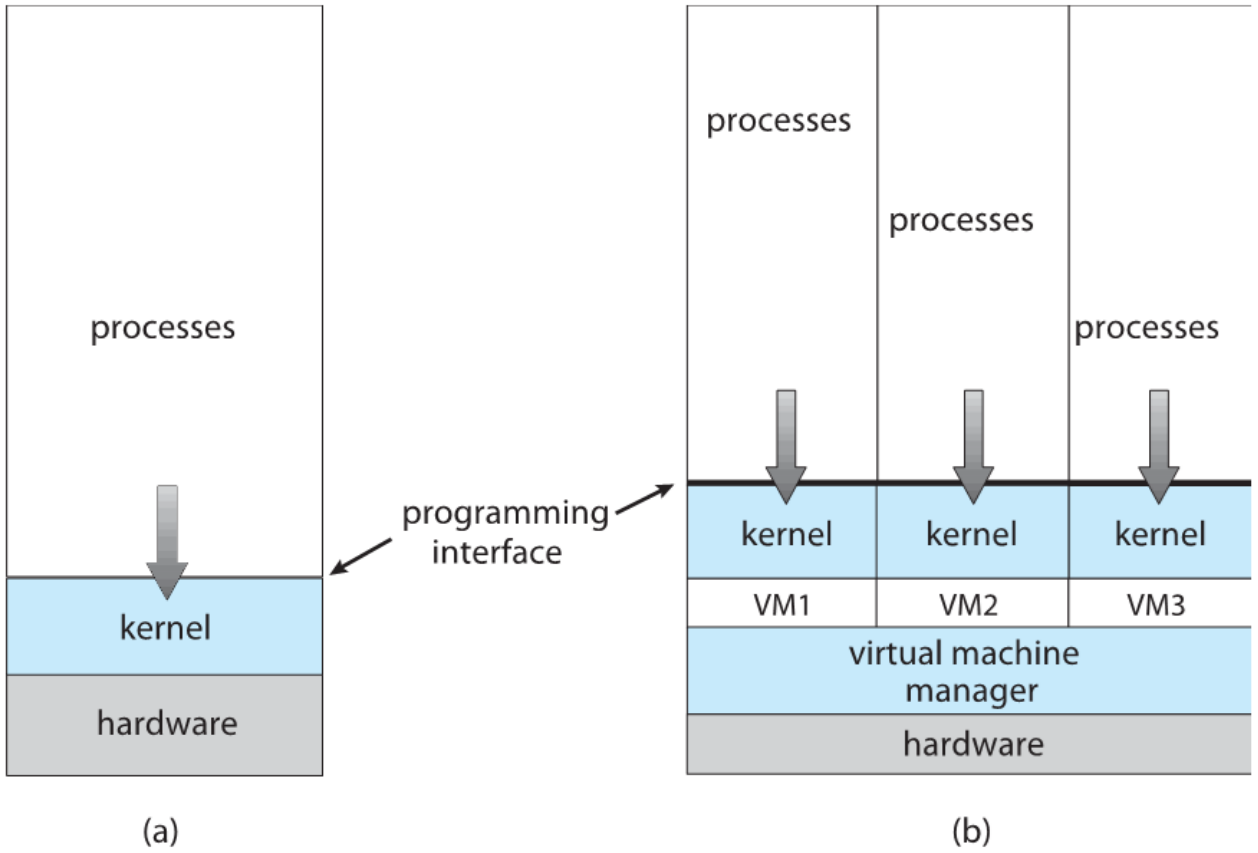
- Another model of distributed system
- P2P does not distinguish clients and servers
  - Instead all nodes are considered peers
  - May each act as client, server or both
  - Node must join P2P network
    - Registers its service with central lookup service on network, or
    - Broadcast request for service and respond to requests for service via discovery protocol
  - Examples include Napster and Gnutella, Voice over IP (VoIP) such as Skype



Computing Environments - Virtualization

- Use cases involve laptops and desktops running multiple OSes for exploration or compatibility
  - Apple laptop running Mac OS X host, Windows as a guest
  - Developing apps for multiple OSes without having multiple systems
  - Executing and managing compute environments within data centers
- VMM can run natively, in which case they are also the host
  - e.g.: VMware ESX, Citrix XenServer, VirtualBox

Computing Environment - Virtualization

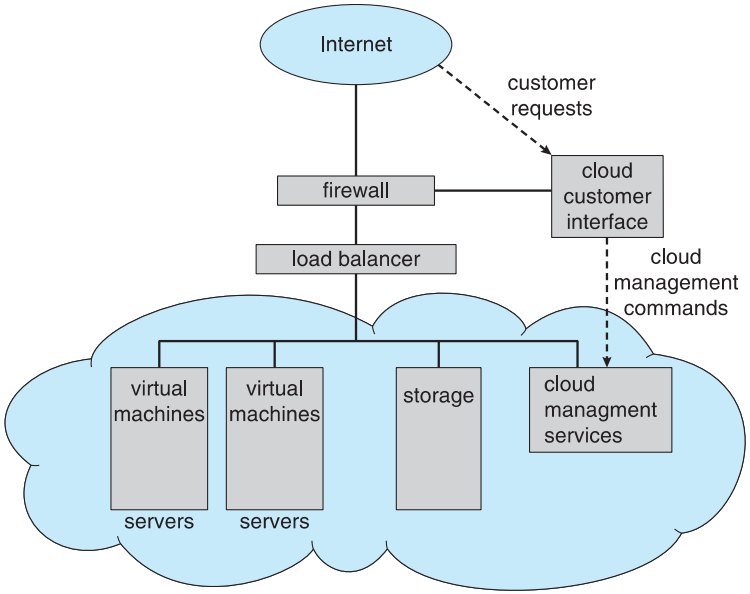


Computing Environments – Cloud Computing

- Delivers computing, storage, even apps as a service across a network
- Logical extension of virtualization because it uses virtualization as the base for it functionality. (e.g., Amazon EC2)
- Many types
  - Public cloud – available via Internet to anyone willing to pay
  - Private cloud – run by a company for the company's own use
  - Hybrid cloud – includes both public and private cloud components
  - Software as a Service (SaaS) – use applications over Internet (e.g., word processor)
  - Platform as a Service (PaaS) – software stack over Internet(i.e., a database server)
  - Infrastructure as a Service (IaaS) – servers or storage over Internet (i.e., storage available for backup use)

Computing Environments – Cloud Computing

- Cloud computing environments composed of traditional OSes, plus VMMs, plus cloud management tools
  - Internet connectivity requires security like firewalls
  - Load balancers spread traffic across multiple applications



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Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary closed-source
- But Free Software Foundation (FSF), provides free OS for exploration using GNU Public License (GPL)
- Examples include GNU/Linux and BSD UNIX (including core of Mac OS X), and many more
- Use Virtualbox (http://www.virtualbox.com) to run guest operating systems for exploration

Credential for slides

Silberschatz, Galvin and Gagne