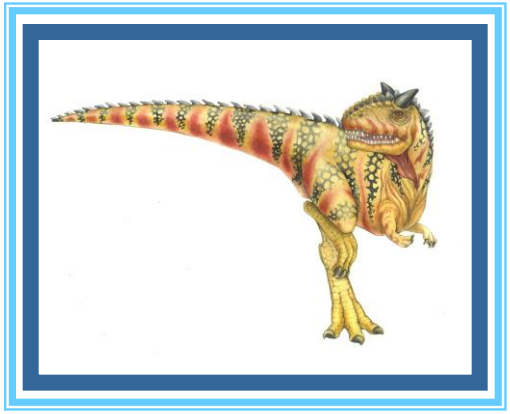
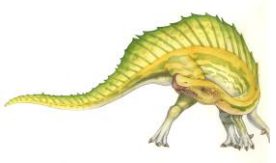
Chapter 1: Introduction



Chapter 1: Introduction

1. What Operating Systems Do
2. Computer-System Organization
3. Computer-System Architecture
4. Operating-System Structure
5. Operating-System Operations
6. Process Management
7. Memory Management
8. Storage Management
9. **Protection and Security**
10. **Kernel Data Structures**
11. **Computing Environments**
12. **Open-Source Operating Systems**

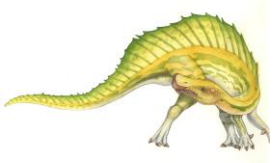
1.9 PROTECTION AND SECURITY



Protection and Security

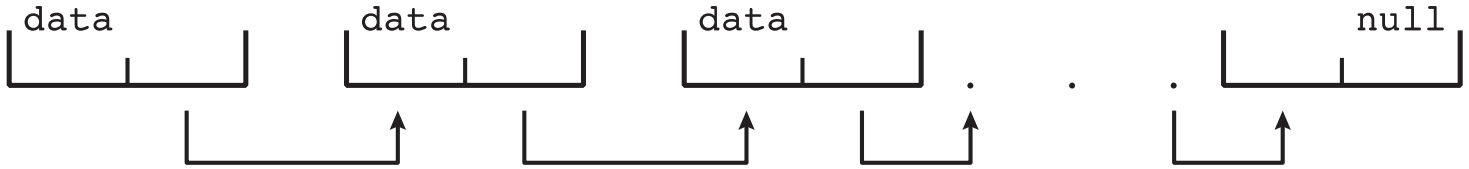
- **Protection** – any mechanism for controlling access of processes or users to resources defined by the OS
- **Security** – defense of the system against internal and external attacks
  - Huge range, including denial-of-service, worms, viruses, identity theft, theft of service
- Systems generally first distinguish among users, to determine who can do what
  - User identities (**user IDs**, security IDs) include name and associated number, one per user
  - User ID then associated with all files, processes of that user to determine access control
  - 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

1.10 KERNEL DATA STRUCTURES

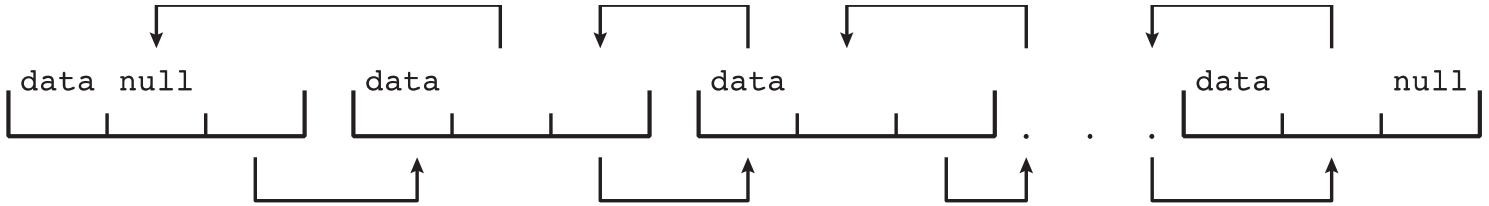


1.10.1 Lists, Stacks, and Queues

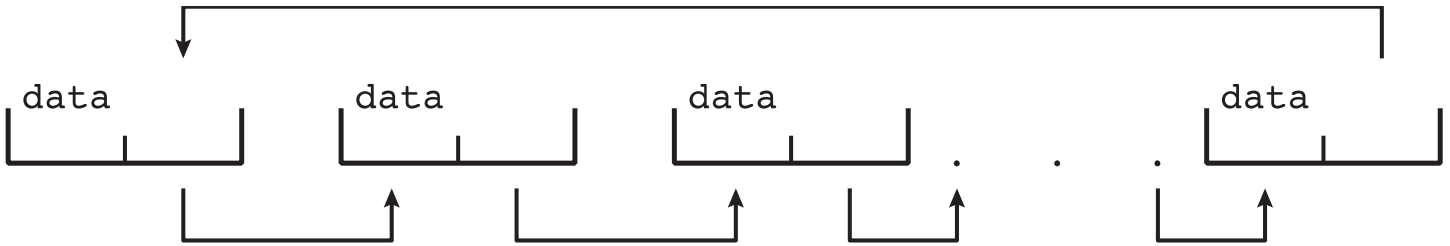
- Many similar to standard programming data structures
- ***Singly linked list***

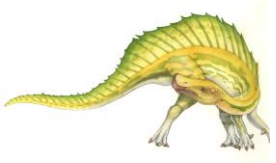


- ***Doubly linked list***



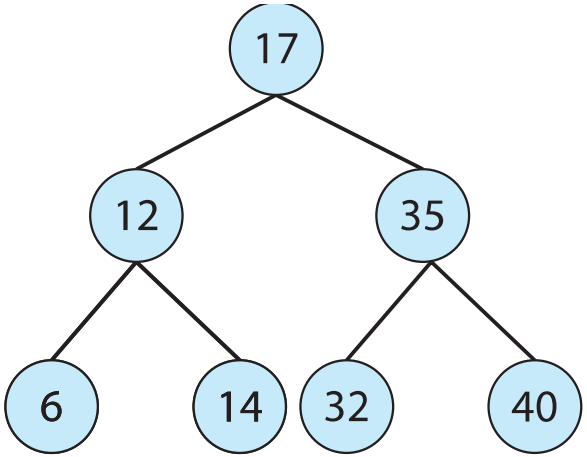
- ***Circular linked list***

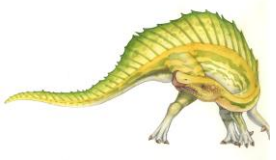




1.10.2 Trees

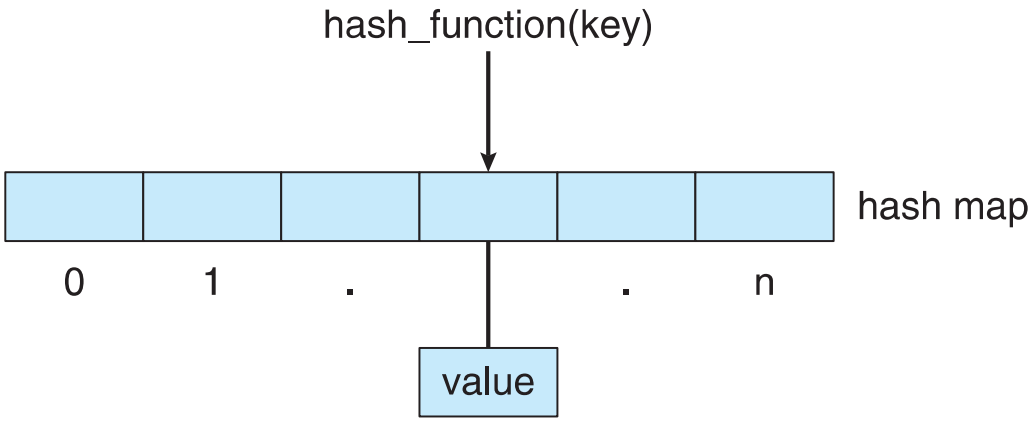
- **Binary search tree**
  left <= right
  - Search performance is *O(n)*
  - **Balanced binary search tree** is *O(lg n)*

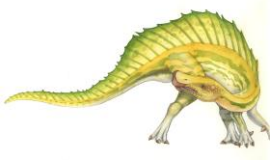




1.10.3 Hash Functions and Maps

- O(1)
- ***hash collision***
- **Hash function** can create a **hash map**
  - associates (or ***maps***) [key:value] pairs using a hash function



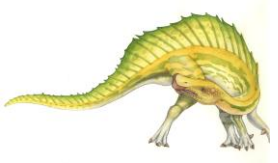


1.10.4 Bitmaps

- **Bitmap** – string of *n* binary digits representing the status of *n* items
  - the availability of each resource is indicated by the value of a binary digit: 0 means that the resource is available, while 1 indicates that it is unavailable (or vice-versa)
  - 001011101

- Linux data structures defined in

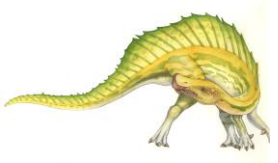
  include files `<linux/list.h>, <linux/kfifo.h>, <linux/rbtree.h>`



1.11 COMPUTING ENVIRONMENTS

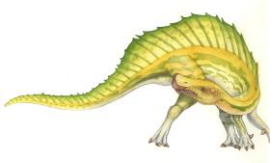
1.11.1 Traditional Computing

- Stand-alone general purpose machines
- But blurred as most systems interconnect with others (i.e., the Internet)
- **Portals** provide web access to internal systems
- **Network computers** (**thin clients**) are like Web terminals
- Mobile computers interconnect via **wireless networks**
- Networking becoming ubiquitous – even home systems use **firewalls** to protect home computers from Internet attacks



1.11.2 Mobile Computing

- Handheld smartphones, tablets, etc
- What is the functional difference between them and a “traditional” laptop?
  - 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**

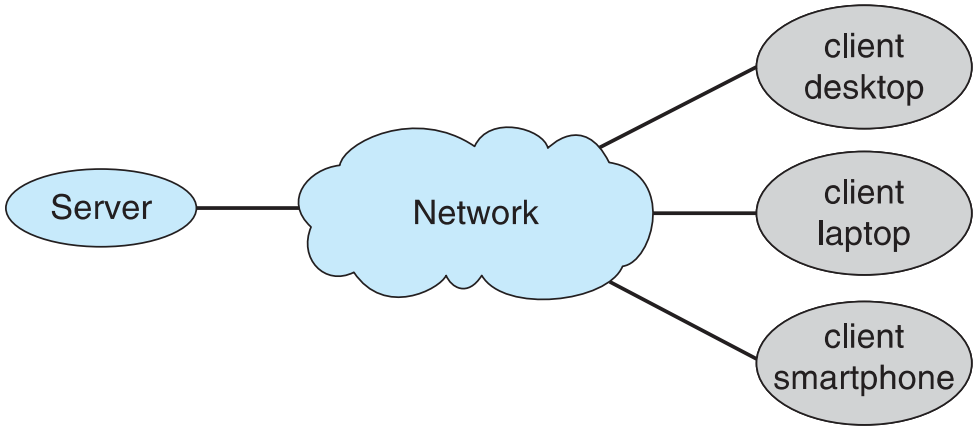


1.11.3 Distributed Systems

- Distributed computing
  - 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

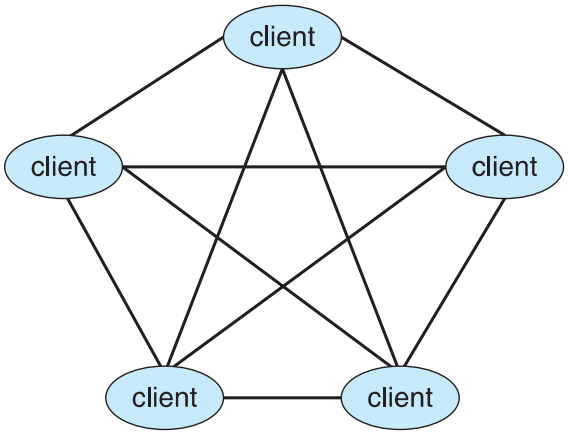
1.11.4 Client–Server Computing

- Client-Server Computing
  - 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

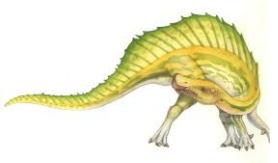


1.11.5 Peer-to-Peer Computing

- Another model of distributed system

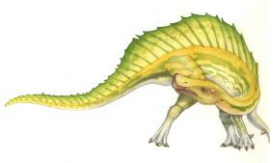


- P2P does not distinguish clients and servers
  - Instead all nodes are considered peers
  - May each act as client, server or both
  - Node must join P2P network
    - Registers its service with central lookup service on network, or
    - Broadcast request for service and respond to requests for service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

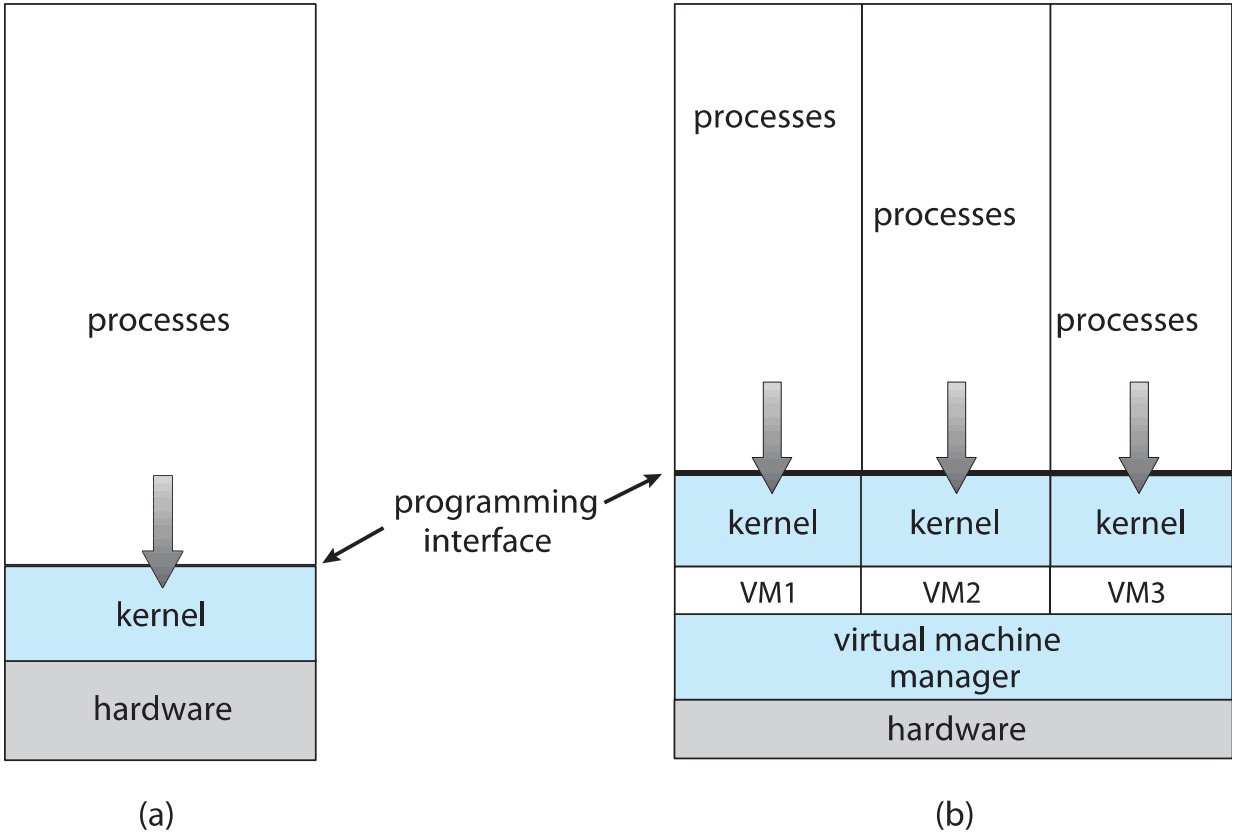


1.11.6 Virtualization (1)

- Allows operating systems to run applications within other OSes
  - Vast and growing industry
- **Emulation** used when source CPU type different from target type (i.e. PowerPC to Intel x86)
  - Generally slowest method
  - When computer language not compiled to native code – **Interpretation**
- **Virtualization** – OS natively compiled for CPU, running **guest** OSes also natively compiled
  - Consider VMware running WinXP guests, each running applications, all on native WinXP **host** OS
  - **VMM** (virtual machine Manager) provides virtualization services

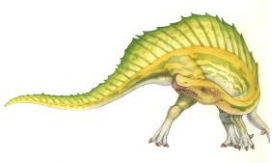


1.11.6 Virtualization (2)



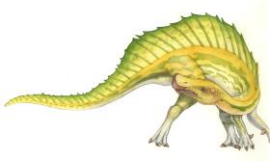
1.11.6 Virtualization (3)

- 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
  - QA testing applications without having multiple systems
  - Executing and managing compute environments within data centers
- VMM can run natively, in which case they are also the host
  - There is no general purpose host then (VMware ESX and Citrix XenServer)



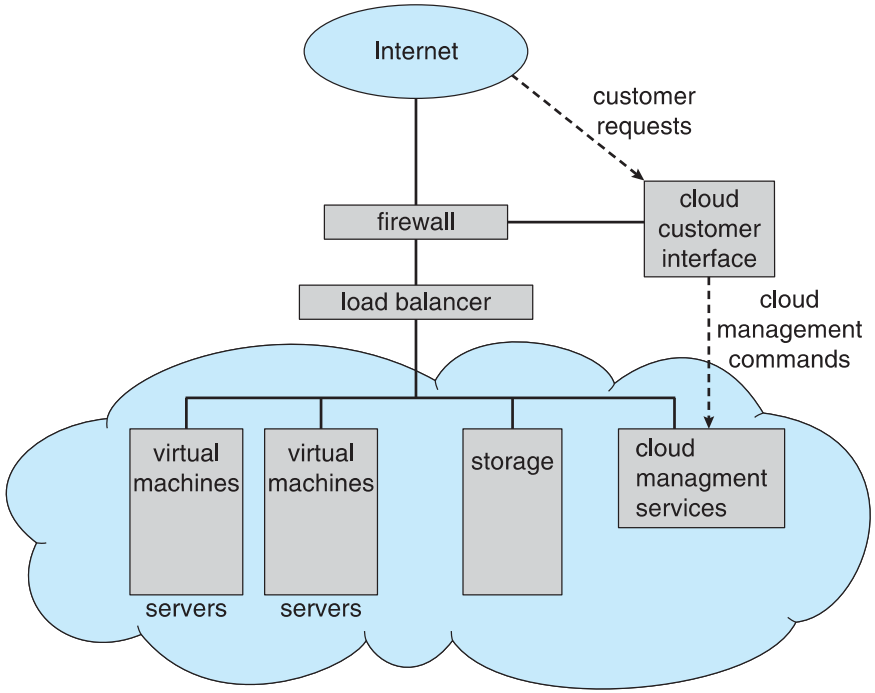
1.11.7 Cloud Computing (1)

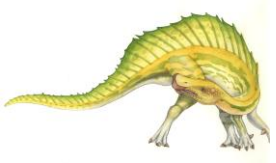
- Delivers computing, storage, even apps as a service across a network
- Logical extension of virtualization because it uses virtualization as the base for it functionality.
  - Amazon **EC2** has thousands of servers, millions of virtual machines, petabytes of storage available across the Internet, pay based on usage
- 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**) – one or more applications available via the Internet (i.e., word processor)
  - Platform as a Service (**PaaS**) – software stack ready for application use via the Internet (i.e., a database server)
  - Infrastructure as a Service (**IaaS**) – servers or storage available over Internet (i.e., storage available for backup use)



1.11.7 Cloud Computing (2)

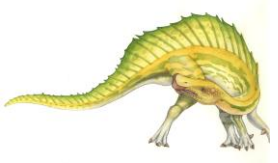
- Cloud computing environments composed of traditional OSes, plus VMMs, plus cloud management tools
  - Internet connectivity requires security like firewalls
  - Load balancers spread traffic across multiple applications



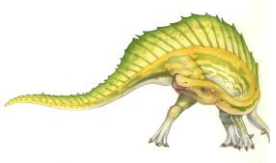


1.11.8 Real-Time Embedded Systems

- Real-time embedded systems most prevalent form of computers
  - Vary considerable, special purpose, limited purpose OS, **real-time OS**
  - Use expanding
- Many other special computing environments as well
  - Some have OSes, some perform tasks without an OS
- Real-time OS has well-defined fixed time constraints
  - Processing must be done within constraint
  - Correct operation only if constraints met



1.12 OPEN-SOURCE OPERATING SYSTEMS



1.12 Open-Source Operating Systems

- Operating systems made available in source-code format rather than just binary **closed-source**
- Counter to the **copy protection** and **Digital Rights Management (DRM)** movement
- Started by **Free Software Foundation (FSF)**, which has “copyleft” **GNU Public License (GPL)**
- Examples include **GNU/Linux** and **BSD UNIX** (including core of **Mac OS X**), and many more
- Can use VMM like VMware Player (Free on Windows), Virtualbox (open source and free on many platforms - http://www.virtualbox.com)
  - Use to run guest operating systems for exploration

End of Chapter 1