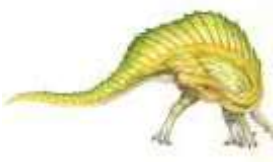


Computing Environments - Traditional

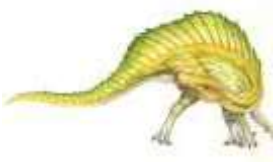
- Stand-alone general purpose machines
- But blurred as most systems interconnect with others (i.e., t he Internet)
- **Portals** provide web access to internal systems
- **Network computers** (**thin clients**) are like Web terminals
- Mobile computers interconnect via **wireless networks**
- Networking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





Computing Environments - Mobile

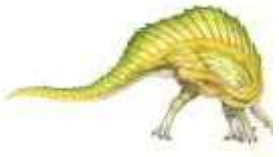
- Handheld smartphones, tablets, etc
- What is the functional difference between them and a “traditio nal” laptop?
- Extra feature – more OS features (GPS, gyroscope)
- Allows new types of apps like ***augmented reality***
- Use IEEE 802.11 wireless, or cellular data networks for conne ctivity
- Leaders are **Apple iOS** and **Google Android**





Computing Environments – Distributed

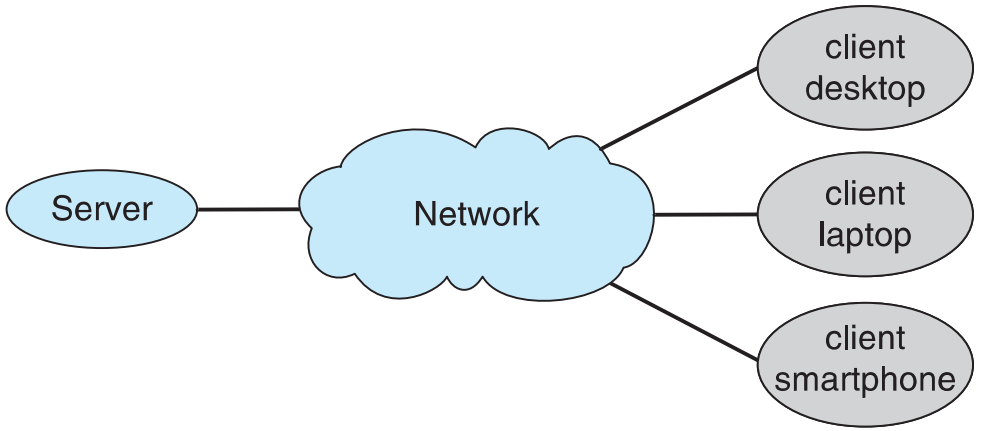
- Distributed computiing
  - Collection of separate, possibly heterogeneous, systems netw orked together
    - **Network** is a communications path, **TCP/IP** most common
      - **Local Area Network** (**LAN**)
      - **Wide Area Network** (**WAN**)
      - **Metropolitan Area Network** (**MAN**)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

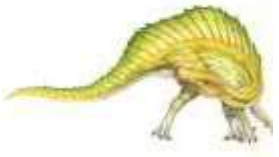




Computing Environments – Client-Server

- 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 r equest services (i.e., database)
    - **File-server system** provides interface for clients to store an d retrieve files

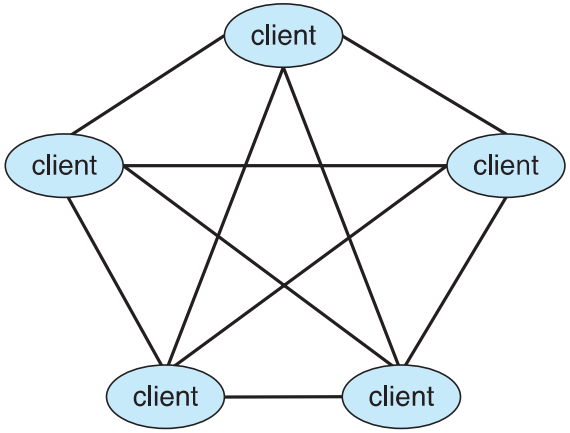


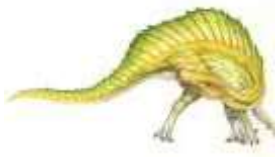




Computing Environments - Peer-to-Peer

- 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 look up service on network, or
    - Broadcast request for service and re spond to requests for service via ***dis covery protocol***
  - Examples include Napster and Gnutella, **Voice over IP** (**VoIP**) such as Skype

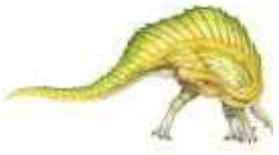




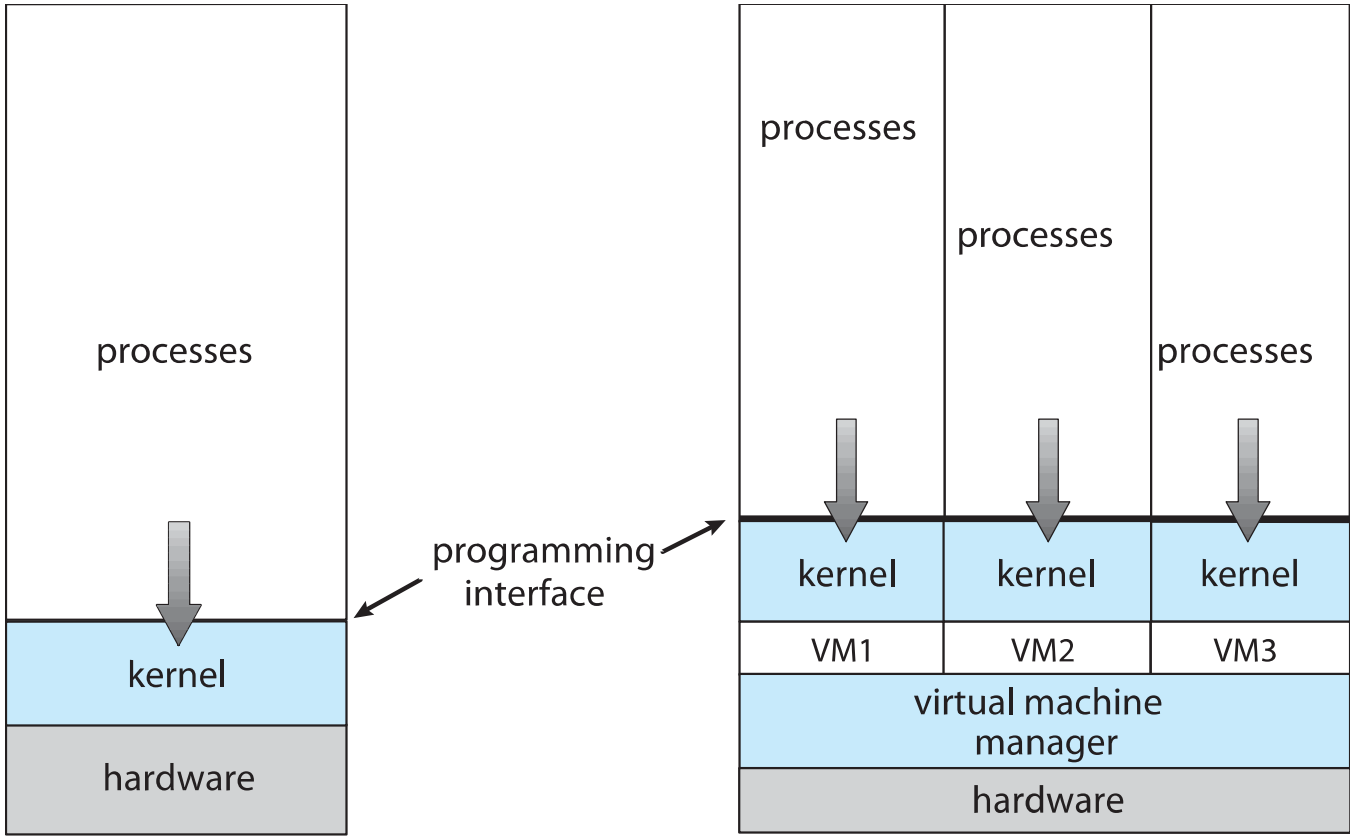


Computing Environments - Virtualization

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



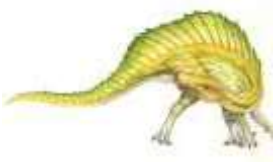
Computing Environments - Virtualization





Computing Environments – Cloud Computing

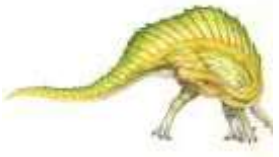
- Delivers computing, storage, even apps as a service across a network
- Logical extension of virtualization because it uses virtualization as the base f or it functionality.
  - Amazon **EC2** has thousands of servers, millions of virtual machines, pe tabytes of storage available across the Internet, 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 t he 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 Int ernet (i.e., storage available for backup use)





Computing Environments – 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





Open-Source Operating Systems

- Operating systems made available in source-code format rather t han just binary **closed-source**
- Counter to the **copy protection** and **Digital Rights Managemen t (DRM)** movement
- Started by **Free Software Foundation (FSF)**, which has “copylef t” **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

