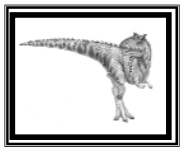
Chapter 21: The Linux System



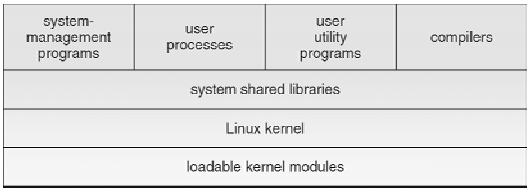
Chapter 21: The Linux System

- Design Principles
- Kernel Modules
- Process Management
- Scheduling

Design Principles

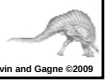
- Linux is a multiuser, multitasking system with a full set of UNIX-compatible tools
- Its file system adheres to traditional UNIX semantics, and it fully implements the standard UNIX networking model
- Main design goals are speed, efficiency, and standardization
- Linux is designed to be compliant with the relevant POSIX documents; at least two Linux distributions have achieved official POSIX certification
- The Linux programming interface adheres to the SVR4 UNIX semantics, rather than to BSD behavior

Components of a Linux System



Components of a Linux System (Cont)

- Like most UNIX implementations, Linux is composed of three main bodies of code; the most important distinction between the kernel and all other components
- The kernel is responsible for maintaining the important abstractions of the operating system
  - Kernel code executes in *kernel mode* with full access to all the physical resources of the computer
  - All kernel code and data structures are kept in the same single address space

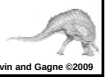


Components of a Linux System (Cont)

- The **system libraries** define a standard set of functions through which applications interact with the kernel, and which implement much of the operating-system functionality that does not need the full privileges of kernel code
- The **system utilities** perform individual specialized management tasks

Kernel Modules

- Sections of kernel code that can be compiled, loaded, and unloaded independent of the rest of the kernel
- A kernel module may typically implement a device driver, a file system, or a networking protocol
- The module interface allows third parties to write and distribute, on their own terms, device drivers or file systems that could not be distributed under the GPL
- Kernel modules allow a Linux system to be set up with a standard, minimal kernel, without any extra device drivers built in
- Three components to Linux module support:
  - module management
  - driver registration
  - conflict resolution

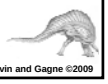


Module Management

- Supports loading modules into memory and letting them talk to the rest of the kernel
- Module loading is split into two separate sections:
  - Managing sections of module code in kernel memory
  - Handling symbols that modules are allowed to reference
- The module requestor manages loading requested, but currently unloaded, modules; it also regularly queries the kernel to see whether a dynamically loaded module is still in use, and will unload it when it is no longer actively needed

Driver Registration

- Allows modules to tell the rest of the kernel that a new driver has become available
- The kernel maintains dynamic tables of all known drivers, and provides a set of routines to allow drivers to be added to or removed from these tables at any time
- Registration tables include the following items:
  - Device drivers
  - File systems
  - Network protocols
  - Binary format

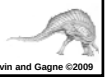


Conflict Resolution

- A mechanism that allows different device drivers to reserve hardware resources and to protect those resources from accidental use by another driver
- The conflict resolution module aims to:
  - Prevent modules from clashing over access to hardware resources
  - Prevent *autoprobes* from interfering with existing device drivers
  - Resolve conflicts with multiple drivers trying to access the same hardware

Process Management

- UNIX process management separates the creation of processes and the running of a new program into two distinct operations.
  - The fork system call creates a new process
  - A new program is run after a call to execve
- Under UNIX, a process encompasses all the information that the operating system must maintain to track the context of a single execution of a single program
- Under Linux, process properties fall into three groups: the process's identity, environment, and context

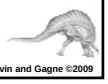


Process Identity

- Process ID (PID). The unique identifier for the process; used to specify processes to the operating system when an application makes a system call to signal, modify, or wait for another process
- Credentials. Each process must have an associated user ID and one or more group IDs that determine the process's rights to access system resources and files
- Personality. Not traditionally found on UNIX systems, but under Linux each process has an associated personality identifier that can slightly modify the semantics of certain system calls
  - Used primarily by emulation libraries to request that system calls be compatible with certain specific flavors of UNIX

Processes and Threads

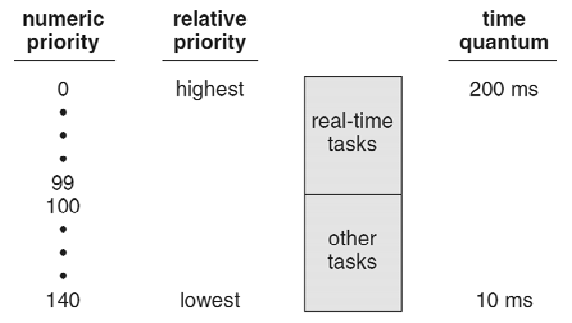
- Linux uses the same internal representation for processes and threads; a thread is simply a new process that happens to share the same address space as its parent
- A distinction is only made when a new thread is created by the clone system call
  - fork creates a new process with its own entirely new process context
  - clone creates a new process with its own identity, but that is allowed to share the data structures of its parent
- Using clone gives an application fine-grained control over exactly what is shared between two threads



Scheduling

- The job of allocating CPU time to different tasks within an operating system
- While scheduling is normally thought of as the running and interrupting of processes, in Linux, scheduling also includes the running of the various kernel tasks
- Running kernel tasks encompasses both tasks that are requested by a running process and tasks that execute internally on behalf of a device driver
- As of 2.5, new scheduling algorithm – preemptive, priority-based
  - Real-time range
  - nice value

Relationship Between Priorities and Time-slice Length



List of Tasks Indexed by Priority