

Operating System Structures

Operating Systems

Yu-Ting Wu

(with slides borrowed from Prof. Jerry Chou and Prof. Tei-Wei Kuo)

Outline

- Operating system services
- System calls and APIs
- Operating system structure
- Operating system debugging

Operating System Services

Operating System Services

- User interface
- Program execution
- I/O operations
- File-system manipulations
- Communication
- Error detection
- Resource allocation
- Accounting
- Protection and security

Operating System Services (cont.)

user and other system programs							
	GUI touch screen command		command line	2			
	user interfaces						
		system calls					
program I/O execution operation	ns file syste	e ms comm	unication	resource allocation	accounting		
error detection services ervices							
operating system							
hardware							

Operating System Services (cont.)



User Interface

Command line interface (CLI)

- Fetch a command from user and execute it
- Shell (command-line interpreter)
 - Ex: CSHELL, BASH
 - Allow to some modification based on user behavior and preference
- Graphic user interface (GUI)
 - Usually with mouse, keyboard, and monitor
 - Icons are used to represent files, directories, programs, etc.
 - Usually built on CLI
- Most systems have both CLI and GUI

Command Line Interface

	● ● 1. root@r6181-d5-us01:~ (ssh)						
× root@r6181-d5-u • #1	×	ssh 🕺 😤 #2 × root@r6181-d5-us01 #3					
Last login: Thu Jul 14 08:47:01 on ttys002 iMacPro:~ pbg\$ ssh root@r6181-d5-us01 root@r6181-d5-us01's password:							
Last login: Thu Jul 14	06:01:11 20	016 from 1	72.16.16.1	162			
[root@r6181-d5-us01 ~]#	uptime						
06:57:48 up 16 days, 1	0:52, 3 us	sers, load	d average	: 129.52, 80.3	33, 56.55		
[root@r6181-d5-us01 ~]#	df -kh						
Filesystem S	ize Used A	Avail Use%	Mounted (on			
/dev/mapper/vg_ks-lv_ro	ot	200 4400					
	50G 19G	28G 41%	/				
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tcp://192.168.150.1:333	4/orangets	6					
	121 5.71	6.41 47% /mnt/orangets					
/dev/gpts-test	231 1.11	1.1T 22T 5% /mnt/gpfs					
[root@r6181-d5-us01 ~]#							
[root@r6181-d5-us01 ~]# ps aux sort -nrk 3,3 head -n 5							
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-r-x 1 root root 2000/101 Jun 3 2015 /usr/lpp/mmts/bln/mmtsa							
LLOOT@r6181-d5-us01 ~]#							

Bourne Shell (default shell of UNIX ver. 7)

Command Line Interface (cont.)

- Two approaches for the command interpreter
 - Contain the codes for executing commands
 - Pros: fast
 - Cons: file size / painful revision
 - Implement commands as system program
 - Search execution files on the fly
 - Pros: easy to upgrade / keep the interpreter small
 - Cons: slow
 - Additional issues
 - Parameters passing
 - Inconsistent interpretation of parameters
- Most OS use a hybrid approach: keep a small subset of core functions in interpreter and use exec. for the others

Graphic User Interface

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Mac OS X GUI

Graphic User Interface (cont.)

- Components
 - Screen
 - Icons
 - Folders
 - Pointers
 - etc.





- History
 - Xerox PARC research facilities (1970's)
 - Mouse (1968)
 - Mac OS (1980's)
 - Windows 1.0 ~ 11

Other Interfaces

- Batch
- Touch-screen
- Voice control



Operating System Services (cont.)



Communication Models

Using either Message Passing or Shared Memory



System Calls and APIs

Operating System Services (cont.)



System Calls

- Programming interface to the services provided by the OS
 - An explicit request to the kernel made via software interrupt
 - Generally available as assembly-language instructions
- Mostly accessed by programs via a high-level Application Programming Interface (API) rather than direct system call use

System Calls (cont.)

• Example: a sequence of system calls for copying a file



System Calls (cont.)

- Request OS services
 - Process control
 - End (normal exit) or abort (abnormal)
 - Load and execute
 - Create and terminate
 - Get or set attributes of process
 - Wait for a specific amount of time or an event
 - Memory dumping, profiling, tracing, allocate, and free
 - File management
 - Create and delete
 - Open and close
 - Read, write, and reposition
 - Get or set attributes
 - Operations for directories

System Calls (cont.)

- Request OS services (cont.)
 - Device management
 - Request or release
 - Logically attach or detach devices
 - Information maintenance
 - Get or set time or date
 - Get or set system data (e.g., maximum memory for a process)
 - Communications
 - Send and receive messages
 - Message passing or shared memory
 - Protection

Application Programming Interface (API)

- An **encapsulation** of system calls for user programs
- Provide portability
- Usually implemented by high-level languages
 - C library, Java
- Could involve zero or multiple system calls
 - abs(): zero
 - fopen(): multiple
 - malloc(), free() → brk()



API (cont.)

- Three most common APIs
 - Win32 API
 - For Microsoft Windows
 - https://en.wikipedia.org/wiki/Windows_API
 - <u>https://docs.microsoft.com/zh-</u> <u>tw/windows/win32/apiindex/windows-api-</u> <u>list?redirectedfrom=MSDN</u>
 - POSIX API
 - POSIX stands for Portable Operating System Interface for Unix
 - Used by Unix, Linux, and Max OS X
 - https://en.wikipedia.org/wiki/POSIX
 - Java
 - For Java virtual machine (JVM)

API (cont.)

• Example: ReadFile() in Win32 API



- Parameters
 - HANDLE file: the file to be read
 - LPVOID buffer: a buffer where the data will be read into
 - DWORD bytesToRead: number of bytes to be read into the buffer
 - LPDWORD bytesRead: number of bytes read during the last read
 - LPOVERLAPPED ovl: indicates if overlapped I/O is being used

Why Do We Need API?

• Simplicity

- API is designed for programmers and applications
- Portability
 - API is a unified defined interface

• Efficiency

• Not all functions require OS services or involve kernel

System Call and API



System Call and API



Passing Parameters

- Three general approaches for passing parameters between a program and the OS
- Using register
- Store in a table in memory (Linux)
 - The address of the table is passed by register
- Push parameters onto the stack by the program
 - And pop off by the OS

Passing Parameters (cont.)

Store in a table in memory (Linux)

• The address of the table is passed by register



System Structure

Overview of OS Structure

- Simple OS architecture
- Layer OS architecture
- Microkernel OS
- Modular OS architecture
- Hybrid systems
- Virtual machine

Design of an OS

- Start the design by defining goals and specifications
- User goals
 - Easy to use and learn
 - Reliable
 - Safe
 - Fast (interactive)

System goals

- Easy to design and implement
- Easy to maintain
- Reliable
- Error-free
- Efficient

Policy and Mechanism

- Policy: what needs to be done?
 - Example: time sharing after every 100 milliseconds
- Mechanism: how to do something
 - Example: timer
- The separation of policy from mechanism is important
 - Allow maximum flexibility if policy decisions are to be changed later

Implementation

- Much variation
 - Early OSes are implemented by assembly language
 - Now high level languages, such as C, C++
- Actually usually a mix of languages
 - Lowest levels in assembly
 - Main body in C
 - System programs in C or C++
 - Scripting languages using PERL, Python, shell scripts
- More high-level language, easier to port to other hardware

Simple OS Architecture

- Only one or two levels
- Drawbacks
 - Unsafe
 - Difficult to enhance





UNIX

Layered OS Architecture

- Lower levels are independent of upper levels
- Pros: easier debugging and maintenance
- Cons: less efficient and difficult to define layers



Microkernel OS

- Kernel should be as small as possible
 - Move most parts of the original kernels into user space
- Communication is provided by message passing
- Easier for extending and porting
- Slow



Modular OS Architecture

Employed by most modern OS

- Object-oriented approach
- Each core component is separate
- Each module talks to the others over known interfaces
- Each module is loadable as needed within the kernel
- Similar to layers but with more flexibility
- Example: Solaris



Hybrid: Mac OS

- Combine layer and microkernel design
 - Aqua graphical user interface
 - Applications environments and common services
 - BSD
 - Command line interface, networking, file systems, POSIX APIs
 - Mach
 - Memory management
 - Remote procedure calls
 - Inter-process communication
 - Kernel environment
 - I/O kit for device drivers
 - Dynamic loadable modules



Hybrid: iOS

- Structured on Mac OS, added functionalities
 - Cocoa Touch
 - Objective-C API for developing apps
 - Media services
 - Layer for graphics, audio, video
 - Core services
 - Cloud computing ,database
 - Core OS
 - Based on Mac OS X kernel



Media Services

Core Services

Core OS

Hybrid: Android

- Developed by Handset Alliance (mostly Google)
 - Open source
- Based on Linux kernel (modified)
 - Add power management
- Runtime environment
 - Core set libraries
 - Dalvik VM

Applications					
Application Framework					
Libraries	runtime				
SQLite openGL	Core L ibraries				
Surface manager libc	Dalvik				
webkit Media framework	machine				
Linux Kernel					

Virtual Machine

- Layered approach
- Provide an interface that is identical to the underlying bare hardware
 - Each process is provided with a (virtual) copy of the underlying computer



Virtual Machine (cont.)



Virtual Machine (cont.)

Advantages

- Provide complete protection of system resources
- Provide an approach to solve system compatibility problems
- Provide a vehicle for OS research and development
- Provide a mean for increasing resource utilization in cloud computing

Operating System Debugging

Operating System Debugging

• Debugging

• An activity in finding and fixing errors or bugs (including performance problems) that exist in hardware or software

Terminologies

- Performance tuning
 - A procedure that seeks to improve performance by removing bottleneck
- Core dump
 - A capture of the memory of a process or OS
- Crash
 - A kernel failure

Operating System Debugging (cont.)

Performance tuning

• OS must provide means of computing and displaying measures of system behavior



Objectives Review

- Identify services provided by an operating system
- Illustrate how system calls are used to provide operating system services
- Compare and contrast monolithic, layered, microkernel, modular, and hybrid strategies for designing operating systems