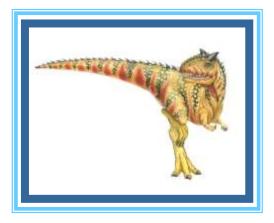
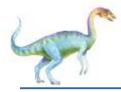
Operating Systems Chapter 2: Operating-System Services



Lecturer: Dalya Samer

Operating System Concepts – 10th Edition



Chapter2 Outlines

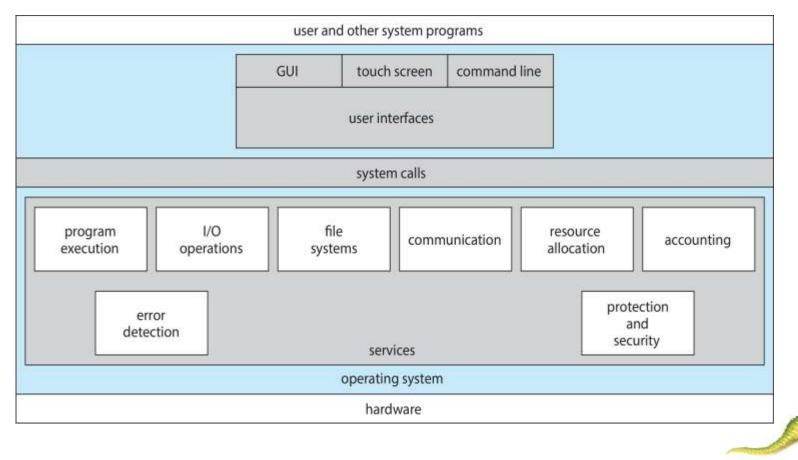
- Operating System Services
- User Operating System Interface
- System Calls
- Types of System Calls
- System Programs
- Operating System Design and Implementation
- Operating System Structure





Operating System Services

 Operating systems provide an environment for execution of programs and services to programs and users



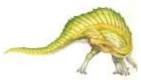


Operating System Services (Cont.)

- One set of operating-system services provides functions that are helpful to the user:
 - User interface Almost all operating systems have a user interface (UI).
 - Varies between Command-Line (CLI), Graphics User
 Interface (GUI), touch-screen, Batch
 - Program execution The system must be able to load a program into memory and to run that program, end execution, either normally or abnormally (indicating error)
 - I/O operations A running program may require I/O, which may involve a file or an I/O device.



- One set of operating-system services provides functions that are helpful to the user (Cont.):
- File-system manipulation The file system is of particular interest.
 Programs need to read and write files and directories, create and delete them, search them, list file Information, permission management
- Communications Processes may exchange information, on the same computer or between computers over a network.
 - Communications may be via shared memory or through message passing (packets moved by the OS)





- One set of operating-system services provides functions that are helpful to the user (Cont.):
 - Error detection OS needs to be constantly aware of possible errors.
 - May occur in the CPU and memory hardware, in I/O devices, in user program.
 - For each type of error, OS should take the appropriate action to ensure correct and consistent computing.
 - Debugging facilities can greatly enhance the user's and programmer's abilities to efficiently use the system.



- Another set of OS functions exists for ensuring the efficient operation of the system itself via resource sharing:
 - Resource allocation When multiple users or multiple jobs running concurrently, resources must be allocated to each of them.
 - Many types of resources CPU cycles, main memory, file storage, I/O devices.
 - Accounting To keep track of which users use how much and what kinds of computer resources.





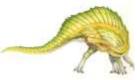
- Another set of OS functions exists for ensuring the efficient operation of the system itself via resource sharing: (Cont.)
 - Protection and security The owners of information stored in a multiuser or networked computer system may want to control use of that information, concurrent processes should not interfere with each other.
 - **Protection** involves ensuring that all access to system resources is controlled.
 - Security of the system from outsiders requires user authentication, extends to defending external I/O devices from invalid access attempts.

Operating System Concepts – 10th Edition



A View of Operating System Services

		user and other	system pro	grams		
		GUI toud	ch screen	command li	ne	
		user i	nterfaces			
		syst	em calls			
program execution	I/O operations	file systems	comm	unication	resource allocation	accounting
	ror ction	se	rvices		a	ection Ind Turity
		operat	ing system	1		
		ha	rdware			





- **CLI** or **command interpreter** allows direct command entry.
- Sometimes implemented in kernel, sometimes by systems program
- Sometimes multiple flavors implemented shells
- Primarily fetches a command from user and executes it
- Sometimes commands built-in, sometimes just names of programs.



User Operating System Interface(2/5)

Bourne Shell Command Interpreter

	1. r	oot@r6181	-d5-us01:~ (ssh)
× root@r6181-d5-u • #1	× ssh	第 年第2	× root@r6181-d5-us01 #3
Last login: Thu Jul 14 08 iMacPro:~ pbg\$ ssh root@r root@r6181-d5-us01's pass Last login: Thu Jul 14 06 [root@r6181-d5-us01 ~]# u	6181-d5-us01 word: :01:11 2016		.16.162
	52, 3 users	load aver	rage: 129.52, 80.33, 56.55
Filesystem Siz /dev/mapper/vg_ks-lv_root	e Used Avai	L Use% Mount	ted on
1944	G 19G 28	5 41% /	
tmpfs 127	G 520K 127	G 1% /dev/	/shm
/dev/sda1 477	M 71M 381	4 16% /boot	t
/dev/dssd0000 1.0	T 480G 545	6 47% /dssc	d_xfs
tcp://192.168.150.1:3334/	orangefs		
12	T 5.7T 6.4	47% /mnt/	/orangefs
/dev/gpfs-test 23	T 1.1T 22	5% /mnt/	/gpfs
[root@r6181-d5-us01 ~]#			
[root@r6181-d5-us01 ~]# p	s aux sort	-nrk 3,3	head -n 5
root 97653 11.2 6.6	42665344 17	520636 ?	S <ll 166:23="" bin="" jul13="" lpp="" mmfs="" mmfsd<="" td="" usr=""></ll>
root 69849 6.6 0.0	0	3 ?	S Jul12 181:54 [vpthread-1-1]
			5 Jul12 177:42 [vpthread-1-2]
root 3829 3.0 0.0	0	3 ? .	S Jun27 730:04 [rp_thread 7:0]
root 3826 3.0 0.0	0	0 ?	S Jun27 728:08 [rp_thread 6:0]
[root@r6181-d5-us01 ~]# 1	s -l /usr/lp	o/mmfs/bin/m	nmfsd
-r-x 1 root root 20	667161 Jun	3 2015 /usr	r/lpp/mmfs/bin/mmfsd
[root@r6181-d5-us01 ~]#			

Operating System Concepts – 10th Edition



User Operating System Interface(3/5)

- Graphics User Interface (GUI)
- User-friendly desktop metaphor interface
 - Usually mouse, keyboard, and monitor
 - **Icons** represent files, programs, actions, etc
 - Various mouse buttons over objects in the interface cause various actions (provide information, options, execute function, open directory (known as a **folder**)
 - Invented at Xerox PARC
- Many systems now include both CLI and GUI interfaces





User Operating System Interface(4/5)

- Touchscreen Interfaces
- Touchscreen devices require new interfaces.
 - Mouse not possible or not desired.
 - Actions and selection based on gestures.
 - Virtual keyboard for text entry.
- Voice commands.



Operating System Concepts – 10th Edition



User Operating System Interface(5/5)

The Mac OS X GUI

sector sector in the local data and a	and State Links			+ 5000	and the second s			
CONTRACTOR AND ADDRESS OF A 19				211	and the second se		-	
Ng 1 has 1 at 12-31 11 feet-da -	the second second	If is althout incide there is			 M. M. Miller and M. M. M. 	100 (t. R.		
	CAMP DOWN DOWN	Contraction of the Contraction o	14.00 States and	and the second se	Line Control of Contro	Deviation of the later	1 M - 64	
	THE STREET	a the share	1.5.00 Witch, 1.5.000	C mare	L DRAW	THEN HOVEN	In the lass out	1.4
-	MAR ATTA TODA		TELEVISION AND A CONTRACTOR		Solver-Biot 2018-09-09 at 1:00-17 PM	Tably #C5 PM	1.8 m8 (*10 rouge	
uit	100.00 Byrrys-1100.0		1000 10000,00000	12-11	in Science (River 2015-08-08 in 1/08: 10 Peril 22	C frame hos-ral	I TERMS MULTIPLE	
	10.00 Article 10.00 A	 3. S.D. prime and 9. S.D. and 	and the second se	-	Sower Shot 2018-09-09 at 3.35.15 Met	there provide	14100 000 0000	
	stan mark. star		Q. dictionary		3. Schem Stot 2016-09-09 at 2.37 (54 PM)	54mc (197.PM	E.E.H.B	1.1
(m)	1918 1/10/16 (12) W	1.00 AL - N	The second se	1100	+ Ar Detitation in Beyond the Second	Falsy Filb/M		
	19140 BURNERS	a statute of	and a second statement of the second s		 Boreev Shot 2018-08-08 at 10.00.02 AM Boreev Shot 2018-08-08 at 10.04.05 AM 	Failing 107-807 Add. Failing 107-807 Add.	And all the second	
	100 0007-0007	s will be	Berte Same Same Same Same P.	-	 Screen Shot 2916-09-08 at 10.12 AD M4 	54bi 10.124M	INVESTIGATION	
	in on andra Science	a soliter.	C. State & Street		+ In Dennefyric Occuments	Fathery (FO4 Add	- Porter	
	en billio, sieh	s 3 Mage	1	PX31	Domer Stot 3116-08-06 at 3.35.85 PM	Patrick UNIN.	787 48 (94) 100	
-	11.01 \$23,13,1,044	3.0.5m	1.4		It Boreen Birel 2018-08-08 at 8-24-82 Mill	Therefore T24/M	18/18 Millinge	1
	13.68 MARCH, SARA	4 2,0 Am.	Charles and Conversion		(ii) Rameri Brat 2016 (de de al 6.53.67 Mil	Federate STIPM	mana Hatlenge	
	100 040-0.4260 100 040-0.4260	a di Masi a di Masi	 detaining - Augus Aussissers 	Scionery	 et als gate performance citit a Scenar: Stor 2214-09-08 at 2.00 Ye Mai 	manufact 200 PM	TOOR NETWOOR	
	448 55515,5282	± 3.76au	B Administration - Commission -	Contraction of Contra	m Somer Shot 2016-08-08 at 5-08-49 Ref	Youny to GR PM	100 KB 3840 strage	
	4.00 STEP-0.400-0	5 C 1000	· man		in Screen Shot 2018-09-08 at 5:05:29 RM	Humbig SORTH	11018 (NU Inc)	
	148 82275, 129-7		- 49.00		Internet Shot 2018-08-08 et 6:06-22 FW	Hamodag (2006 PA)	2.70 k/k (0140) terrings	
	100 0001-0.0000	3.0344	E The Daniel Manfront	THE ADDRESS OF THE OWNER	 Burger, Weid 2018; OB 108 at 8:04-31 PM — Burger, Blud 2018; OB -OB at 8:04:27 PM 	Summers 201076	11128 Odland	
	418 1017 a 1019	0 1.7 m	and and and a set of the set of t	There below	in Bureen Bial 3018 OF OB at 6:06.21 PM in Bureen Bial 2016 OF OB at 6:06.29 PM	Parametery STORYM	207 EX Politings	
-	101 E2014,4140	is Sillian	and start land to	And the second		famming which he	11113 Willings	
	HELDE MALERA STREET	3.10m	a new particulation		10. Screen Shot 2016-08-08 pt 4.55.14 RM	Dateries, FDFTM	STATE PROPERTY	6.5
	11.00 BILLIN 10449	a second a		and the second s	in. Sonar-Shot 2018-08-08 et 4 53:43 PM	Tentenber, Add PA	UTION INCOMP	
-	19-08 LEFT-C-124-P			222 Notes	 Borner: Shot 1918-08-08 at 4.44.57 No Borner: Bod 2016-08-08 at 4.45.7 JU 	Personal Laters	TRUKE Hillings	
	108 BEER 6097					New York Control of Co	19418 Hitlings	
	448 MAVE.304/4			The second	 Sower Shot 2018-08-08 at 4,25(2) Per 	Instruction Williams	-TARR Highlight	
	-A.00 \$255.0.508.0			122 ****	a: Some Stor 2015-00-08 at 3-41 41 Ref	thereing DATEM.	TING INCOME	1.5
	and American American				#: Screen Shot 2318-09-08 #: 3-46.43 PM	Tentering (2-49-0%)	DIALS - INCOMPA	1
	418 811-1.000			and the second s	Streep Shot 2018-08-08 at 11.48.08 AM	Faity by T145304	GIG 18 THIC Insigh	1
**	1418 852-5-1282				Screen Stol 1218-28 (28 at 11.45.45.44)	Tempter, CLAUAN	252.49 Hillings	
	440 00000 0000			(1) **	Burner- Bud 2018-C0-C8 at 11.4.8.38.554	(100000) (1142.00)	2023.0 (1012).004	_
	A LAN DESCRIPTION OF THE			12 m	A Replace - I and - I	THE REAL PROPERTY AND ADDRESS	and serve	
	A LAN DESCRIPTION OF THE	TT THE P	STATISTICS (C.	E and a second		Concerne (1 an and	and the second	
				Alter and	A name - 2 and - 2 day - 2 day - 1 Days			
			ana an	Chinese and	Andrew Barry of Andrew Chemistry	Completer re.		
				Chinese and	2			
			ana an	Alternation of the second seco	Andre Mar Par State (Des Village Description	Completel inc.		-
			ana an	Chinese and	Andream Barrier de Mariane Chama Santane Barrier de Mariane Chama Santane Barrier de Mariane Barrier de Maria	Computer nc.		
Democratica				Alternation of the second seco	Andrew Mart Park Tale Andrew (1996)	Computer nc.		
			ana an	Christian and Ch	Andrew Carrow Construction Const Construction Constructio	Computer inc.		1 1 1
aja i				Channels Chromosomer American Ame	Andrew Mar 1991 Total Andrew (1996)			
a la Maria Sanata Anna				All second	Andrew Carrow Construction Const Construction Constructio	Consults inc.		
a a second coperating system - become course				Channels Chromosomer American Ame	Andree - Anno - Constanting -	Consults inc.		
a a second coperating system - become course				Annual Control of Cont	Andree - Anno - Constanting -	Consults inc.		
a la second second sec				20 annual 21 annual 22 annual 23 annual 24 annual 24 annual 24 annual 24 annual 25 annual 26 ann	Andrew - Barr Polit (Bolter - Class) Vicinitian Control - Classical Control - Classic	Consulty inc.		
a a second coperating system - become com				Annual An	Andree - Anno - Canada - Canad	Consulty inc.		
a a comparing system (loss and) and the comparing system (loss and) and the comparing system (loss and) and the comparing the comparing system (loss and) and (l				201 annual 201 annual	Andrew - Barr Polit (Bolter - Class) Vicinitian Control - Classical Control - Classic	Complete inc.	290.2425	
a a comparing system (loss and) and the comparing system (loss and) and the comparing system (loss and) and the comparing the comparing system (loss and) and (l				201 annual 201 annual	Andrew - Barrier de la Sector d'Anna - Constant - Anna - Anna - Anna	Consulter inc.	290.2425	
o de la comparada y stan de la comparad estan de la comparada y stan				201 annual 201 annual	Andrew - Barr Polit (Bolter - Class) Vicinitian Control - Classical Control - Classic	Complete inc.	290.2425	
a a comparing system (lossed) and the comparing system (lossed) and the comparing system (lossed) and the comparing the comparin				201 annual 201 annual	Andrew - Barrier de la Sector d'Anna - Constant - Anna - Anna - Anna	Corrector inc.		
o a la comparada y stan i dessente and		DSSD HIGH PERF		201 annual 201 annual	Andrew - Barrier de la Sector d'Anna - Constant - Anna - Anna - Anna	Consulter inc.	290.2425	
o a la comparada y stan i dessente and				201 annual 201 annual	Andrew - Barrier de la Sector d'Anna - Constant - Anna - Anna - Anna	Corrector inc.		
o a la comparada y stan i dessente and		DSSD HIGH PERF	ORMANCE YSTEMS	201 annual 201 annual	Andrew Barr Program Street Communications	Composer inc.	290.2425	
o a la comparada y stan i dessente and		DSSD HIGH PERF	ORMANCE YSTEMS	201 annual 201 annual	Andrew Barr Production Concernance	Comparer inc.	290.2425	
o a la comparada y stan i dessente and		DSSD HIGH PERF	ORMANCE YSTEMS	201 annual 201 annual	Andrew - Barr Program Street Commercial Comm	Composer inc.	290.2425	
Compared in the second se	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual	Andrew - Barr Program Street Commercial Comm	Composer inc.	290.2425	
Compared for a second s		DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual	Andrew - Barr Program Street Commercial Comm	Composer inc.		
Compared for a second s	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual	Andrew - Barr Program Street Commercial Comm	Composer inc.	290.2425	
Constant of Lagon Longer	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual	Andrew - Barr Program Street Commercial Comm	Composer inc.		
Constant of Lagon Longer	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual		Consister inc.		
Constant of Lagon Longer	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	American American	Andrew - Barr Program Street Commercial Comm	Composer inc.		
Compared for a second s	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	DSSD HIGH PERF PARALLEL FILE S' CLIOX TO EDIT MASTER SUERT	FORMANCE YSTEMS mus shue	201 annual 201 annual		Consister inc.		

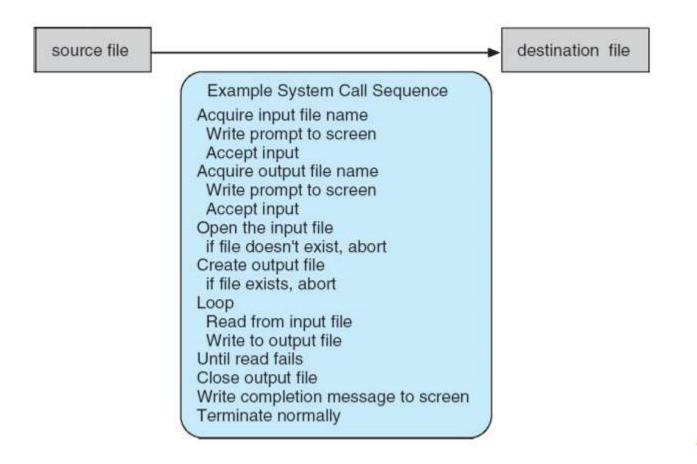


- Programming interface to the **services provided** by the **OS**.
- Typically written in a high-level language (C or C++)
- Mostly accessed by programs via a high-level Application
 Programming Interface (API) rather than direct system call use.
- Three most common APIs are Win32 API for Windows, POSIX API for POSIX-based systems (including virtually all versions of UNIX, Linux, and Mac OS X), and Java API for the Java virtual machine (JVM).





• **Example:** System call sequence to copy the contents of one file to another file





System Calls

EXAMPLE OF STANDARD API

As an example of a standard API, consider the read() function that is available in UNIX and Linux systems. The API for this function is obtained from the man page by invoking the command

man read

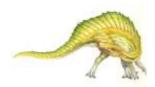
on the command line. A description of this API appears below:

#include	<unistd.h></unistd.h>					
ssize_t	read(int	fd,	voiđ	*buf,	size_t	count)
return value	function name		p	aramete	ers	

A program that uses the read() function must include the unistd.h header file, as this file defines the ssize_t and size_t data types (among other things). The parameters passed to read() are as follows:

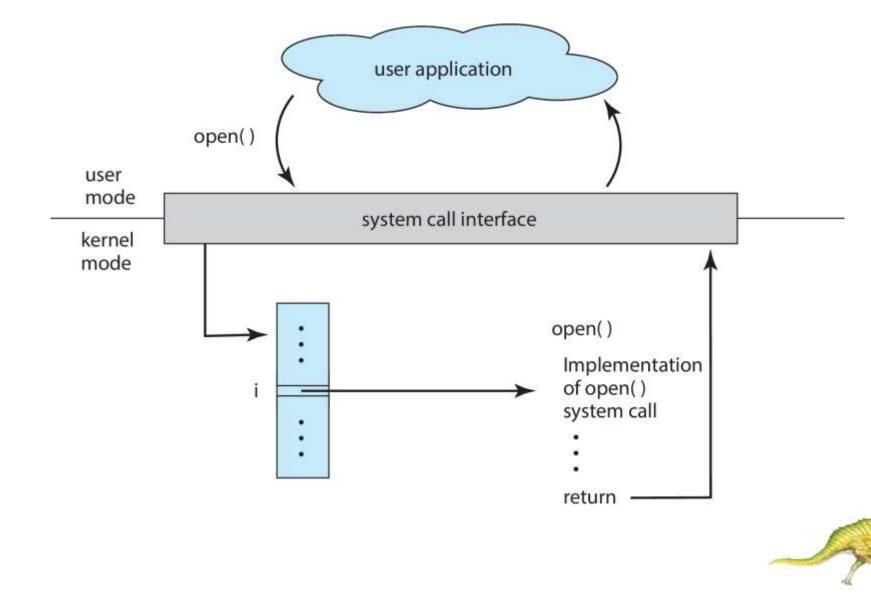
- int fd—the file descriptor to be read
- void *buf —a buffer into which the data will be read
- size_t count—the maximum number of bytes to be read into the buffer

On a successful read, the number of bytes read is returned. A return value of 0 indicates end of file. If an error occurs, read() returns -1.



Operating System Concepts – 10th Edition

API – System Call – OS Relationship



Operating System Concepts – 10th Edition



Examples of Windows and Unix System Calls

EXAMPLES OF WINDOWS AND UNIX SYSTEM CALLS

The following illustrates various equivalent system calls for Windows and UNIX operating systems.

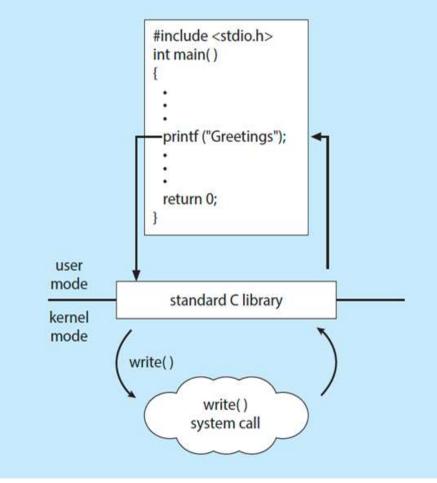
	Windows	Unix
Process	CreateProcess()	fork()
control	ExitProcess()	exit()
	WaitForSingleObject()	wait()
File	CreateFile()	open()
management	ReadFile()	read()
	WriteFile()	write()
	CloseHandle()	close()
Device	SetConsoleMode()	ioctl()
management	ReadConsole()	read()
	WriteConsole()	write()
Information	GetCurrentProcessID()	getpid()
maintenance	SetTimer()	alarm()
	Sleep()	<pre>sleep()</pre>
Communications	CreatePipe()	pipe()
	CreateFileMapping()	shm_open()
	MapViewOfFile()	mmap()
Protection	SetFileSecurity()	chmod()
	InitlializeSecurityDescriptor()	umask()
	SetSecurityDescriptorGroup()	chown()

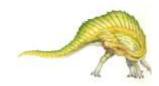


Operating System Concepts – 10th Edition



C program invoking printf() library call, which calls write() system call





Operating System Concepts – 10th Edition



Types of System Calls

Process control

- create process, terminate process
- end, abort
- load, execute
- get process attributes, set process attributes
- wait for time
- wait event, signal event
- allocate and free memory
- Dump memory if error
- **Debugger** for determining **bugs**, **single step** execution
- Locks for managing access to shared data between processes





Types of System Calls (Cont.)

- File management
 - create file, delete file
 - open, close file
 - read, write, reposition
 - get and set file attributes
- Device management
 - request device, release device
 - read, write, reposition
 - get device attributes, set device attributes
 - logically attach or detach devices





- Information maintenance
 - get time or date, set time or date
 - get system data, set system data
 - get and set process, file, or device attributes

Communications

- create, delete communication connection
- send, receive messages if message passing model to host name or process name
 - From client to server
- Shared-memory model create and gain access to memory regions
- transfer status information
- attach and detach remote devices





Types of System Calls (Cont.)

Protection

- Control access to resources
- Get and set permissions
- Allow and deny user access





- System programs provide a convenient environment for program development and execution.
- They can be divided into:
 - File manipulation
 - Status information sometimes stored in a file
 - Programming language support
 - Program loading and execution
 - Communications
 - Background services
 - Application programs





- File management Create, delete, copy, rename, print, dump, list, and generally manipulate files and directories/
- Status information
 - Some ask the system for info date, time, amount of available memory, disk space, number of users
 - Others provide detailed performance, logging, and debugging information
 - Typically, these programs format and print the output to the terminal or other output devices.





File modification

- > Text editors to create and modify files
- Special commands to search contents of files or perform transformations of the text
- Programming-language support Compilers, assemblers, debuggers and interpreters sometimes provided.
- Communications Provide the mechanism for creating virtual connections among processes, users, and computer systems.
 - Allow users to send messages to one another's screens, browse web pages, send electronic-mail messages, log in remotely, transfer files from one machine to another



- Background Services
 - Launch at boot time
 - Some for system startup, then terminate
 - Some from system boot to shutdown
 - Provide facilities like disk checking, process scheduling, error logging, printing

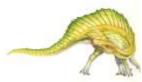
Application programs

- Don't pertain to system
- Run by users
- Not typically considered part of OS





- Design and Implementation of OS is not "solvable", but some approaches have proven successful.
- Internal structure of different Operating Systems can vary widely
- Start the design by **defining goals** and specifications
- Affected by choice of hardware, type of system.
- User goals and System goals:
 - <u>User goals</u> operating system should be convenient to use, easy to learn, reliable, safe, and fast
 - <u>System goals</u> operating system should be easy to design, implement, and maintain, as well as flexible, reliable, error-free, and efficient
- Specifying and designing an OS is highly creative task of software engineering



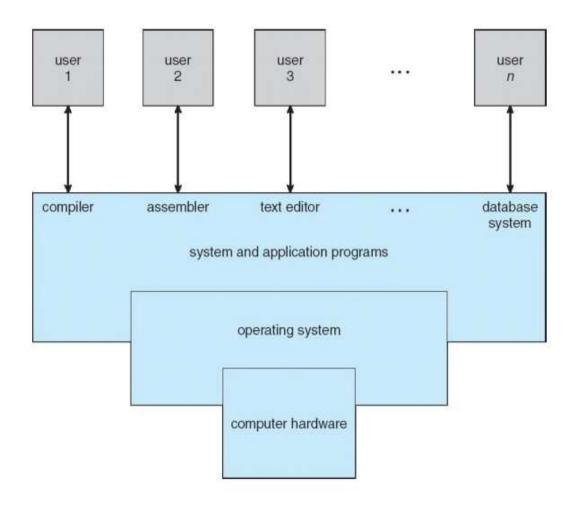


OS Design and Implementation

- Much variation
 - Early OSes in assembly language
 - Then system programming languages like Algol, PL/1
 - Now C, C++
- Actually usually a mix of languages
 - Lowest levels in assembly
 - Main body in C
 - Systems programs in C, C++, scripting languages like PERL, Python, shell scripts



Operating System Structure



Operating System Concepts – 10th Edition



Operating System Structure

- General-purpose OS is very large program
- Various ways to structure ones
 - Simple structure MS-DOS
 - More complex UNIX
 - Layered an abstraction
 - Microkernel Mach



End of Chapter 2

