Operating System Services

CPEN333 – System Software Engineering
2021 W2
University of British Columbia

Electrical and
Computer
Engineering

Introduction

- Operating systems are the essential part of any computer system.

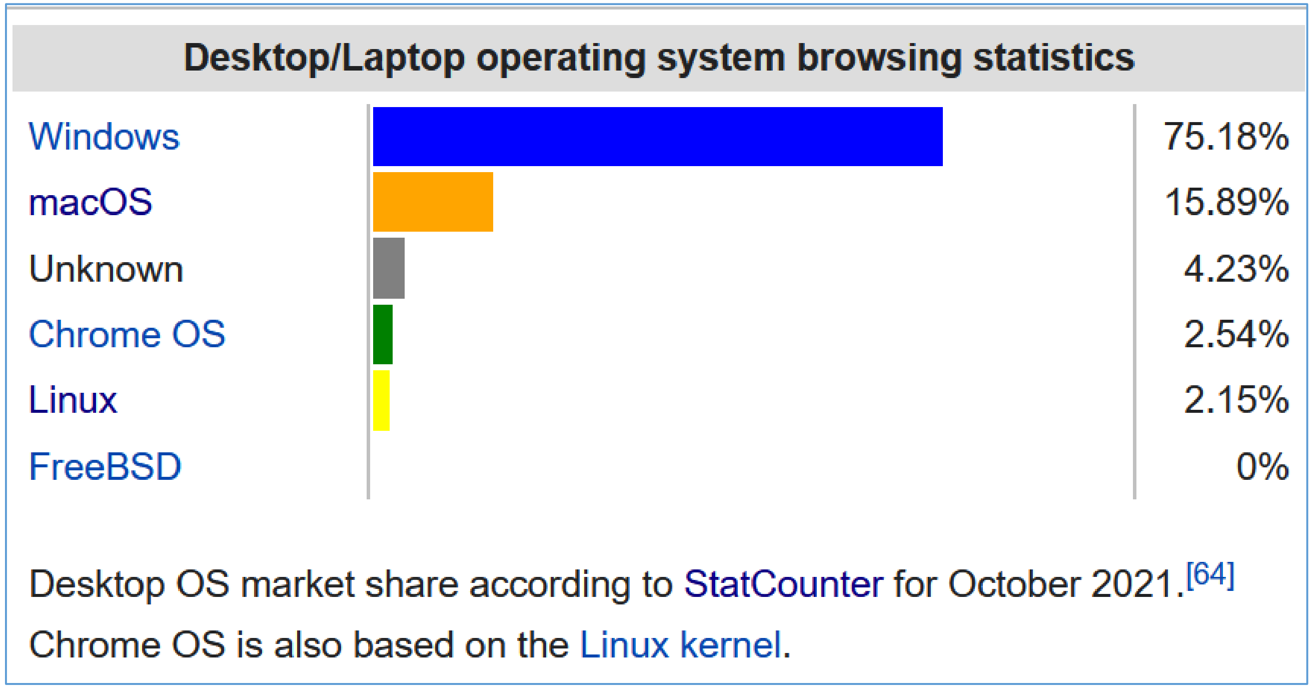
- There have been many exciting advancements in the recent years: Mobile devices (i.e. pushing the limits), clouds (ubiquitous global computing), …

- In this set of slides, we discuss some terminology related to operating systems and operating systems services.

Objectives

- describe
  - what an operating system is
  - what it does
- describe the services an operating system provides to users, processes, and other systems
- describe open-source operating systems

OS Market Share?

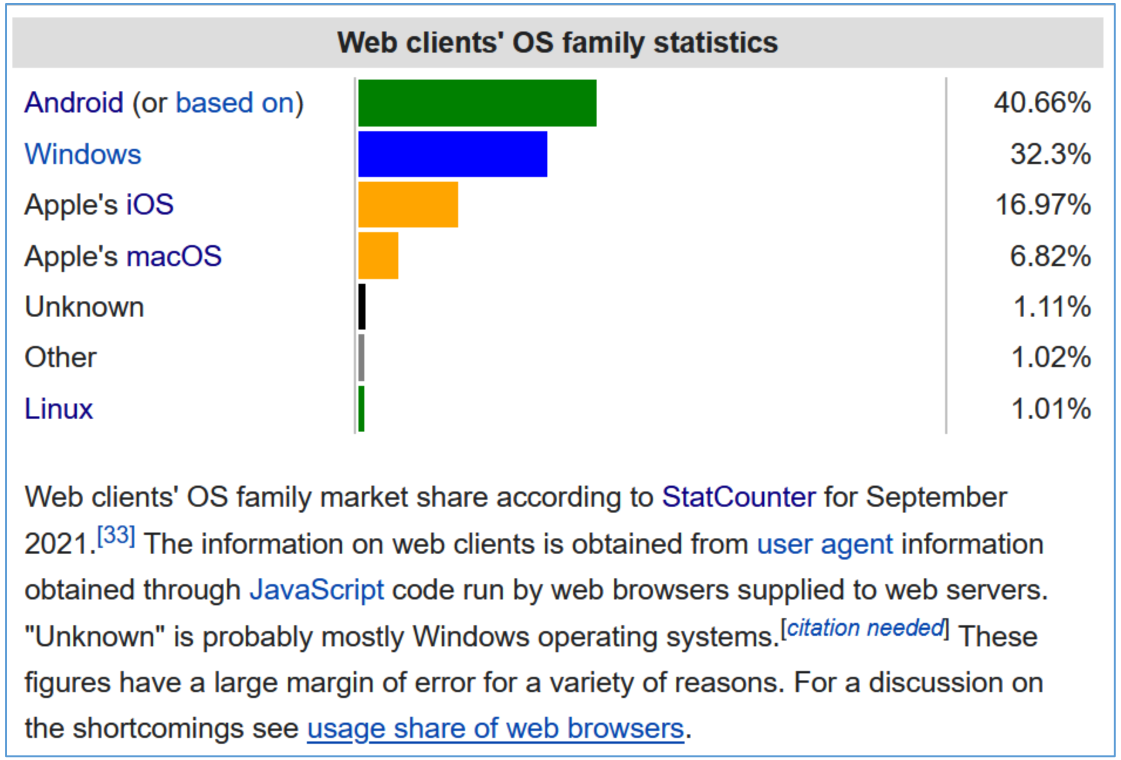


Desktop/Laptop operating system browsing statistics

Windows	75.18%
macOS	15.89%
Unknown	4.23%
Chrome OS	2.54%
Linux	2.15%
FreeBSD	0%

Desktop OS market share according to StatCounter for October 2021.[64] Chrome OS is also based on the Linux kernel.

source: wikipedia.org
(Wikimedia Commons License)



Web clients' OS family statistics

Android (or based on)	40.66%
Windows	32.3%
Apple's iOS	16.97%
Apple's macOS	6.82%
Unknown	1.11%
Other	1.02%
Linux	1.01%

Web clients' OS family market share according to StatCounter for September 2021.[33] The information on web clients is obtained from user agent information obtained through JavaScript code run by web browsers supplied to web servers. "Unknown" is probably mostly Windows operating systems.[citation needed] These figures have a large margin of error for a variety of reasons. For a discussion on the shortcomings see usage share of web browsers.

Note that the usage share may vary greatly from one category to another (application and computing device), as well as location.

The figures here are for comparison only. You may find different values on different websites. For an alternative see http://www.netmarketshare.com

Operating systems

- General-purpose operating systems
  - Windows, macOS, Linux
  - Mobile: iOS, Android

- Special-purpose operating systems
  - e.g. ARM Mbed (for IoT) or FreeRTOS (for real-time OS)

- Bare-machine or bare-metal
  - Refers to a computing system that executes instructions directly on the logic hardware, for a single dedicated application
  - Example use: microcontrollers or embedded systems
  - Usually for small dedicated application: fast and efficient, but more difficult to implement/debug/maintain

Operating Systems Examples

UNIX

macOS

Windows

Linux

iOS

android

Google Chrome OS

freeRTOS

Mbed

Images sources: wikipedia.org
(Wikimedia Commons License)

Operating System

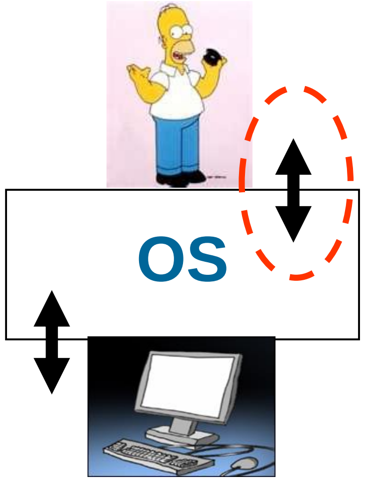
- An operating system is
  - a program
  - that acts as an intermediary between a user of a computer and the computer hardware
  - and provides an environment in which a user can execute programs.

- Operating system goals:
  - Execute user programs and make solving user problems easier
  - Make the computer system convenient to use
  - Use the computer hardware in an efficient manner

- Two views: User view and System view

Operating System Definition

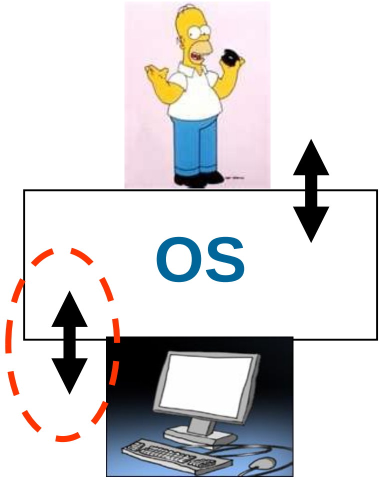
- User View:
  - OS is a control program
  - It controls execution of programs, prevents errors and improper use of the computer



- What matters for a user in front of a
  - PC (single user): ease of use and performance
  - handheld (limited power, speed and interface): personal usability and performance (e.g., battery life)

Operating System Definition (cont)

- System View:
  - OS is a resource allocator
  - Manages the hardware and all resources (CPU, Memory, I/O, …)
  - Decides between conflicting requests for efficient and fair resource use test



- In general, no completely and universally accepted definition
- "The one program running at all times on the computer" is the kernel. Everything else is either a system program (ships with the operating system) or an application program.

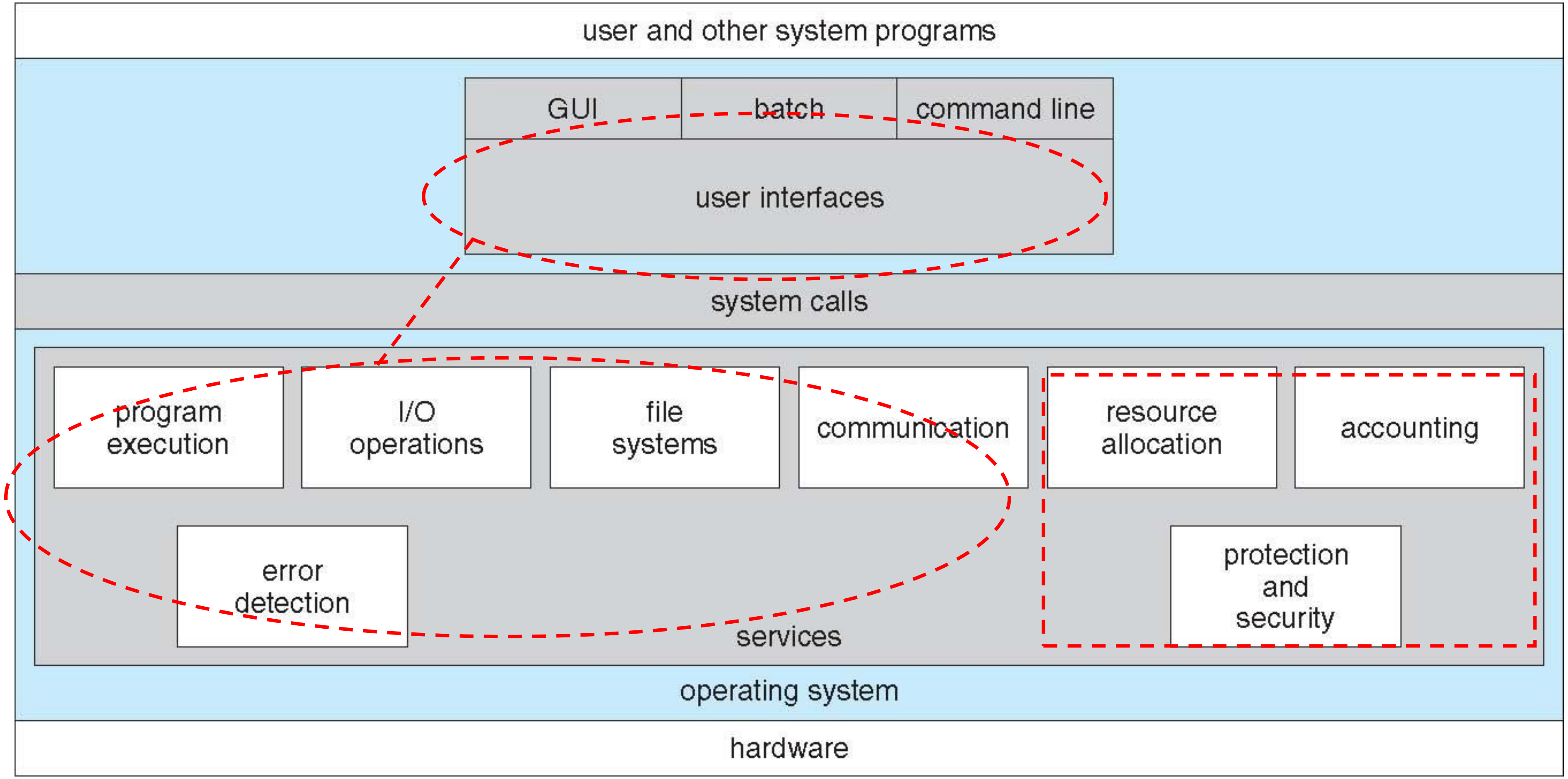
Computer Startup

- For a computer to start running (when powered up or rebooted), it needs to have an initial program to run.

- bootstrap program is loaded at power-up or reboot
  - Typically stored in ROM/EEPROM (generally known as firmware)
  - Initializes all aspects of system (CPU registers, memory contents and check, I/O, …)
  - Loads operating system kernel and starts its execution

A View of Operating System Services

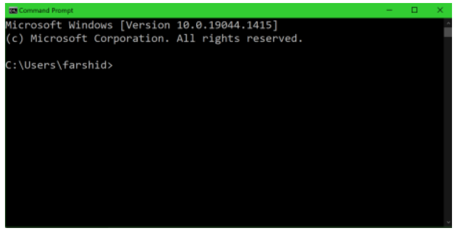
- As an environment for the execution of programs, an OS provides certain services to the programs and the users of those programs.



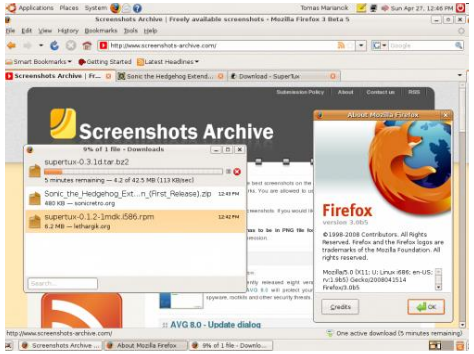
Operating System Services

- One set of OS services provides functions that are helpful to the user:

1. User interface
   - Command-Line (CLI),
   - Graphical User Interface (GUI),
   - and also Batch



```
Microsoft Windows [Version 10.0.19044.1415]
(c) Microsoft Corporation. All rights reserved.

C:\Users\farshid>
```



supertux-0.3.1d.tar.bz2
5 minutes remaining — 4.2 of 42.5 MB (113 KB/sec)

Sonic_the_Hedgehog_Ext...n_(First_Release).zip 12:43 PM
480 KB — sonicretro.org

supertux-0.1.2-1mdk.i586.rpm 12:42 PM
6.2 MB — lethargik.org

©1998-2008 Contributors. All Rights Reserved. Firefox and the Firefox logos are trademarks of the Mozilla Foundation. All rights reserved.

Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.9b5) Gecko/2008041514 Firefox/3.0b5

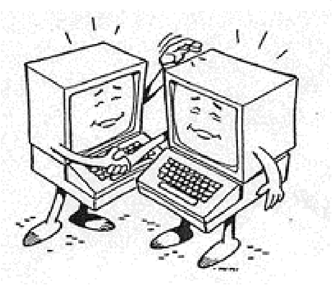
http://www.screenshots-archive.com/

One active download (5 minutes remaining)

2. Program execution
   - loading a program into memory and to run that program,
   - ending execution (either normally or abnormally (indicating error))
3. I/O operations - A running program may require I/O, which may involve a file or an I/O device
4. File-system manipulation
   - Programs need to read and write files and directories, create and delete them, search them, list file Information, permission management.

Operating System Services (cont.)

5. Communications – Processes may exchange information, on the same computer or between computers over a network



6. 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

Operating System Services (Cont)

- Another set of OS functions exists not for helping the user but rather to ensuring the efficient operation of the system itself.

1. Resource allocation
   - When multiple users or *multiple* jobs running concurrently, resources must be allocated to each of them
   - Many types of resources are managed by OS.
     - e.g. CPU scheduling or request/release to allocate an I/O device
2. Accounting
   - To keep track of which users use how much and what kinds of computer resources

Operating System Services (Cont)

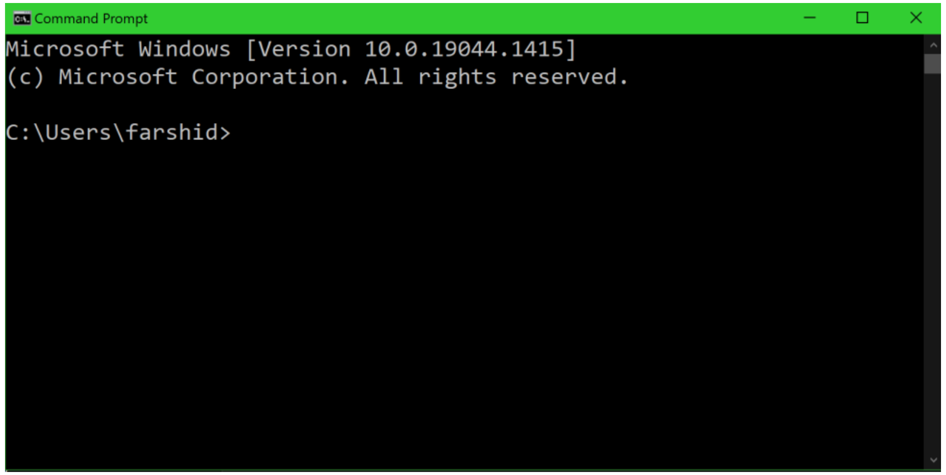
3. Protection and security
    - When a computer system has multiple users and allows the concurrent execution of multiple processes, then access to data must be regulated.
    - Protection involves any mechanism for controlling access of processes or users to resources defined by the OS (e.g. protecting a process from other's interference)
    - Security is defending the system from external and internal attacks, done through OS functions, policy or additional software.
        - Huge range, including denial-of-service, worms, viruses, identity theft, theft of service
    - Security and protection require the system to be able to distinguish among all its users (authentication …)
    - If a system is to be protected and secure, precautions must be instituted throughout it.
        - A chain is only as strong as its weakest link.

UI (User Interface)

- Two fundamental approaches for users to interface with the OS are *command-line interface* and *graphical user interface*.

- Command Line Interface (CLI) allows direct command entry:
  - Primarily fetches a command from user and executes it
  - On systems with multiple command interpreters to choose from, the interpreters are known as shells (e.g. in UNIX)
- Graphical User Interface (GUI): User-friendly desktop metaphor interface
  - 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)
- Many systems include both CLI and GUI interfaces

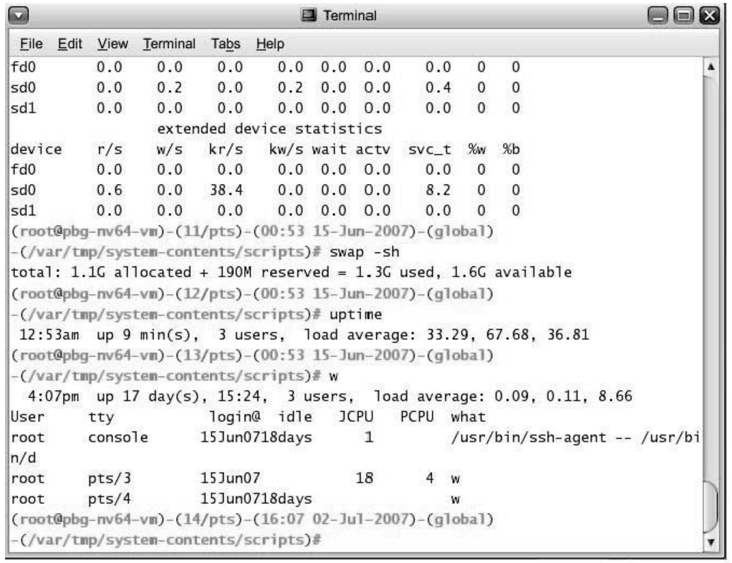
Command Interpreters/Shells Examples



```
Microsoft Windows [Version 10.0.19044.1415]
(c) Microsoft Corporation. All rights reserved.

C:\Users\farshid>
```

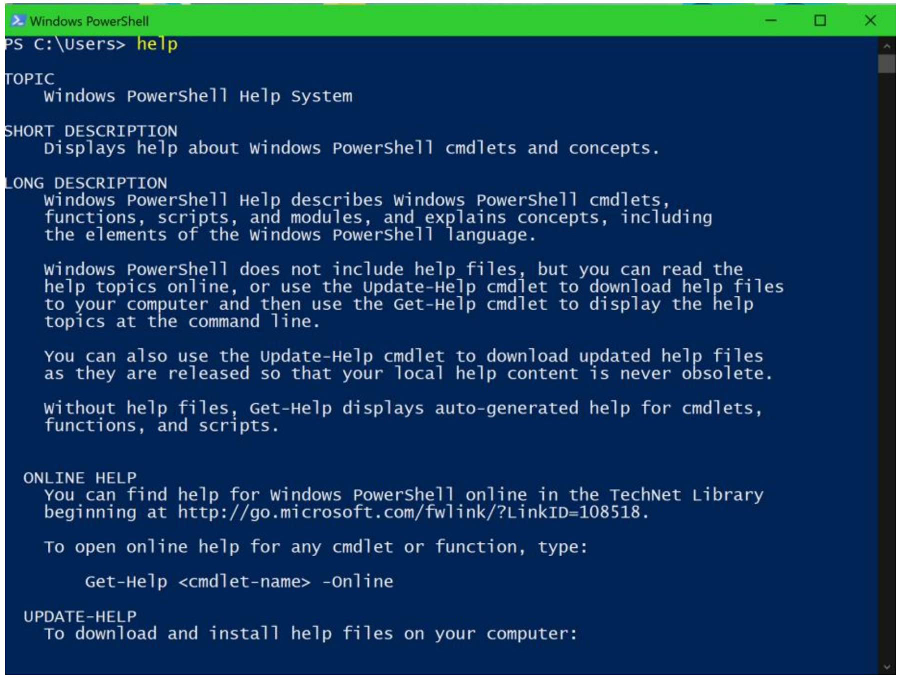
Windows cmd

Terminal



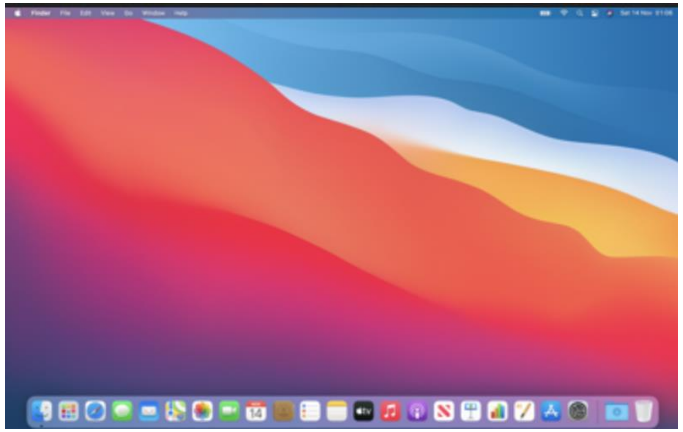
```
fd0        0.0    0.0    0.0    0.0  0.0  0.0    0.0   0    0
sd0        0.0    0.2    0.0    0.2  0.0  0.0    0.4   0    0
sd1        0.0    0.0    0.0    0.0  0.0  0.0    0.0   0    0
                  extended device statistics
device     r/s    w/s    kr/s   kw/s wait actv  svc_t  %w   %b
fd0        0.0    0.0    0.0    0.0  0.0  0.0    0.0   0    0
sd0        0.6    0.0   38.4    0.0  0.0  0.0    8.2   0    0
sd1        0.0    0.0    0.0    0.0  0.0  0.0    0.0   0    0
(root@pbg-nv64-vm)-(11/pts)-(00:53 15-Jun-2007)-(global)
-(/var/tmp/system-contents/scripts)# swap -sh
total: 1.1G allocated + 190M reserved = 1.3G used, 1.6G available
(root@pbg-nv64-vm)-(12/pts)-(00:53 15-Jun-2007)-(global)
-(/var/tmp/system-contents/scripts)# uptime
 12:53am  up 9 min(s),  3 users,  load average: 33.29, 67.68, 36.81
(root@pbg-nv64-vm)-(13/pts)-(00:53 15-Jun-2007)-(global)
-(/var/tmp/system-contents/scripts)# w
  4:07pm  up 17 day(s), 15:24,  3 users,  load average: 0.09, 0.11, 8.66
User     tty           login@  idle   JCPU   PCPU  what
root     console      15Jun0718days      1         /usr/bin/ssh-agent -- /usr/bi
n/d
root     pts/3        15Jun07           18      4  w
root     pts/4        15Jun0718days                w
(root@pbg-nv64-vm)-(14/pts)-(16:07 02-Jul-2007)-(global)
-(/var/tmp/system-contents/scripts)#
```

Windows PowerShell

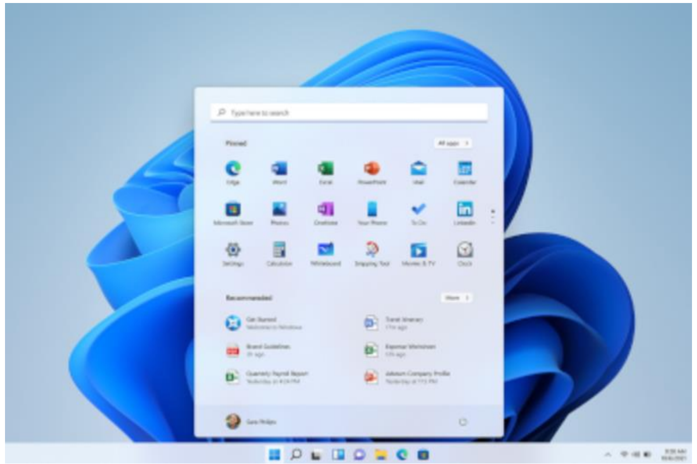


```
PS C:\Users> help

TOPIC
    Windows PowerShell Help System

SHORT DESCRIPTION
    Displays help about Windows PowerShell cmdlets and concepts.

LONG DESCRIPTION
    Windows PowerShell Help describes Windows PowerShell cmdlets,
    functions, scripts, and modules, and explains concepts, including
    the elements of the Windows PowerShell language.

    Windows PowerShell does not include help files, but you can read the
    help topics online, or use the Update-Help cmdlet to download help files
    to your computer and then use the Get-Help cmdlet to display the help
    topics at the command line.

    You can also use the Update-Help cmdlet to download updated help files
    as they are released so that your local help content is never obsolete.

    Without help files, Get-Help displays auto-generated help for cmdlets,
    functions, and scripts.


  ONLINE HELP
    You can find help for Windows PowerShell online in the TechNet Library
    beginning at http://go.microsoft.com/fwlink/?LinkID=108518.

    To open online help for any cmdlet or function, type:

        Get-Help <cmdlet-name> -Online

  UPDATE-HELP
    To download and install help files on your computer:
```

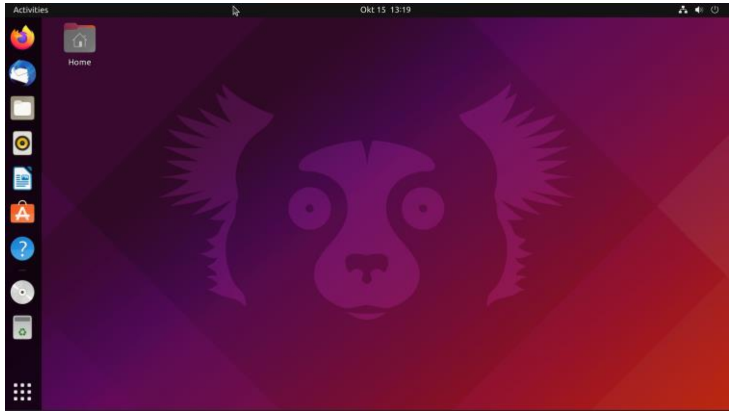
GUI Examples



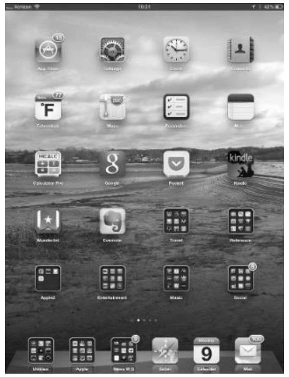
macOS



Windows



Ubuntu



Touchscreen

Process Management

- A process is a program in execution. It is a unit of work within the system. A program is a *passive entity*, process is an active entity.
- Process needs resources to accomplish its task (CPU, memory, I/O, files)

- The operating system is responsible for the following activities in connection with process management:
    - Creating and deleting both user and system processes
    - Suspending and resuming processes
    - Providing mechanisms for process synchronization
    - Providing mechanisms for process communication
    - Providing mechanisms for deadlock handling

Memory Management

- Main memory is central to the operation of a computer system:
  - All data in memory before and after processing
  - All instructions in memory in order to execute

- Memory management determines what is in memory and when
  - Optimizing CPU utilization and computer response to users

- Memory management activities
  - Keeping track of which parts of memory are currently being used and by whom
  - Deciding which processes (or parts thereof) and data to move into and out of memory
  - Allocating and deallocating memory space as needed

Storage Management

- The OS abstracts from the physical properties of its storage devices to define a logical storage unit, the file.

- File-System management
  - Files usually organized into directories
  - Access control on most systems to determine who can access what
  - OS activities include: creating and deleting files and directories, primitives to manipulate files and directories, backup files onto stable (non-volatile) storage media

- OS activities in connection with disk management
  - Free-space management
  - Storage allocation
  - Disk scheduling

Open-Source Operating Systems

- Open source OS: 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)

- “The Free Software Foundation (FSF) is the principal organizational sponsor of the GNU Project. The FSF receives very little funding from corporations or grant-making foundations but relies on support from individuals ...” (http://www.gnu.org/)

What is free software?

- The following is an excerpt from http://www.gnu.org/
  - “Free software is a matter of liberty, not price. To understand the concept, you should think of free as in free speech, not as in free beer.
  - Free software is a matter of the users' freedom to run, copy, distribute, study, change and improve the software. More precisely, it refers to four kinds of freedom, for the users of the software.
  - freedom 0: The freedom to run the program, for any purpose.
  - freedom 1: The freedom to study how the program works, and adapt it to your needs. Access to the source code is a precondition for this.
  - freedom 2: The freedom to redistribute copies so you can help your neighbour.
  - freedom 3: The freedom to improve the program, and release your improvements to the public, so that the whole community benefits. Access to the source code is a precondition for this.”

References

- Some sections from chapter 1 and chapter 2 of Operating Systems Concepts

Acknowledgement: This set of slides is partly based on the PPTs provided by the Wiley's companion website for the operating system concepts book (including textbook images, when not explicitly mentioned/referenced).