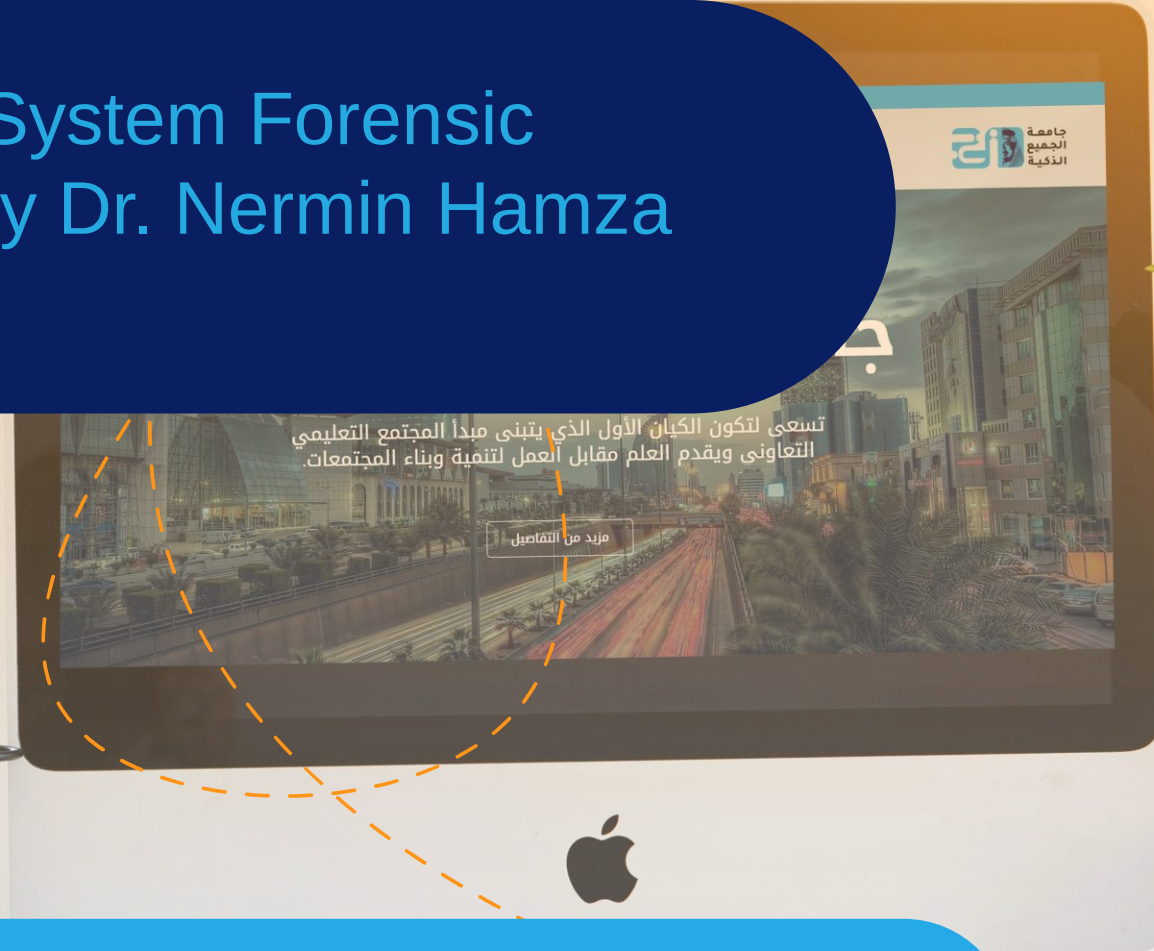


Operating System Forensic

Prepared by Dr. Nermin Hamza

Lecture 5



جامعة العنبر الذكية
EVERYONE'S SMART UNIVERSITY

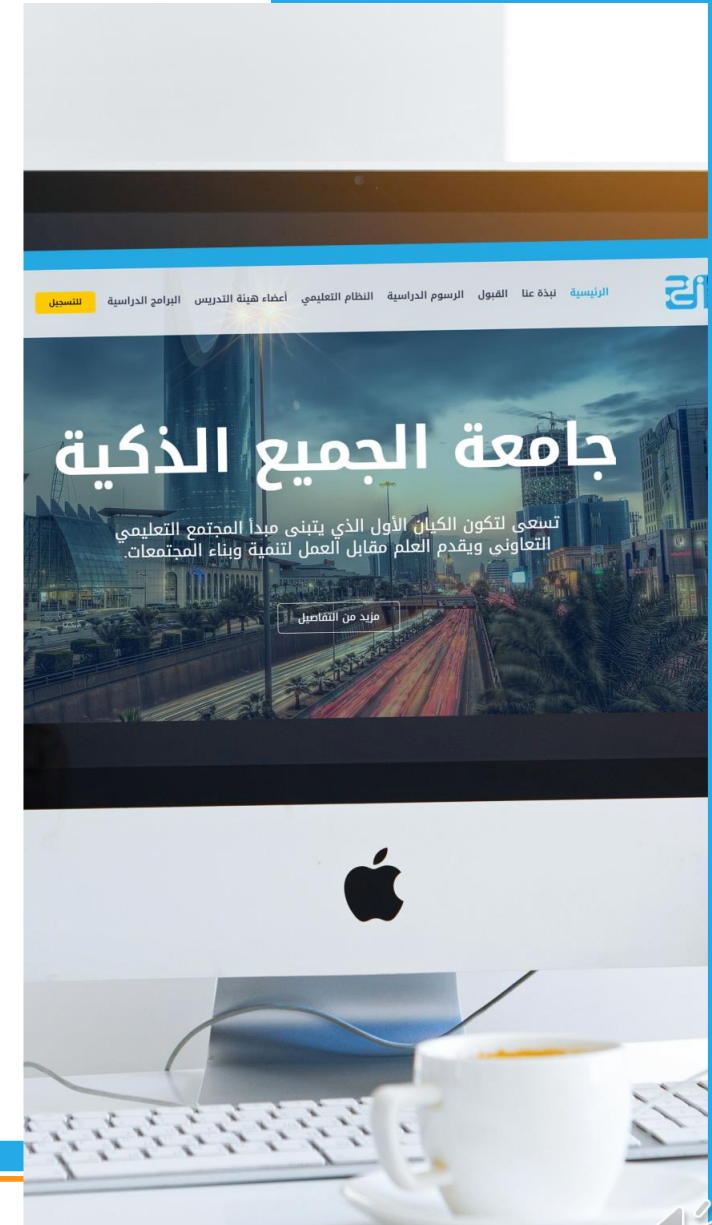
CYB 670
IT Forensics



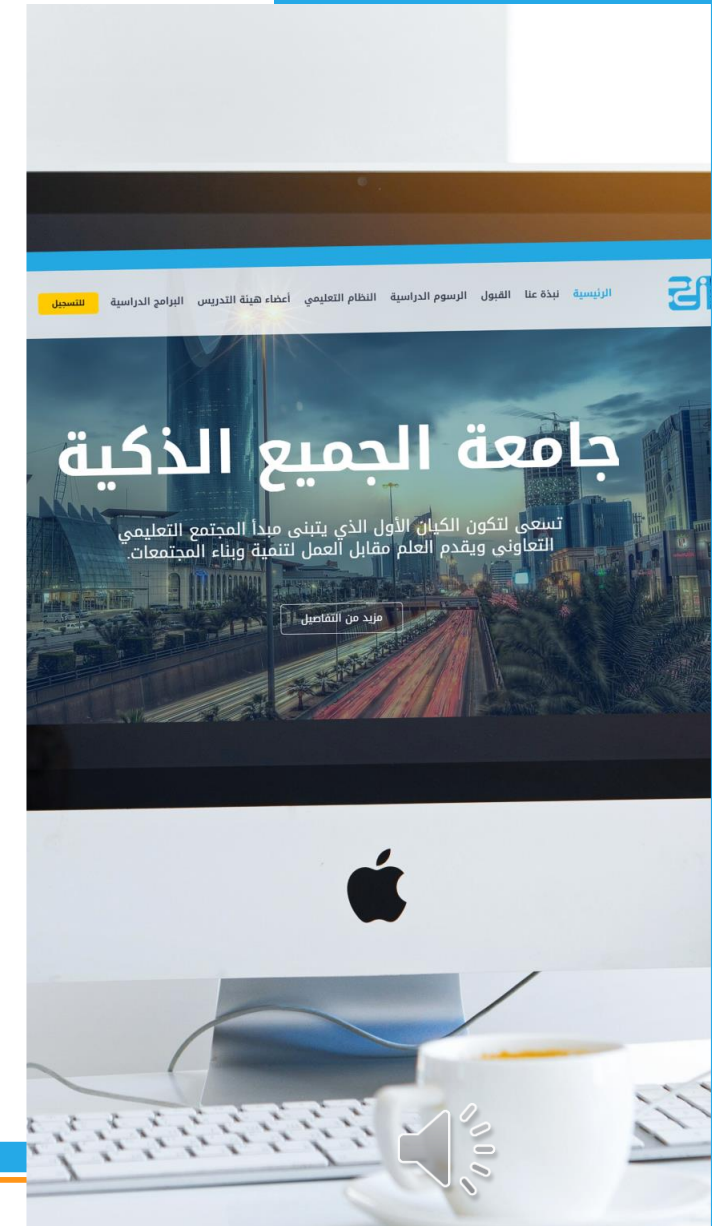
Lecture 5

Outline

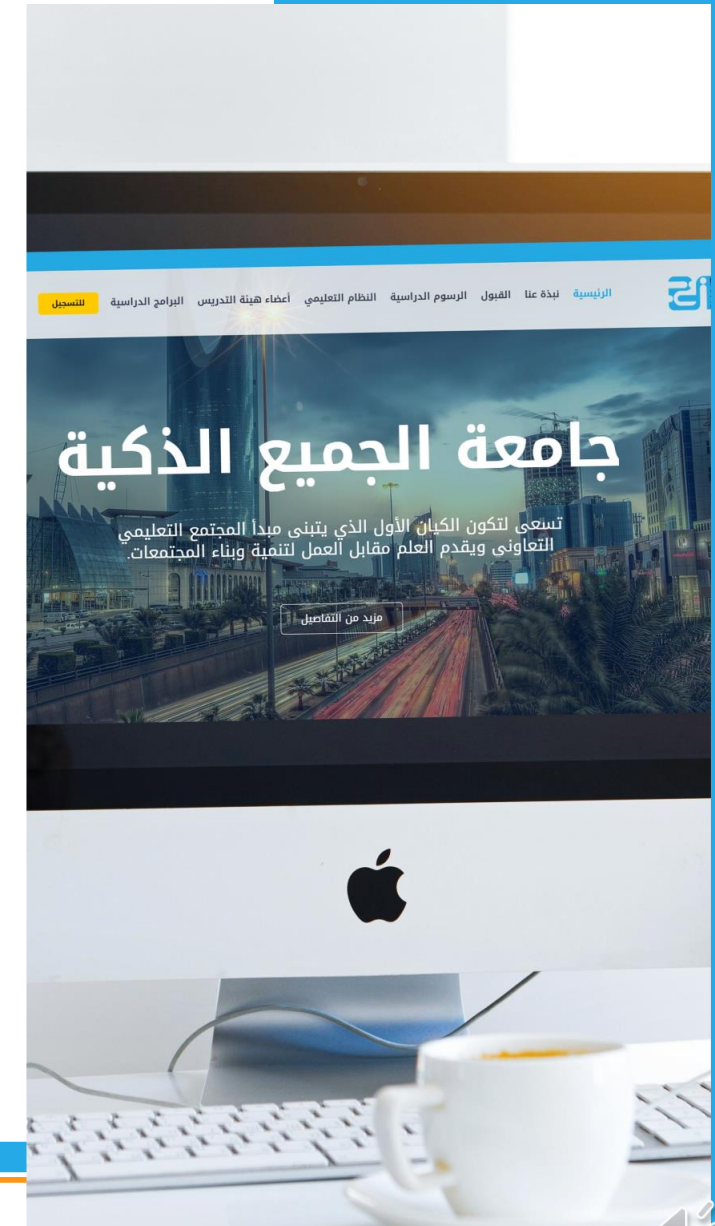
- Operating System and Operating System Forensic
- Kind of operating Systems
- Windows
- Linux Forensic



- An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs.
- An operating system is a program which controls the execution of application programs and acts as an intermediary between the user of a computer and the computer hardware.
- A program which is being executed is also called a process or job.

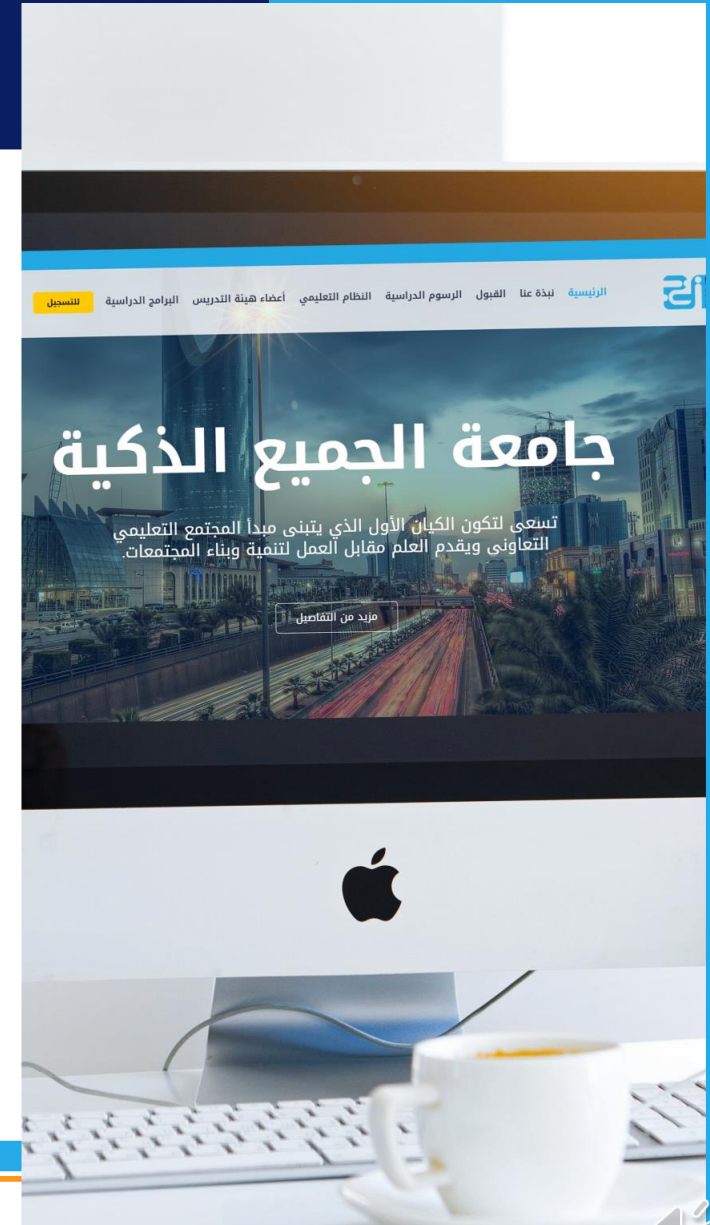


Definition: Operating System Forensics is the process of retrieving useful information from the Operating System (OS) of the computer or mobile device in question.



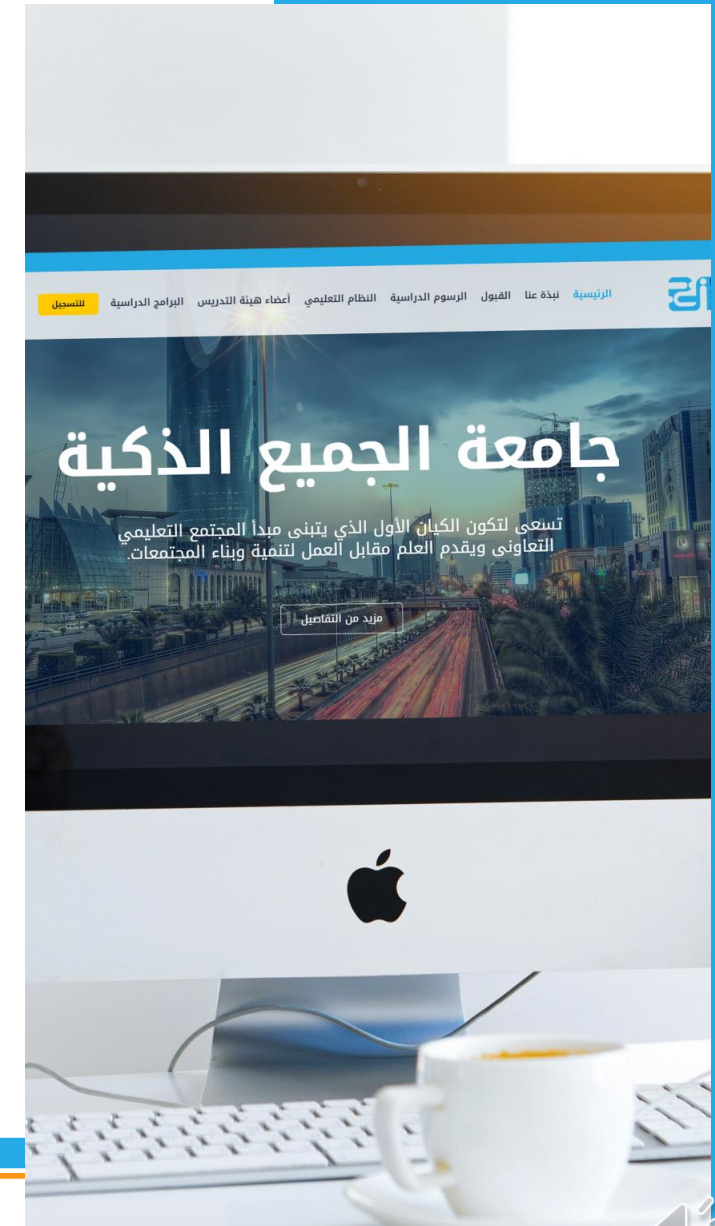
What are the types of Operating Systems?

- The most popular types of Operating Systems are Windows, Linux, Mac, iOS, and Android.

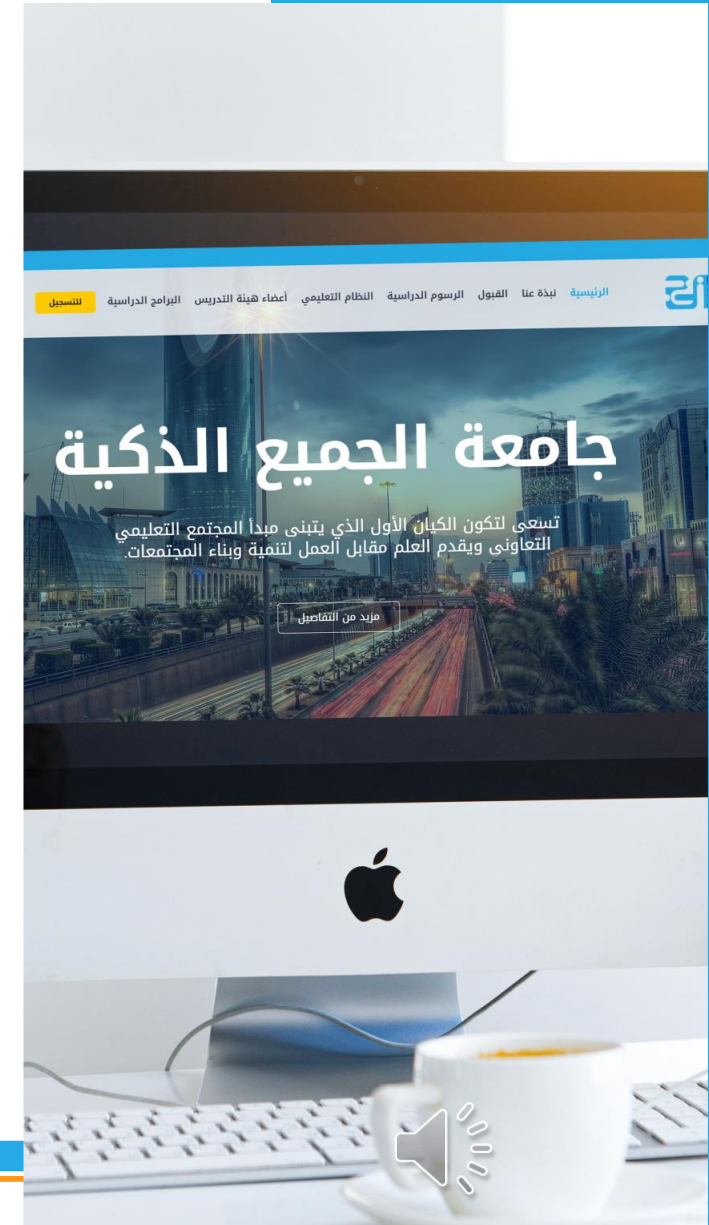


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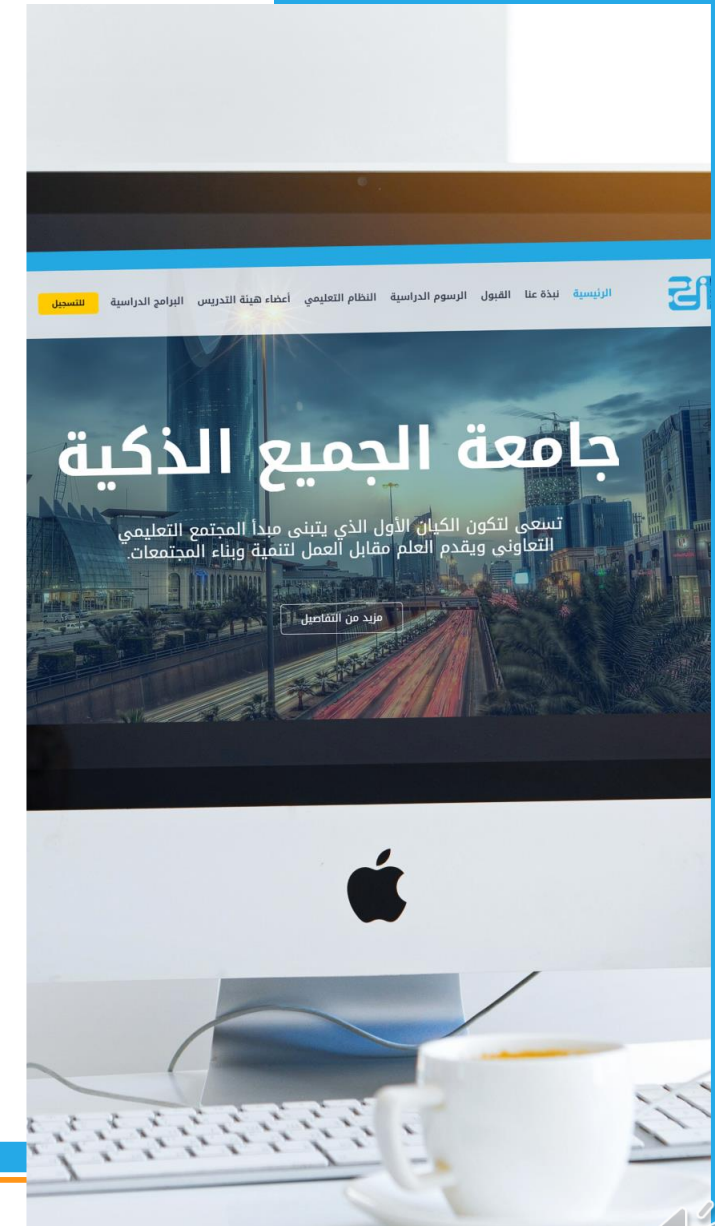
Operating system Types



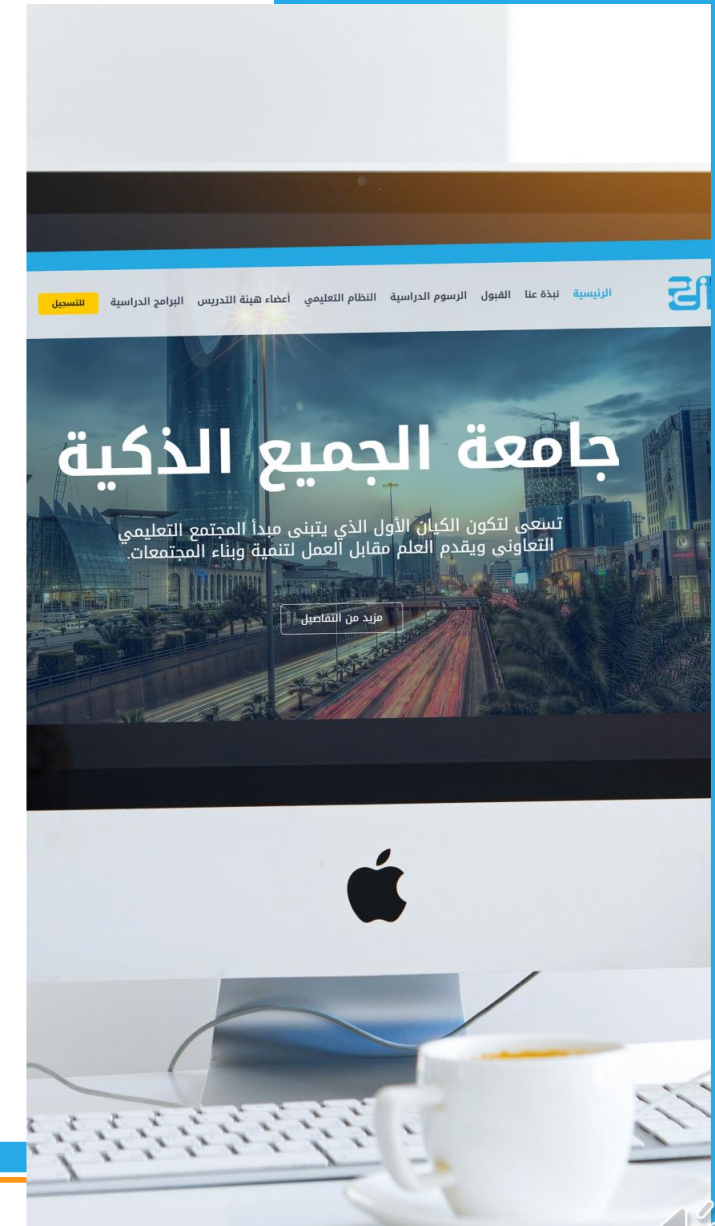
- Windows is a widely used OS designed by Microsoft. The file systems used by Windows include FAT, exFAT, NTFS, and ReFS.



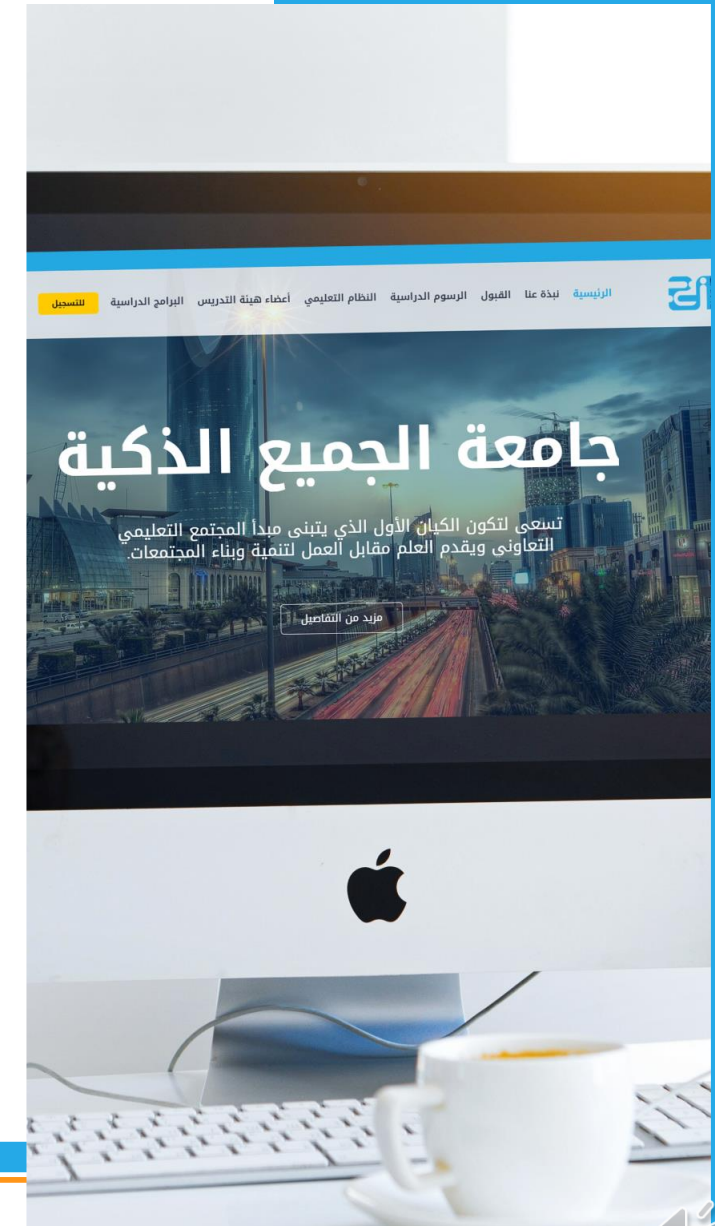
- Linux is an open source, Unix-like, and elegantly designed operating system that is compatible with personal computers, supercomputers, servers, mobile devices, netbooks, and laptops. Unlike other OSs, Linux holds many file systems of the ext family, including ext2, ext3, and ext4.



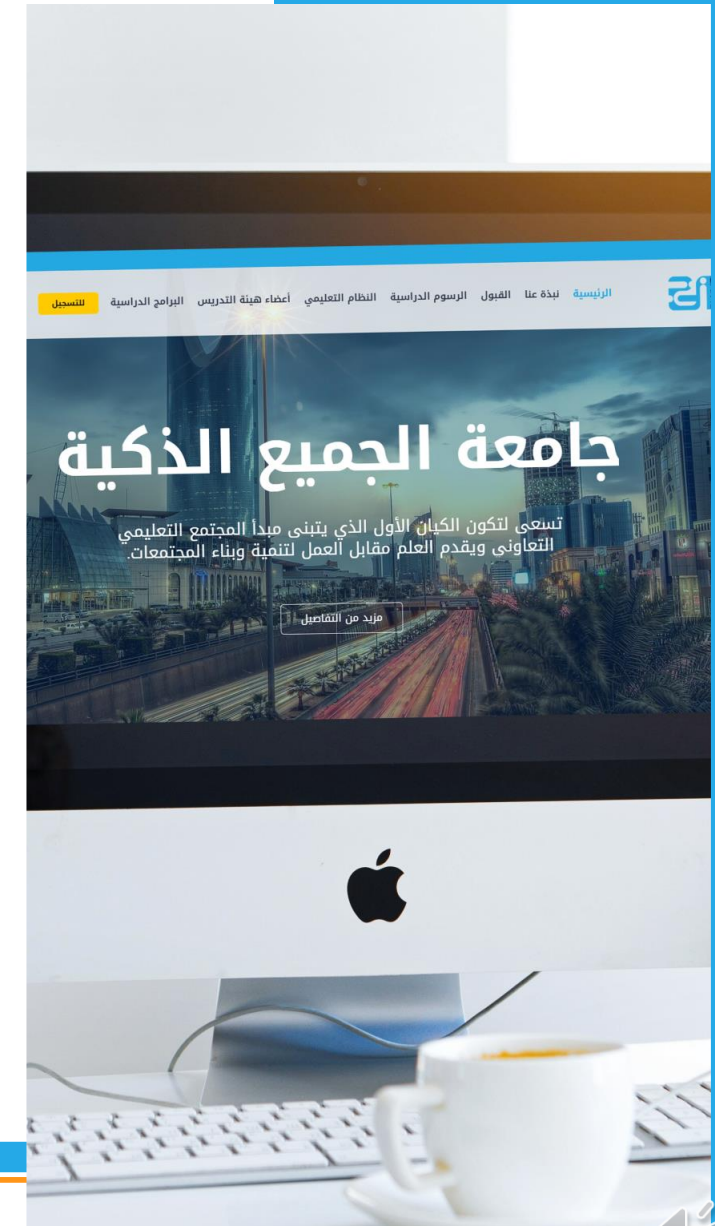
- Mac OS X is the UNIX-based operating system that contains a Mach 3 microkernel and a FreeBSD-based subsystem. Its user interface is Apple-like, whereas the underlying architecture is UNIX-like.



- Apple iOS is the UNIX-based operating system first released in 2007. It is a universal OS for all of Apple's mobile devices, such as iPhone, iPod Touch, and iPad. An iOS embedded device retrieved from a crime scene can be a rich source of empirical evidence.

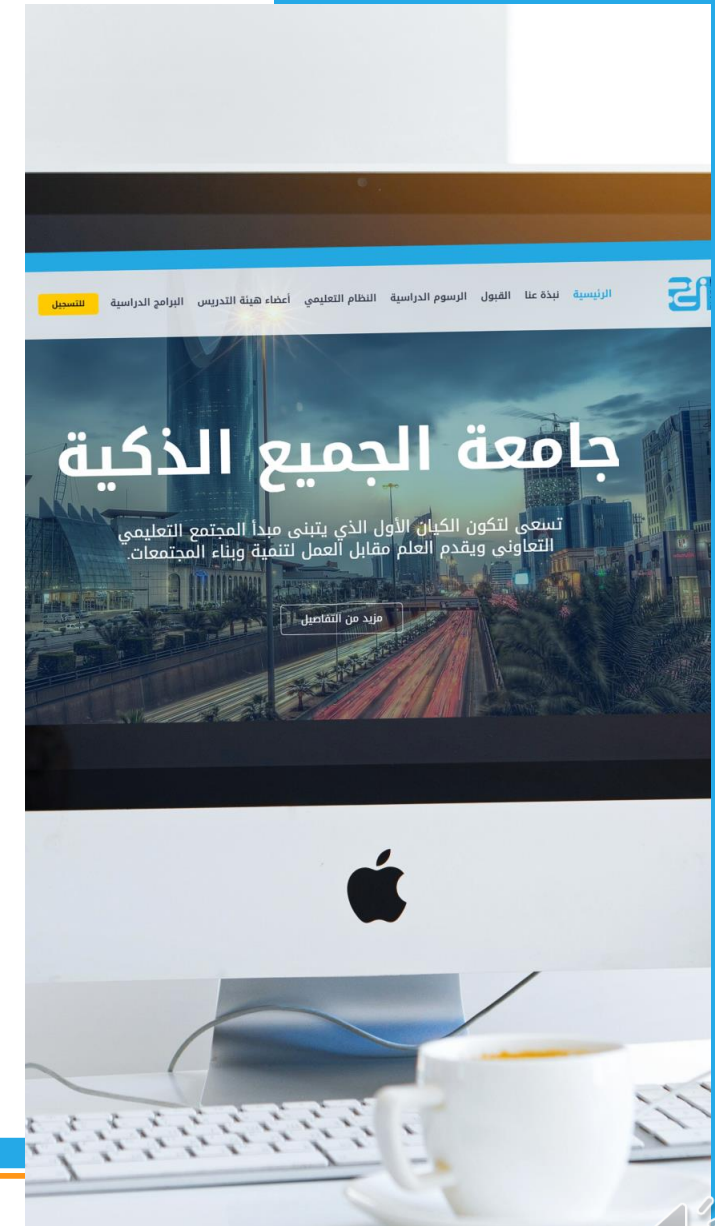


- Android is a Google's open-source platform designed for mobile devices. It is widely used as the mobile operating system in the handsets industry. The Android operating system runs on a Linux-based kernel which supports core functions, such as power management, network infrastructure, and device drivers



Lecture 5

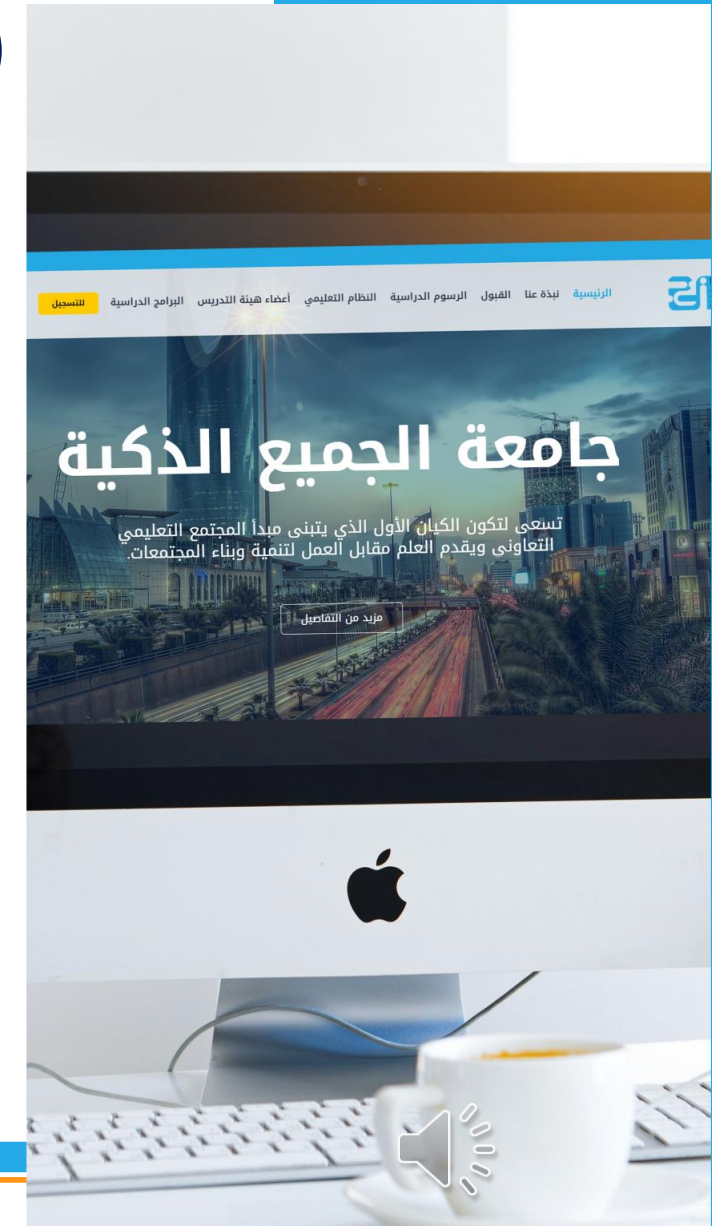
Windows Forensic



Lecture 5

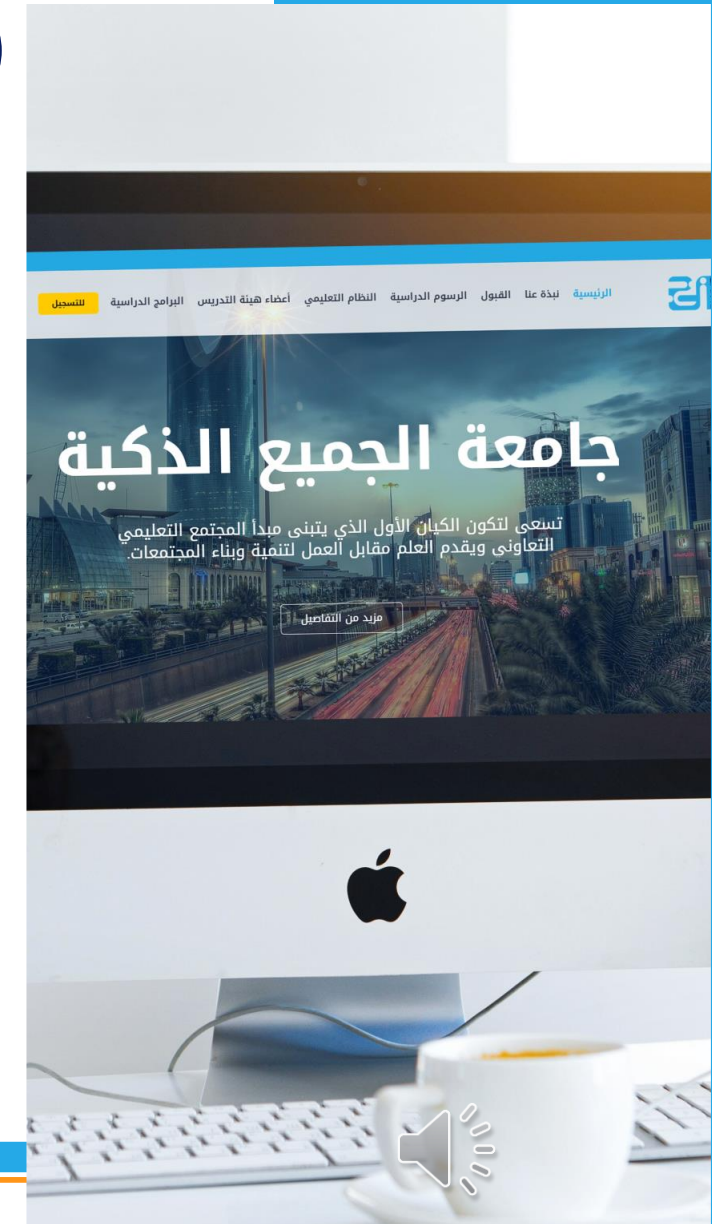
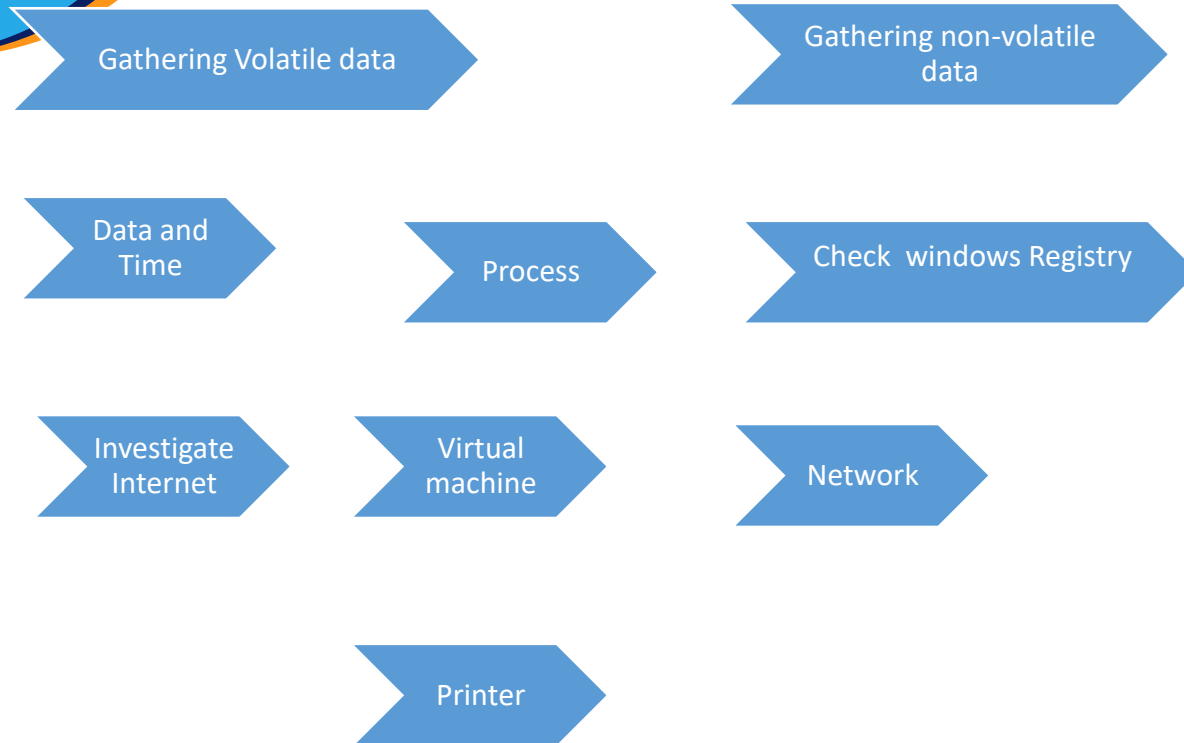
Windows Forensic Analysis

Some of the most crucial areas to check for evidence within volatile data , registers, physical and virtual memory, network connections, running processes, and system files.



Lecture 5

Windows Forensic analysis



Coordinated universal time

- cmd
- Date /t & time /t

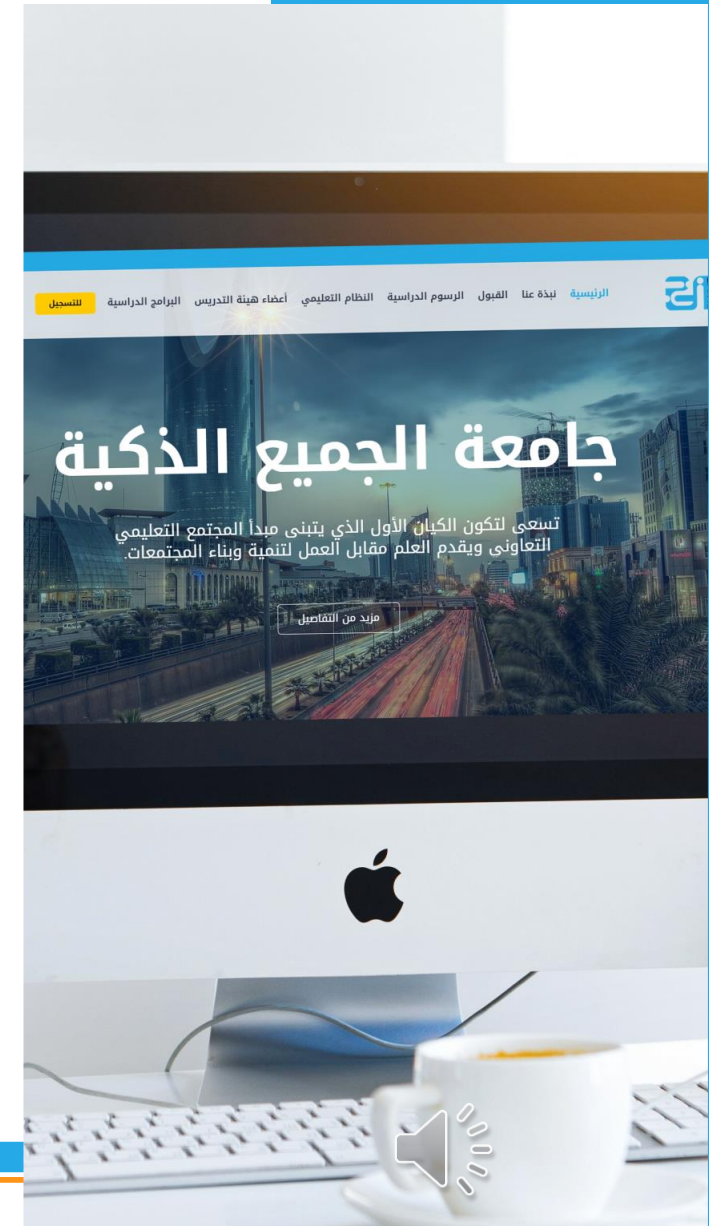
```
C:\Users\Nermin>date
The current date is: Mon 10/24/2022
Enter the new date: (mm-dd-yy)

C:\Users\Nermin>date/t
Mon 10/24/2022

C:\Users\Nermin>time
The current time is: 13:10:34.25
Enter the new time:

C:\Users\Nermin>time/t
01:10 PM

C:\Users\Nermin>
```



- Running Jobs
- Task manager
- Tasklist

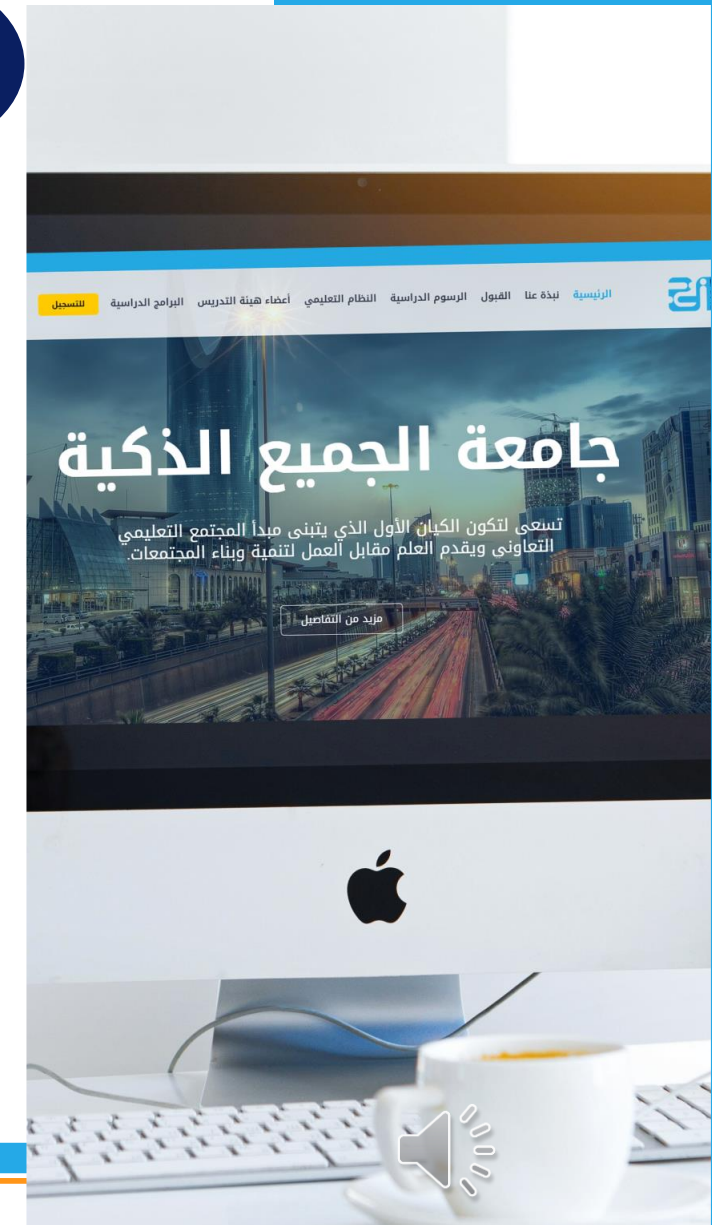
C:\Users\Nermin>tasklist

Image Name	PID	Session Name	Session#	Mem Usage
System Idle Process	0	Services	0	8 K
System	4	Services	0	136 K
Registry	124	Services	0	113,488 K
smss.exe	576	Services	0	1,088 K
csrss.exe	824	Services	0	5,736 K
wininit.exe	956	Services	0	6,460 K
csrss.exe	964	Console	1	7,664 K
services.exe	352	Services	0	9,676 K
winlogon.exe	612	Console	1	12,244 K
lsass.exe	864	Services	0	25,460 K
svchost.exe	1120	Services	0	37,252 K
fontdrvhost.exe	1144	Console	1	8,140 K
fontdrvhost.exe	1152	Services	0	2,808 K
WUDFHost.exe	1216	Services	0	21,756 K
svchost.exe	1276	Services	0	19,380 K
svchost.exe	1336	Services	0	8,444 K
WUDFHost.exe	1380	Services	0	9,648 K
dwm.exe	1480	Console	1	150,184 K
svchost.exe	1576	Services	0	8,832 K
svchost.exe	1592	Services	0	11,424 K
svchost.exe	1612	Services	0	7,400 K
svchost.exe	1660	Services	0	10,524 K
svchost.exe	1668	Services	0	11,560 K
svchost.exe	1776	Services	0	5,864 K
svchost.exe	1792	Services	0	9,856 K
svchost.exe	1876	Services	0	15,176 K
svchost.exe	1940	Services	0	10,168 K
svchost.exe	1948	Services	0	11,704 K
svchost.exe	1972	Services	0	12,976 K
IntelCpHDCPSvc.exe	1756	Services	0	5,024 K
svchost.exe	2060	Services	0	8,436 K
svchost.exe	2088	Services	0	11,348 K



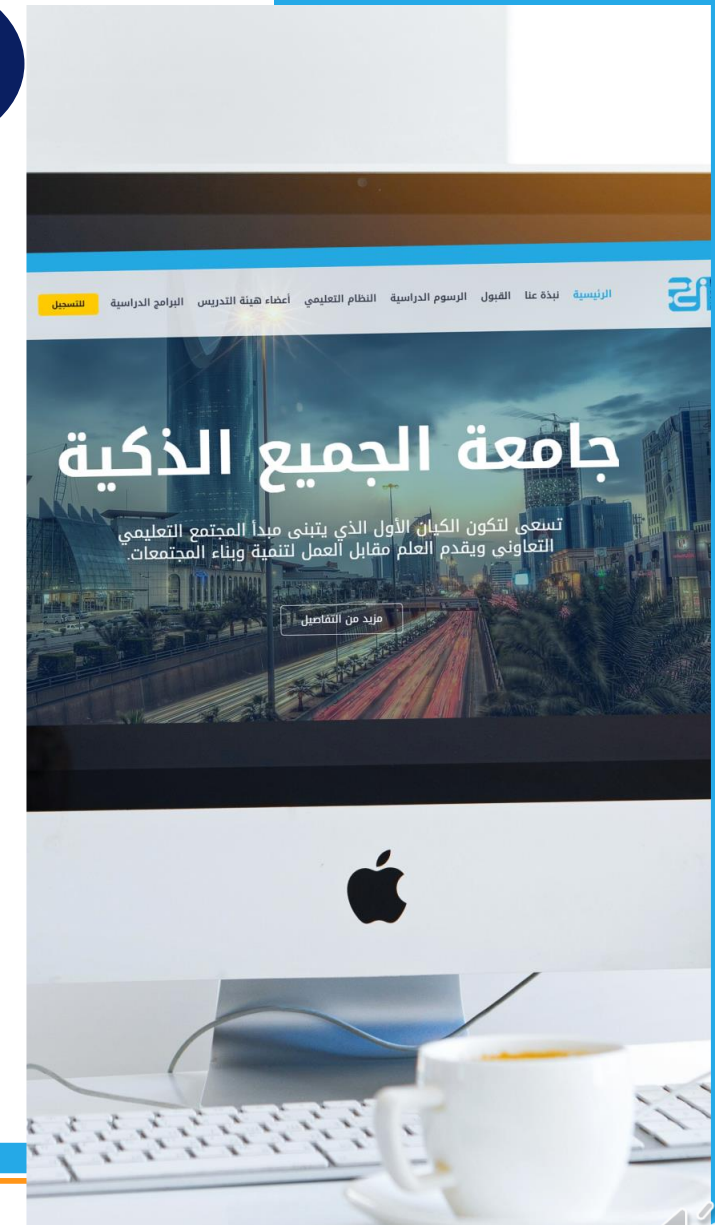
What is the registry?

- Microsoft defines the registry as a central hierarchical database. This database is used to store configuration information about users, hardware devices, and applications.



What about registry forensic investigator?

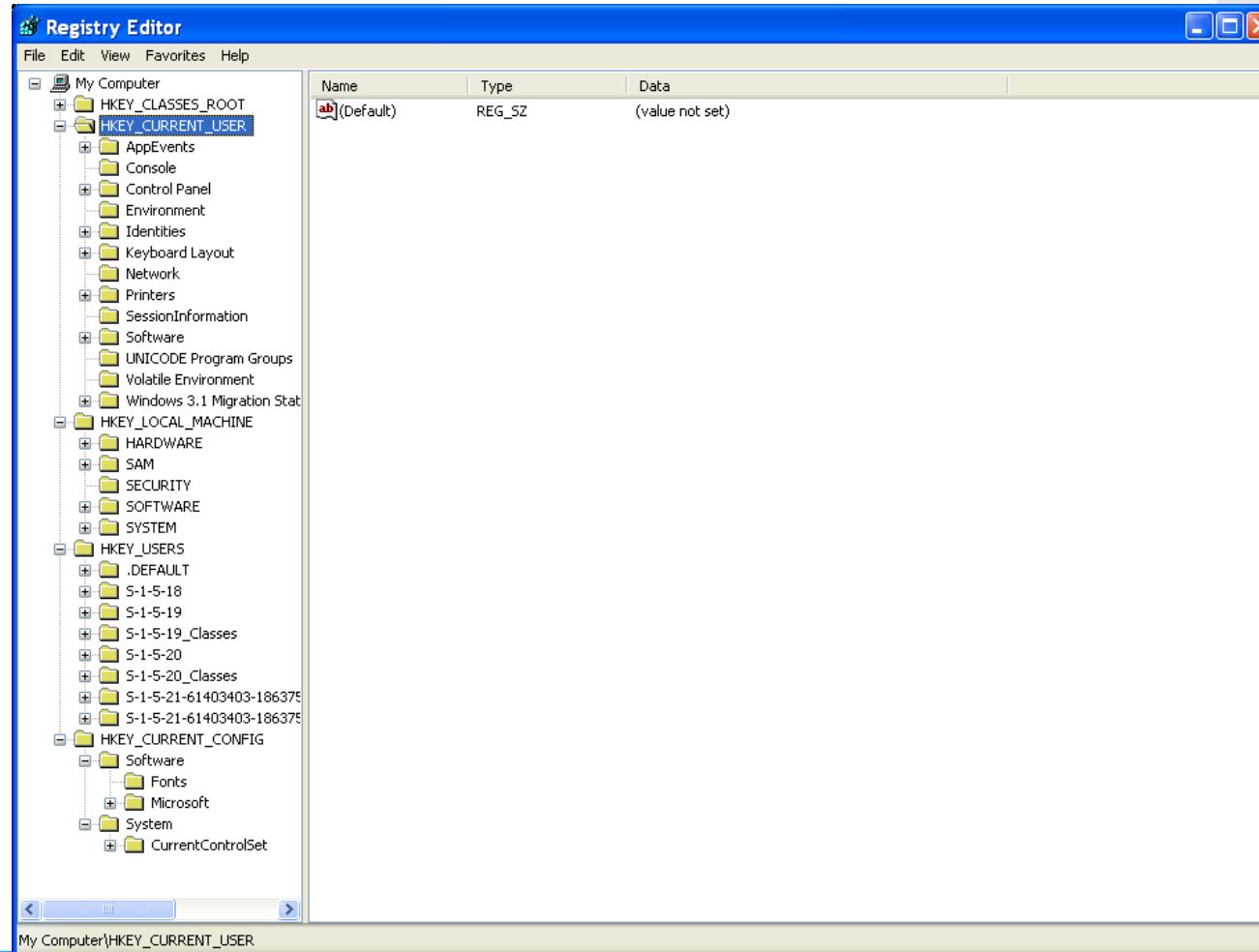
- Information in the registry will contain profiles for each user, installed applications, different document types, and property settings for folders and application icons.
- The registry will also contain information about the hardware on the system, to include networking information such as the ports that are being used.



Lecture 5

Understanding Windows Registry

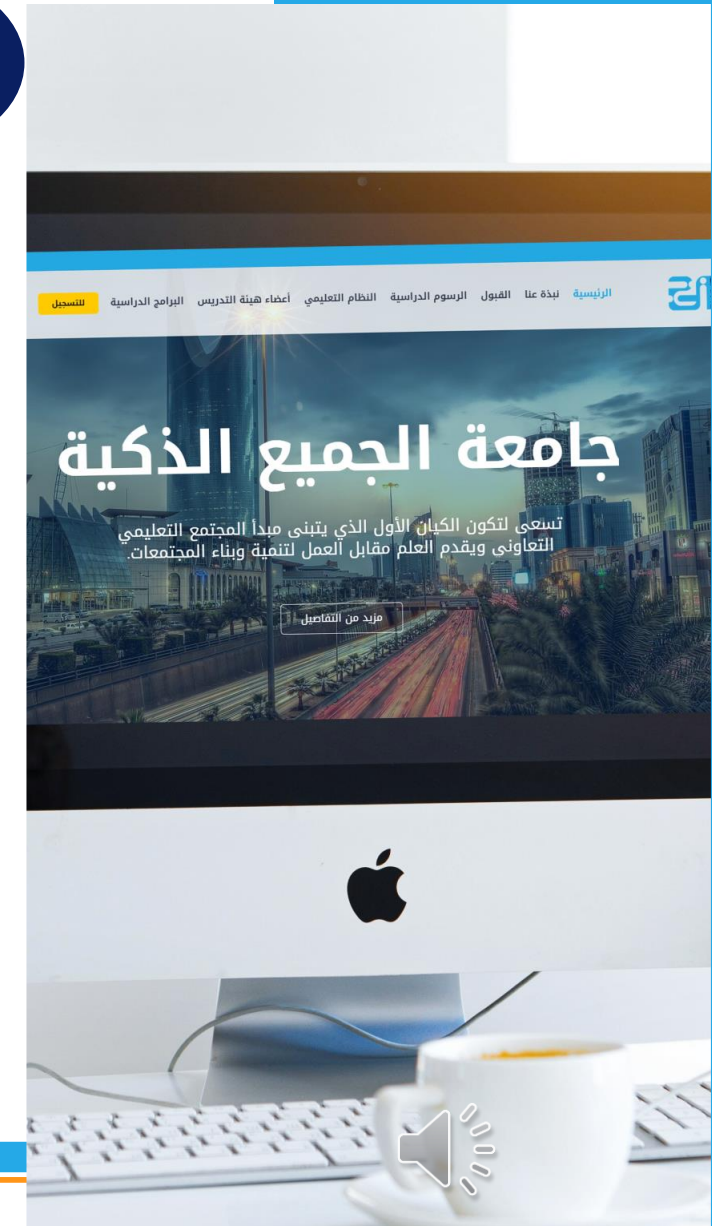
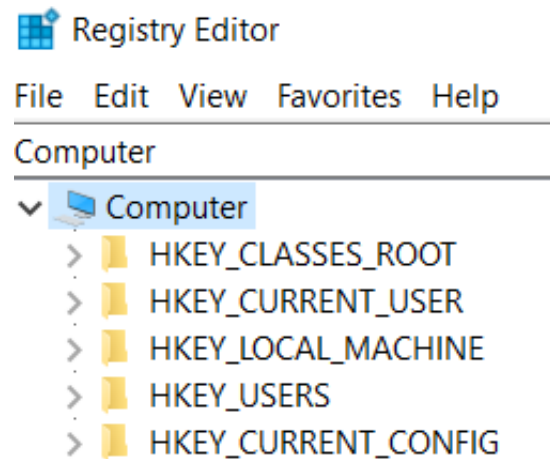
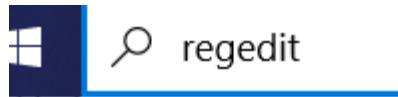
regedit



Lecture 5

Understanding Windows Registry

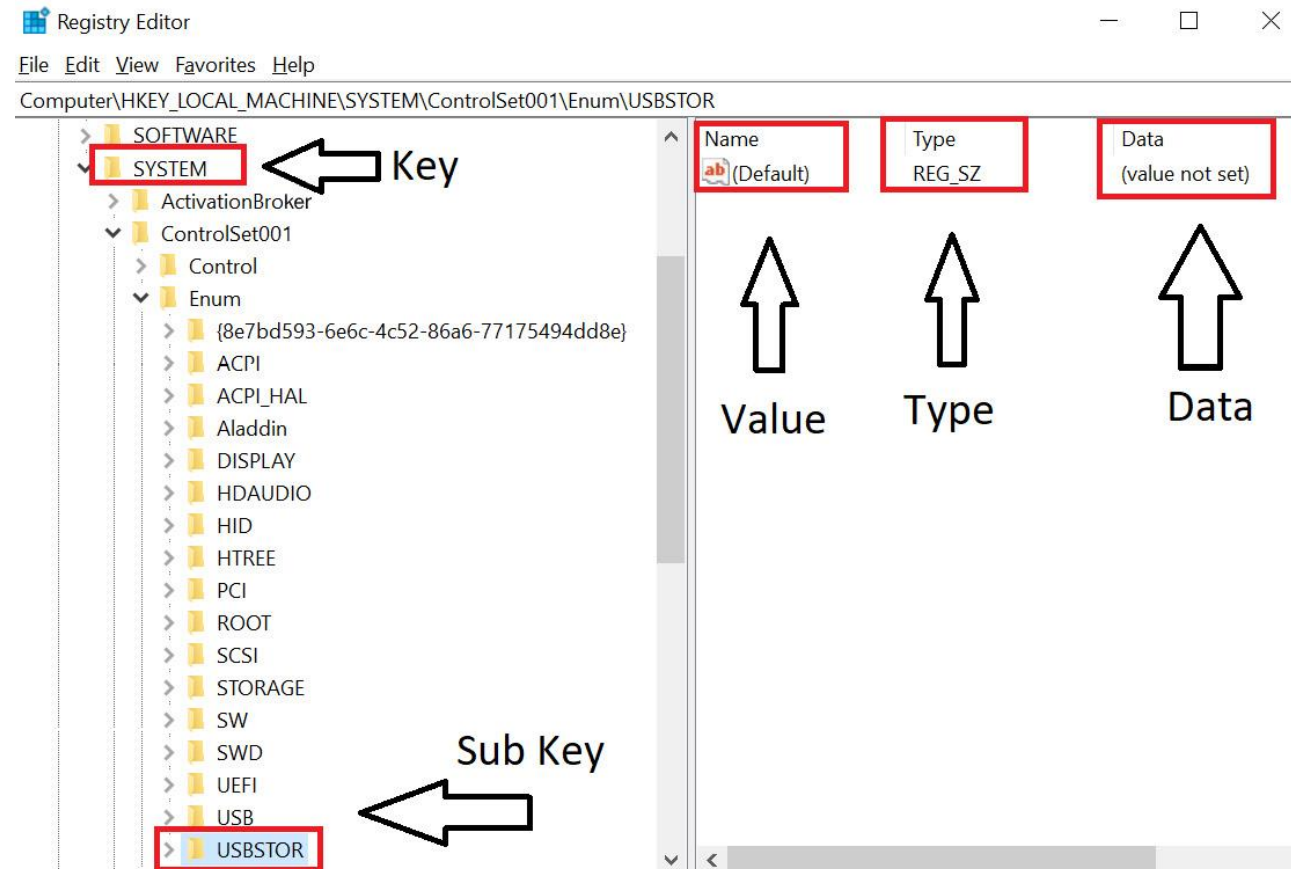
- In the search box on the taskbar, type regedit, then select Registry Editor (Desktop app) from the results.



Lecture 5

Understanding Windows Registry

- The comprises **subkeys** that contain the **Value**, **Type**, and specific **Data** or settings being saved.



Lecture 5

Understanding Windows Registry

Registry Editor

File Edit View Favorites Help

Computer

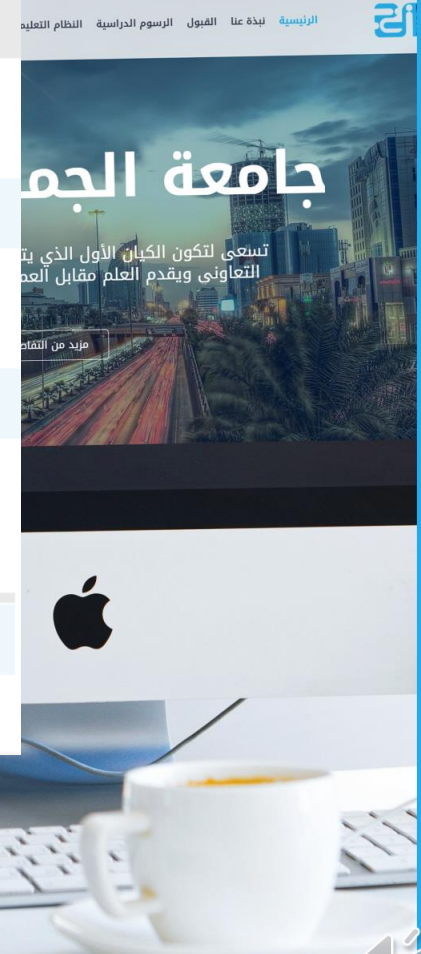
Computer

- > HKEY_CLASSES_ROOT
- > HKEY_CURRENT_USER
- > HKEY_LOCAL_MACHINE
- > HKEY_USERS
- > HKEY_CURRENT_CONFIG

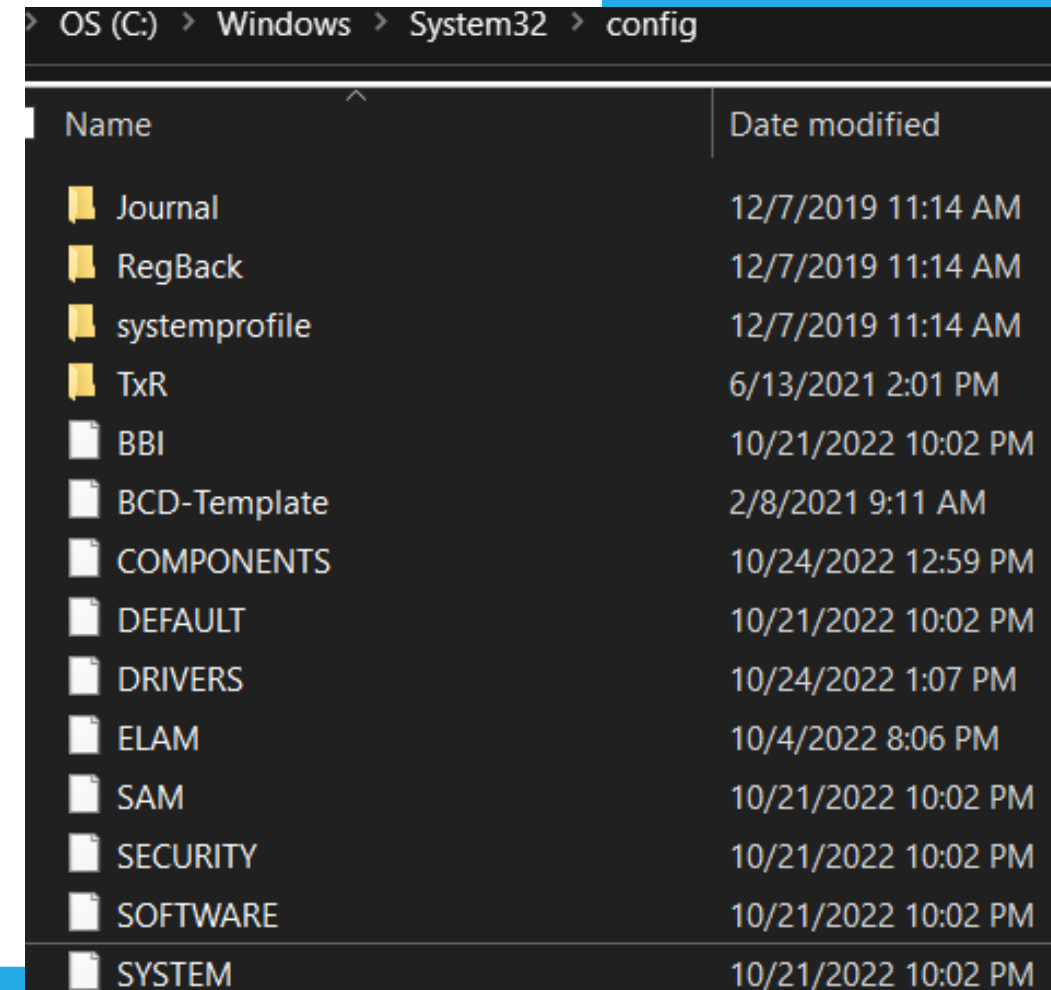
Registry Key	Abbr.	Associated files	Incorporates
HKEY_LOCAL_MACHINE HKEY_USERS	HKLM HKU	NTUSER.DAT	System settings Settings related to all currently logged-in users
HKEY_CURRENT_USER	HKCU		Both system and application Settings with regard to all currently logged-in users
HKEY_CURRENT_CONFIG	HKCC		Registry will be created at runtime and contains hardware settings and performance details
HKLM\SYSTEM		System	File involves system settings about services and hardware
HKLM\SOFTWARE		Software	File incorporates configuration settings for all installed applications including windows
HKLM\SAM		Sam	Includes security info and user password hashes for all users on the system

Registry file locations and purposes

Filename and location	Purpose of file
Users\user-account\Ntuser.dat	User-protected storage area; contains the list of most recently used files and desktop configuration settings
Windows\system32\config\Default.dat	Contains the computer's system settings
Windows\system32\config\SAM.dat	Contains user account management and security settings
Windows\system32\config\Security.dat	Contains the computer's security settings
Windows\system32\config\Software.dat	Contains installed programs' settings and associated usernames and passwords
Windows\system32\config\System.dat	Contains additional computer system settings
Windows\system32\config\systemprofile	Contains additional NTUSER information



- The components of the registry are found in the **%SystemRoot%\System32\Config** folder and are called hive files. You will find the SAM, SECURITY, SOFTWARE, and SYSTEM hives:
- The **SAM** hive is the Security Accounts Manager and contains login information about the users.
- The **SECURITY** hive contains security information and, potentially, password information.
- The **SOFTWARE** hive contains information about application information and the default Windows settings.
- The **SYSTEM** hive includes information on the hardware and system configuration.



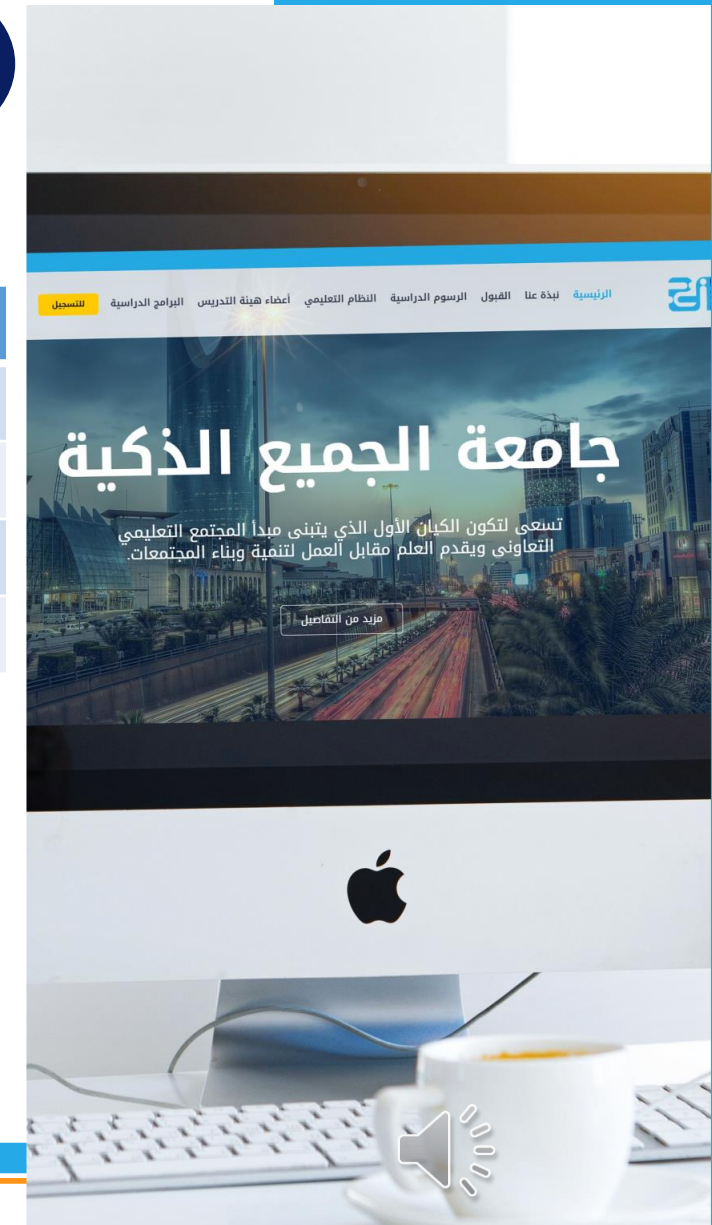
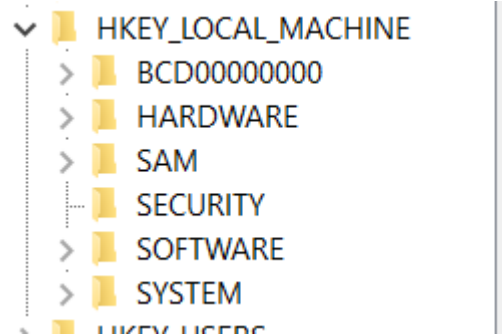
Name	Date modified
Journal	12/7/2019 11:14 AM
RegBack	12/7/2019 11:14 AM
systemprofile	12/7/2019 11:14 AM
TxR	6/13/2021 2:01 PM
BB1	10/21/2022 10:02 PM
BCD-Template	2/8/2021 9:11 AM
COMPONENTS	10/24/2022 12:59 PM
DEFAULT	10/21/2022 10:02 PM
DRIVERS	10/24/2022 1:07 PM
ELAM	10/4/2022 8:06 PM
SAM	10/21/2022 10:02 PM
SECURITY	10/21/2022 10:02 PM
SOFTWARE	10/21/2022 10:02 PM
SYSTEM	10/21/2022 10:02 PM



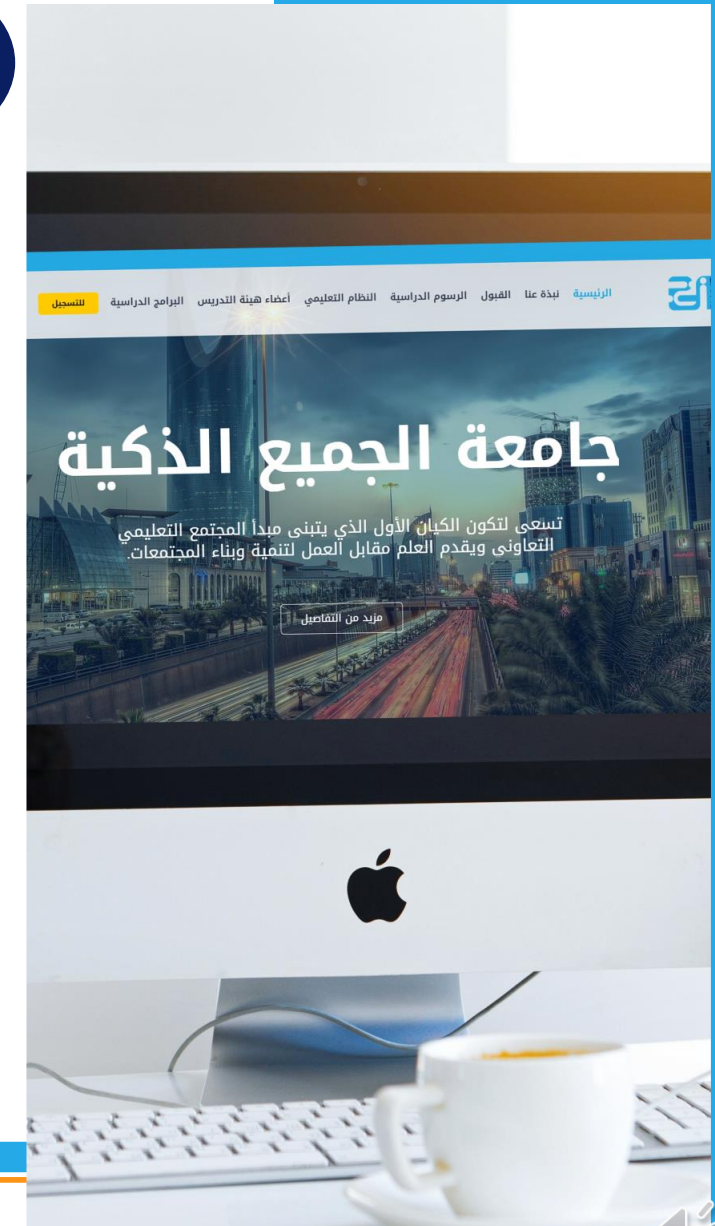
Lecture 5

Understanding Windows Registry

Subtree	Filename
HKEY_LOCAL_MACHINE\System	Windows\system32\config\System
HKEY_LOCAL_MACHINE\Software	Windows\system32\config\Software
HKEY_LOCAL_MACHINE\Security	Windows\system32\config\Security
HKEY_LOCAL_MACHINE\SAM	Windows\system32\config\SAM



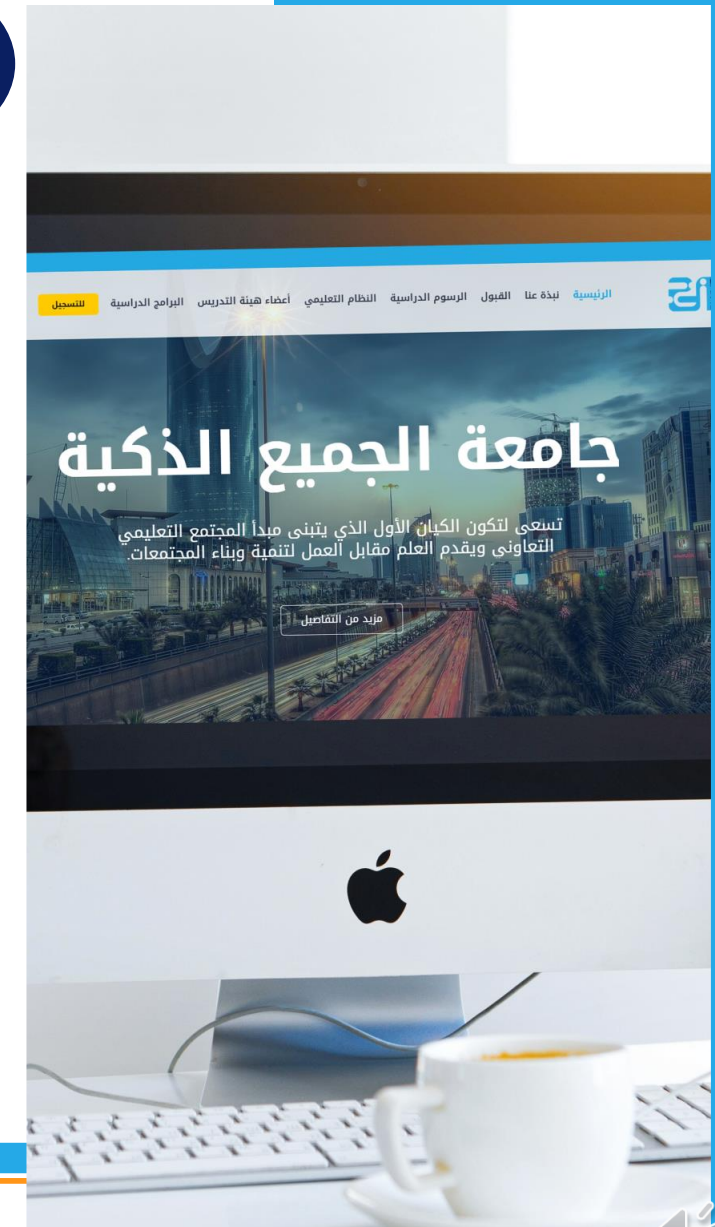
- Some forensics tools, such as X-Ways Forensics, OSForensics, Forensic Explorer, and FTK, have built-in or add-on Registry viewers.



- The Windows Event Log is used by Microsoft Windows to store application and system logs. Typical Event Logs are: Application, System, and Security.
- Windows Server records events in the following logs:

❑ Application log

- The application log contains events that are logged by programs. Events that are written to the application log are determined by the developers of the software program.

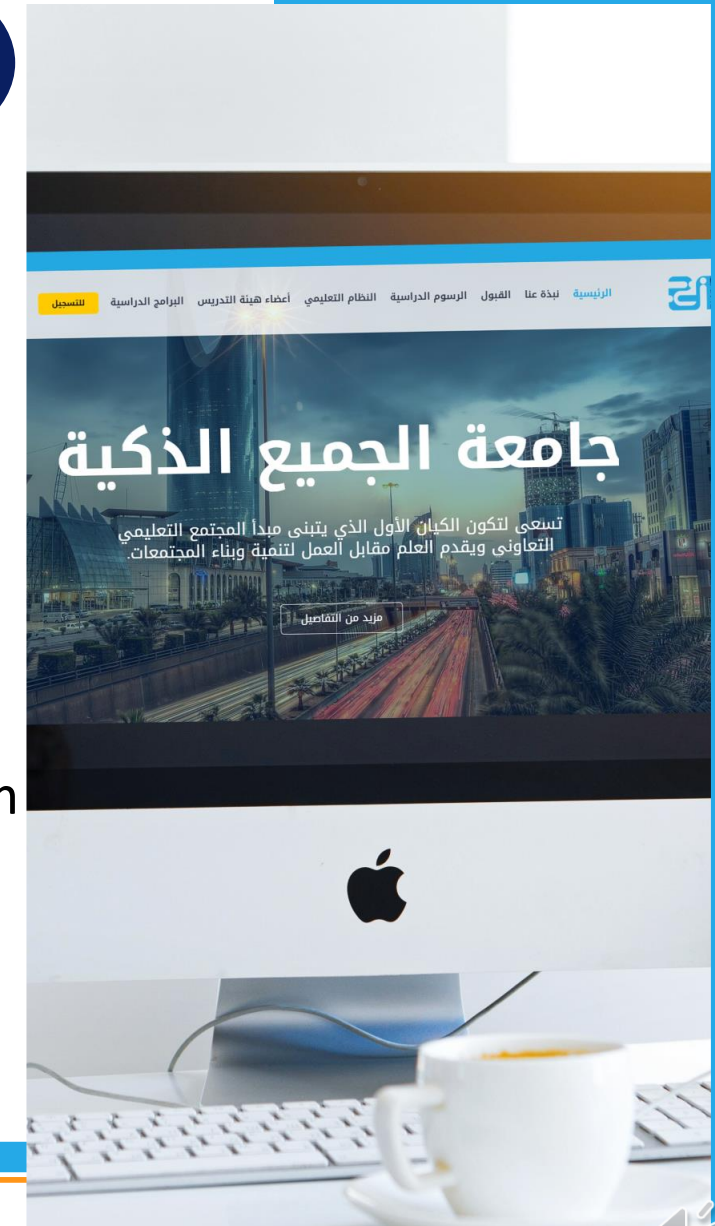


☐ Security log

- The security log contains events such as valid and invalid logon attempts. It also contains events that are related to resource use, for example, when you create, open, or delete files. You must be logged on as an administrator or as a member of the Administrators group to turn on, to use, and to specify which events are recorded in the security log.

☐ System log

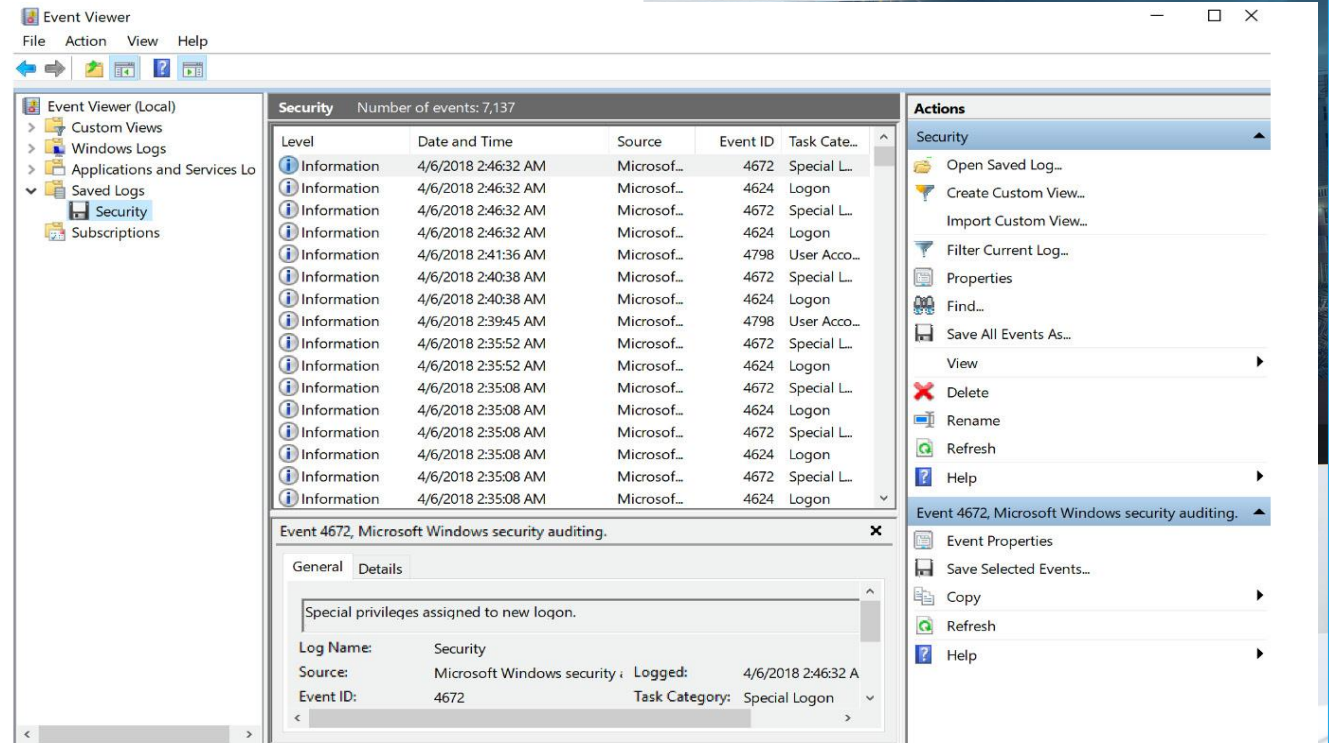
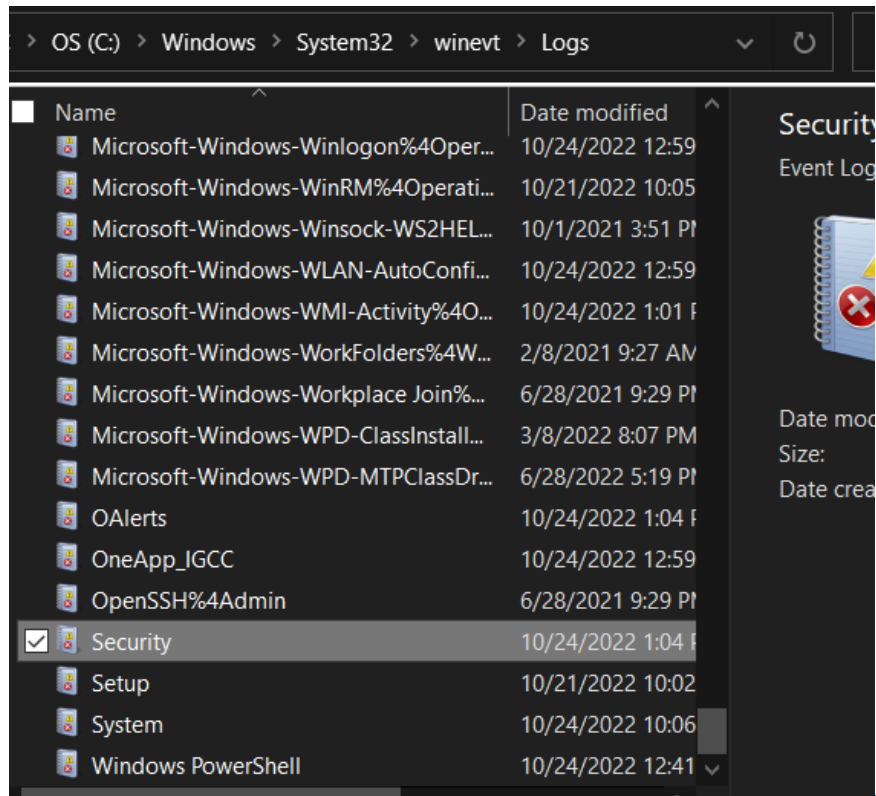
- The system log contains events that are logged by Windows system components. These events are predetermined by Windows.



Lecture 5

Log Files

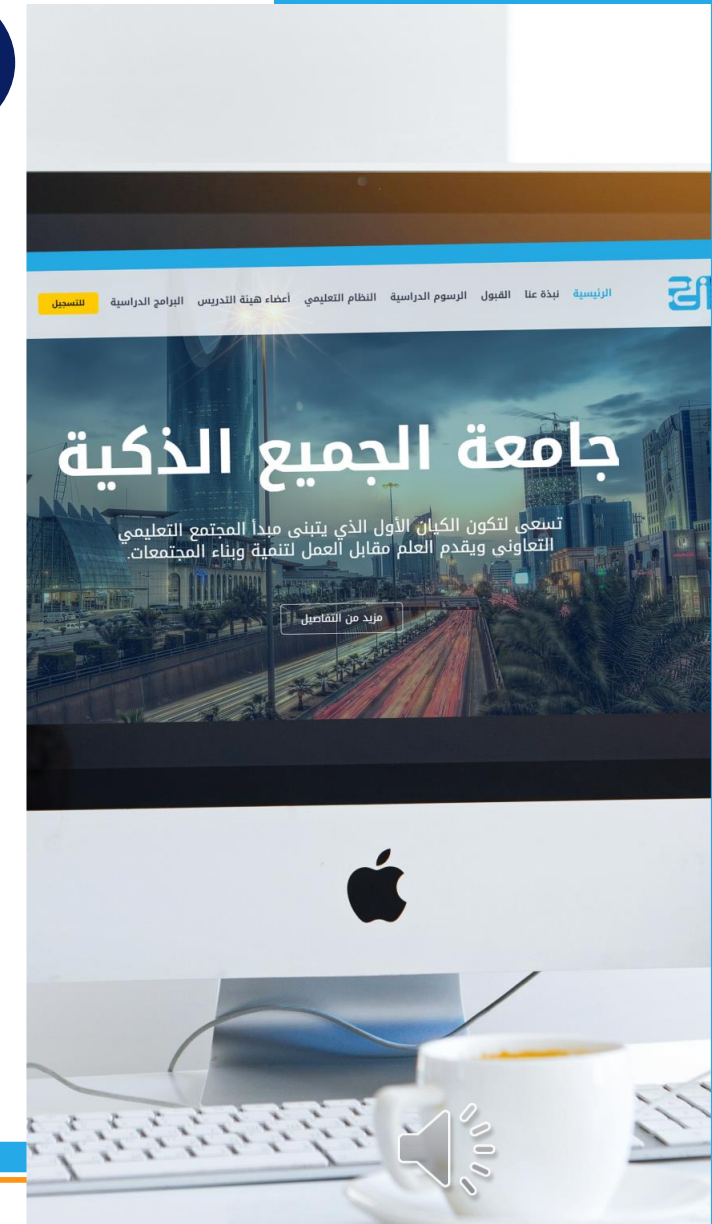
- C:\Windows\System32\winevt\logs



- Book has more details

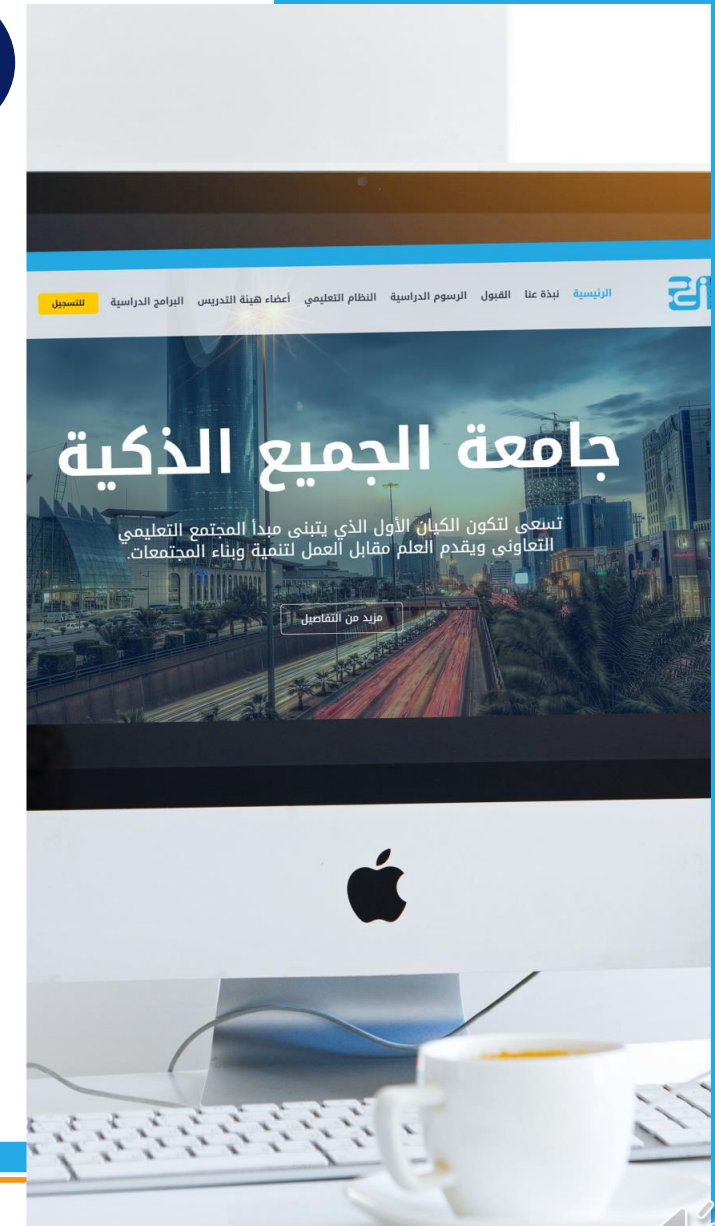
Subject:	
Security ID:	SYSTEM
Account Name:	DESKTOP-PM6C56D\$
Account Domain:	WORKGROUP
Logon ID:	0x3E7
Logon Information:	
Logon Type:	2
Restricted Admin Mode:	-
Virtual Account:	No
Elevated Token:	No
Impersonation Level:	
Impersonation	
New Logon:	
Security ID:	S-1-5-21-2734969515-1644526556-1039763013-1001
Account Name:	jcloudy
Account Domain:	DESKTOP-PM6C56D
Logon ID:	0x11F43947
Linked Logon ID:	0x11F4390D
Network Account Name:	-
Log Name: Security	
Source:	Microsoft Windows security
Event ID:	4624
Level:	Information
User:	N/A
OpCode:	Info
More Information: Event Log Online Help	
Logged:	4/6/2018 05:26
Task Category:	Logon
Keywords:	Audit Success
Computer:	DESKTOP-PM6C56D

4624: An account was successfully logged on

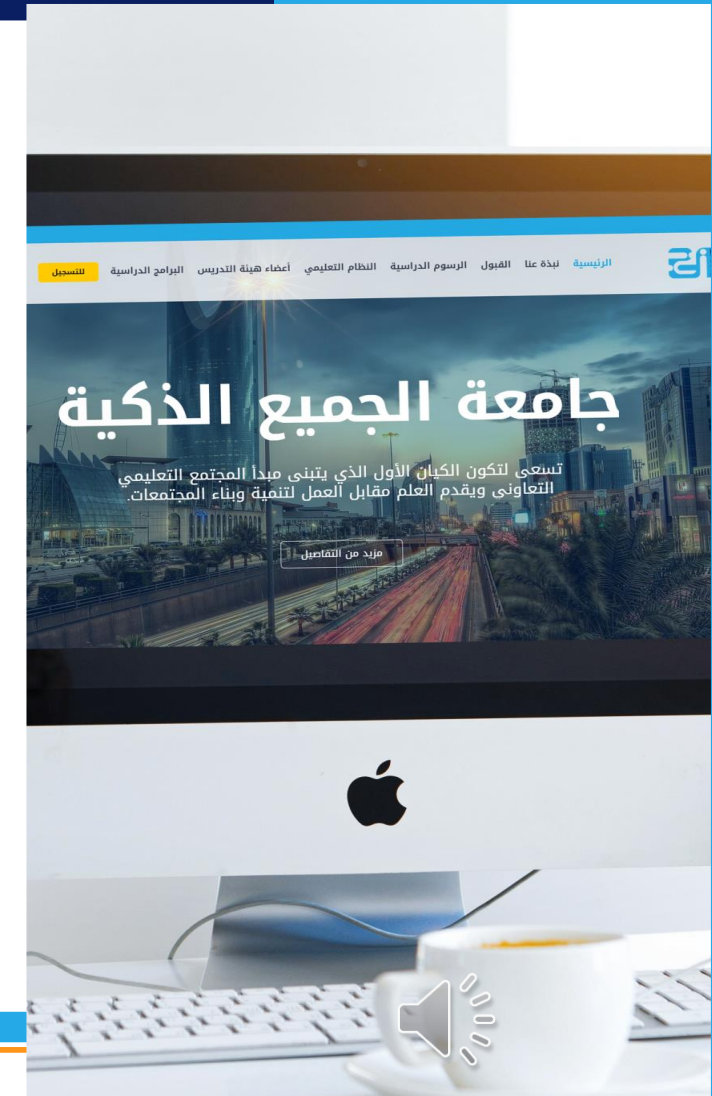


Internet has some issues that should be checked for evidence.

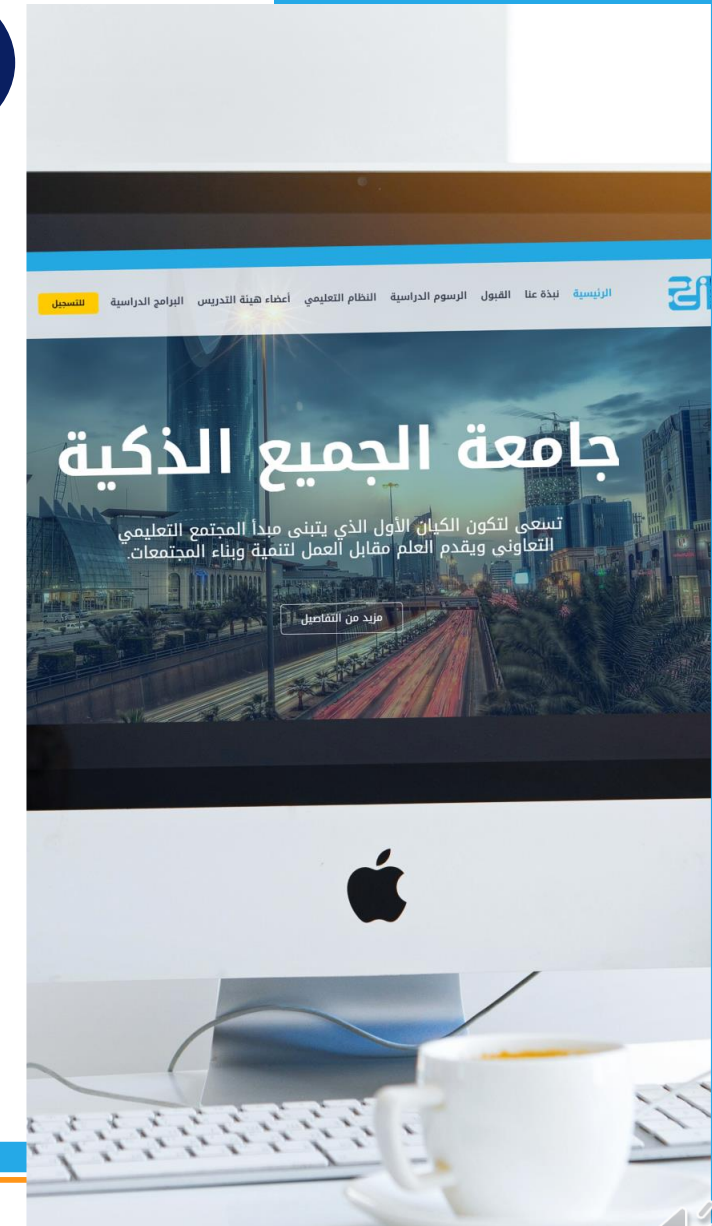
- History
- Temporary Internet files
- Cookies



- Knowing which networks, be they wired or wireless, the suspect has connected to might give you location information about their whereabouts at the time in question.
- The Wi-Fi document will be found at the following path:
C:\ProgramData\Microsoft\Wlansvc\Profiles\Interfaces



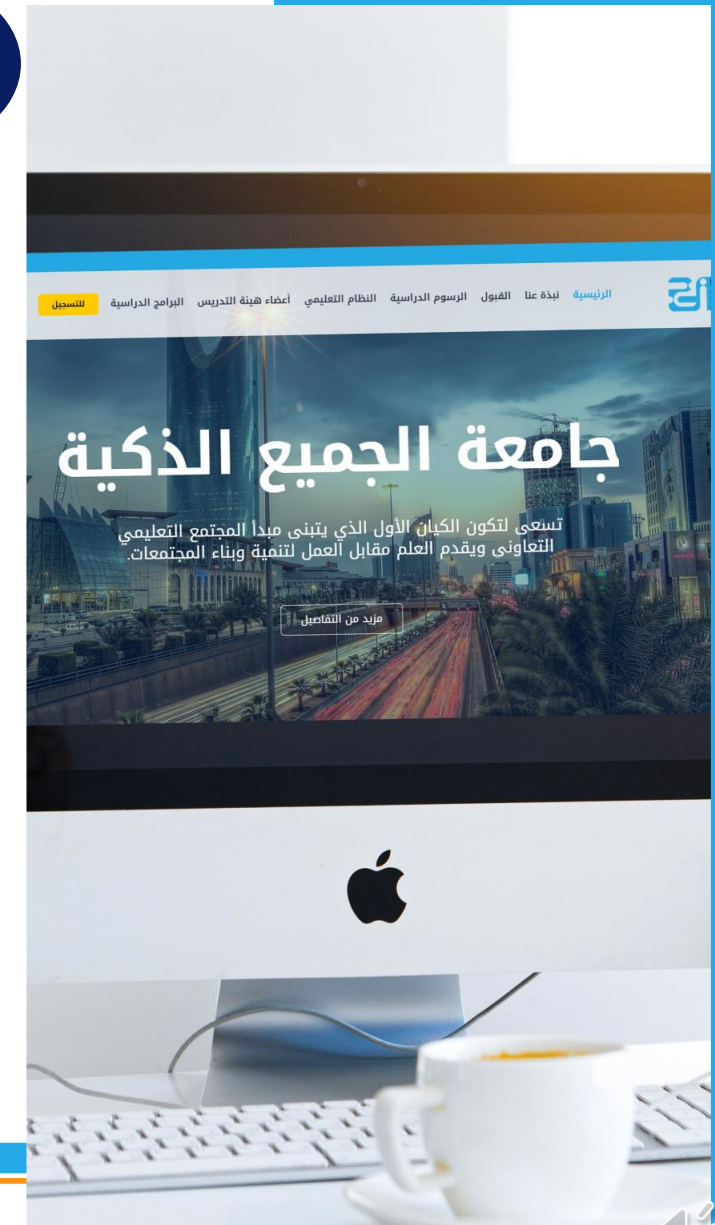
- Microsoft uses the same method to record a user's file activity and internet history as they use with the Internet Explorer/File Explorer/Edge browsers.
- It records local and remote file access. Most commercial forensics tools parse these files easily.
- Depending on the version, the history file will be located in the following areas:
 - ❑ IE6-7: %USERPROFILE%\LocalSettings\History\History.IE5
 - ❑ IE8-9:
%USERPROFILE%\AppData\Local\Microsoft\WindowsHistory\History.IE5
 - ❑ IE10-11:
%USERPROFILE%\AppData\Local\Microsoft\Windows\WebCache\WebCacheV*.dat



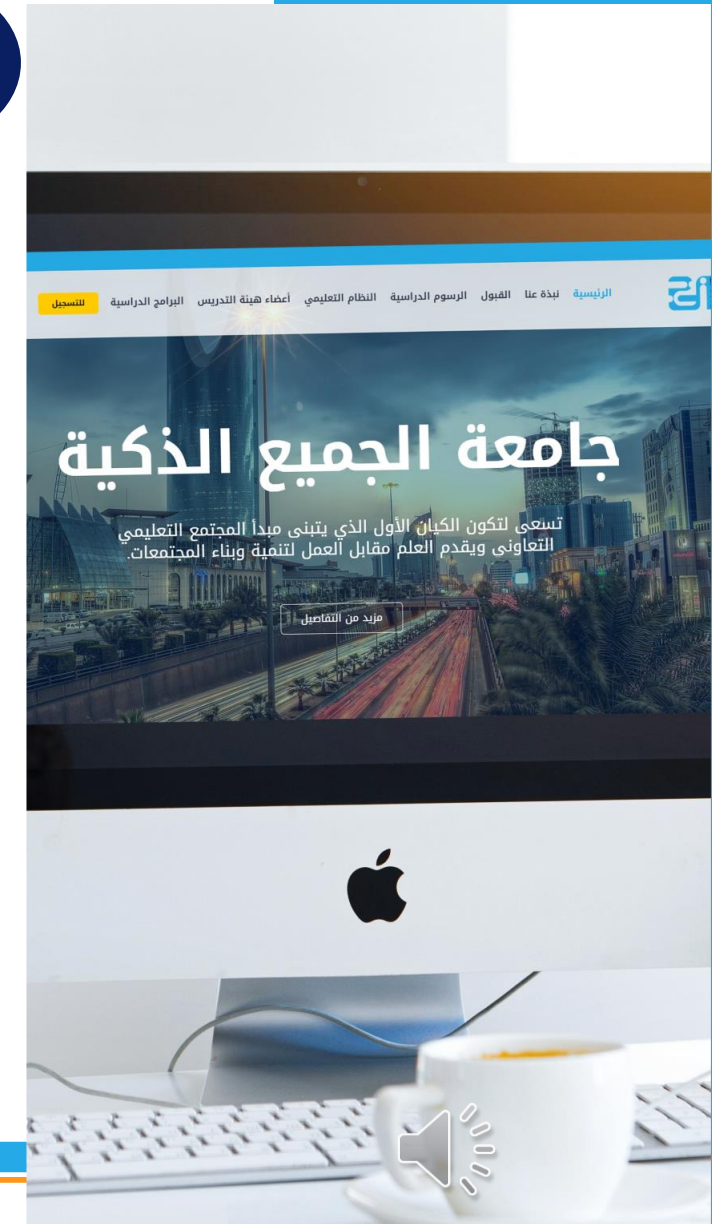
Lecture 5

Exploring History

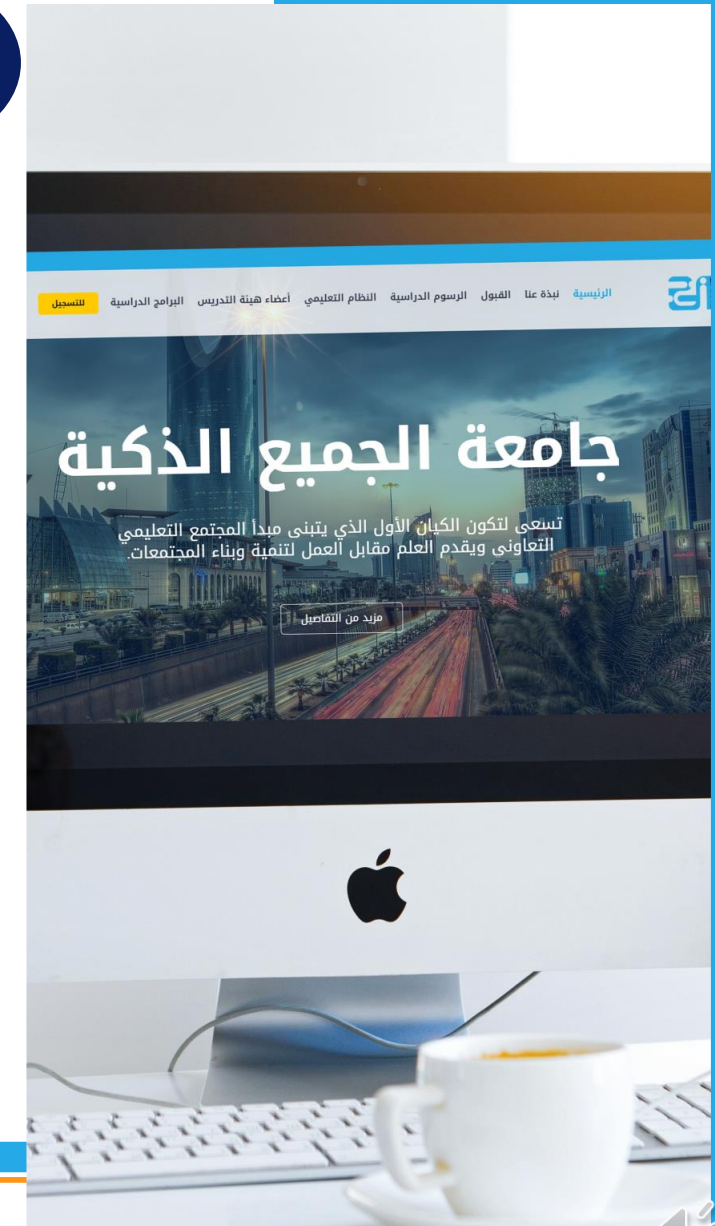
\\Users\\jcloudy\\AppData\\Local\\Microsoft\\Windows\\WebCache	
Name ^	Type
.. = Windows (351)	
. = WebCache (24)	
V01res00001.jrs	jrs
V01res00002.jrs	jrs
V01.chk	chk
V01.log	edblog
V0100016.log	edblog
V0100017.log	edblog
V0100018.log	edblog
V01tmp.log	edblog
WebCacheV01.dat (1)	edb
WebCacheV01.jfm	jfm
V01.log	log
V01tmp.log	log
WebCacheV01.dat	dat
WebCacheV01.dat	hxx
V01.chk	chk
V01.chk	chk



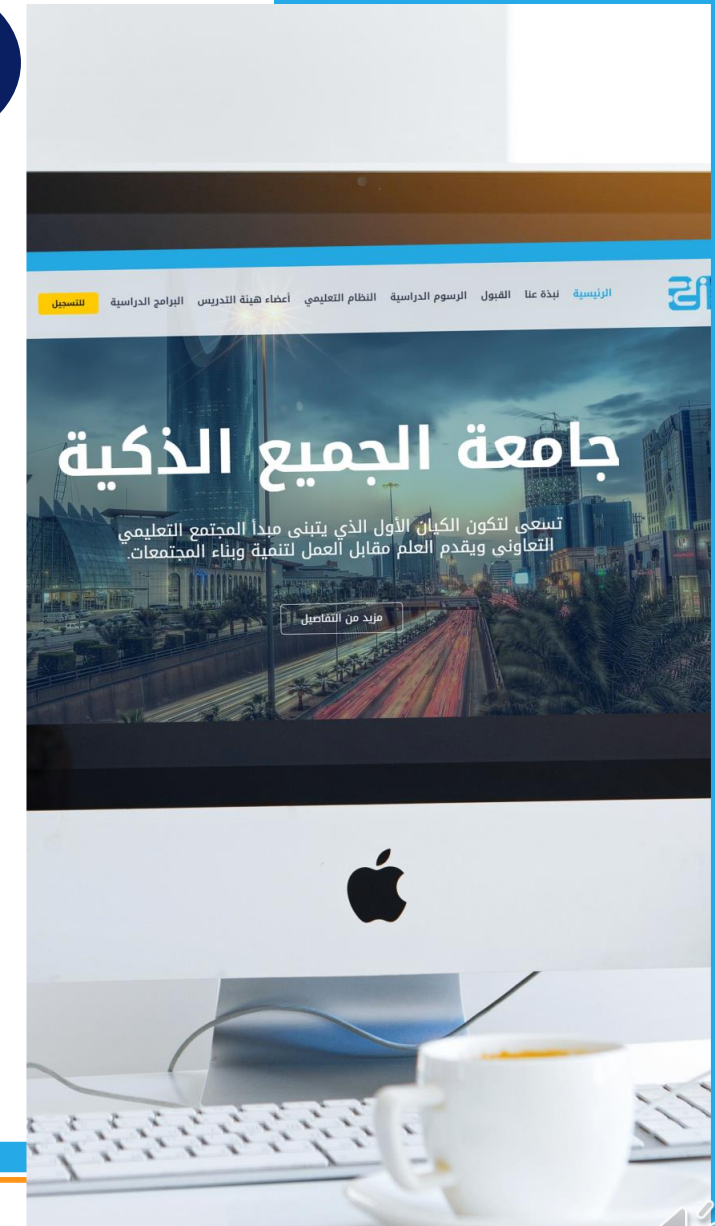
- When you visit a website, your computer stores tiny pieces of data from the site so that its pages will display faster during return visits.
- Most computers store such files in a cache file or a folder called “Temporary Internet Files.” Occasionally the files can become corrupt or outdated and need to be deleted.



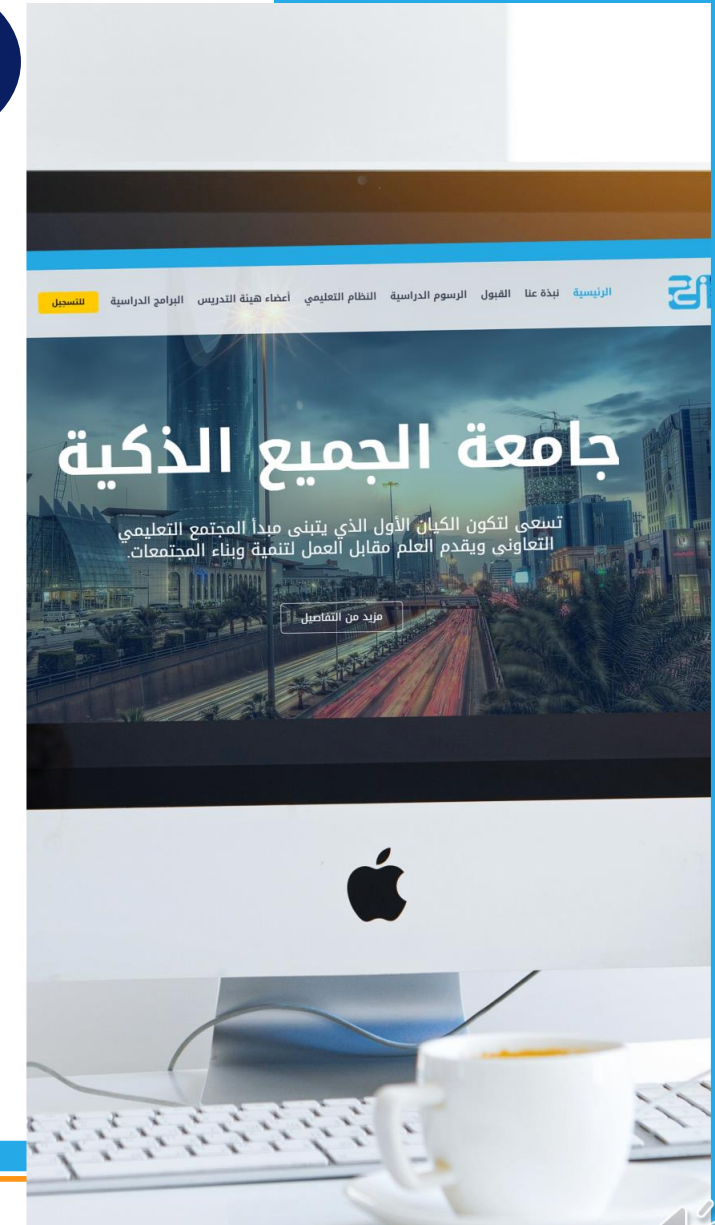
- Microsoft Internet Explorer (IE) uses temporary internet files to store copies of web content on a local hard drive.
- While it's useful for improving network performance, it can quickly fill the hard drive with large amounts of unwanted data.



- C:\Users\[username]\AppData\Local\Microsoft\Windows\INetCache: This temp files location is relevant in Windows 10 and Windows 8.
- C:\Users\[username]\AppData\Local\Microsoft\Windows\Temporary Internet Files: This is where temporary internet files are stored in Windows 7 and Windows Vista.
- C:\Documents and Settings\[username]\Local Settings\Temporary Internet Files: This is where Windows XP IE temp internet files are stored.



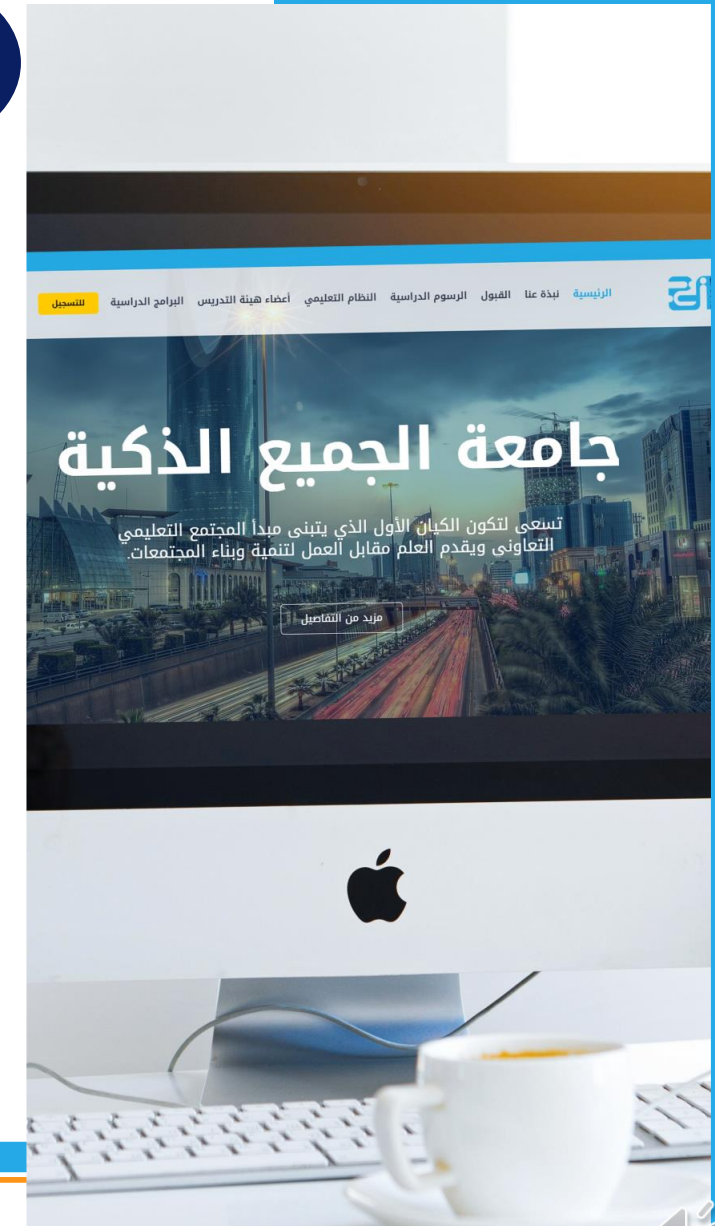
- Cookies are text files with small pieces of data — like a username and password — that are used to identify your computer as you use a computer network.
- Specific cookies known as HTTP cookies are used to identify specific users and improve your web browsing experience.
- Data stored in a cookie is created by the server upon your connection. This data is labeled with an ID unique to you and your computer.



- Microsoft Edge to store cookies is similar to the Chrome cookies location. All the cookies are also stored in a single file called Cookies. Launch File Explorer and insert the following path into the address bar:

“C:\Users\Your_User_Name\AppData\Local\Microsoft\Edge\User Data\Default”

- Mozilla Firefox stores all the cookies from every website you visit in a single file called cookies.sqlite. the following path in File Explorer's address bar:
“C:\Users\Your_User_Name\AppData\Roaming\Mozilla\Firefox\Profiles”

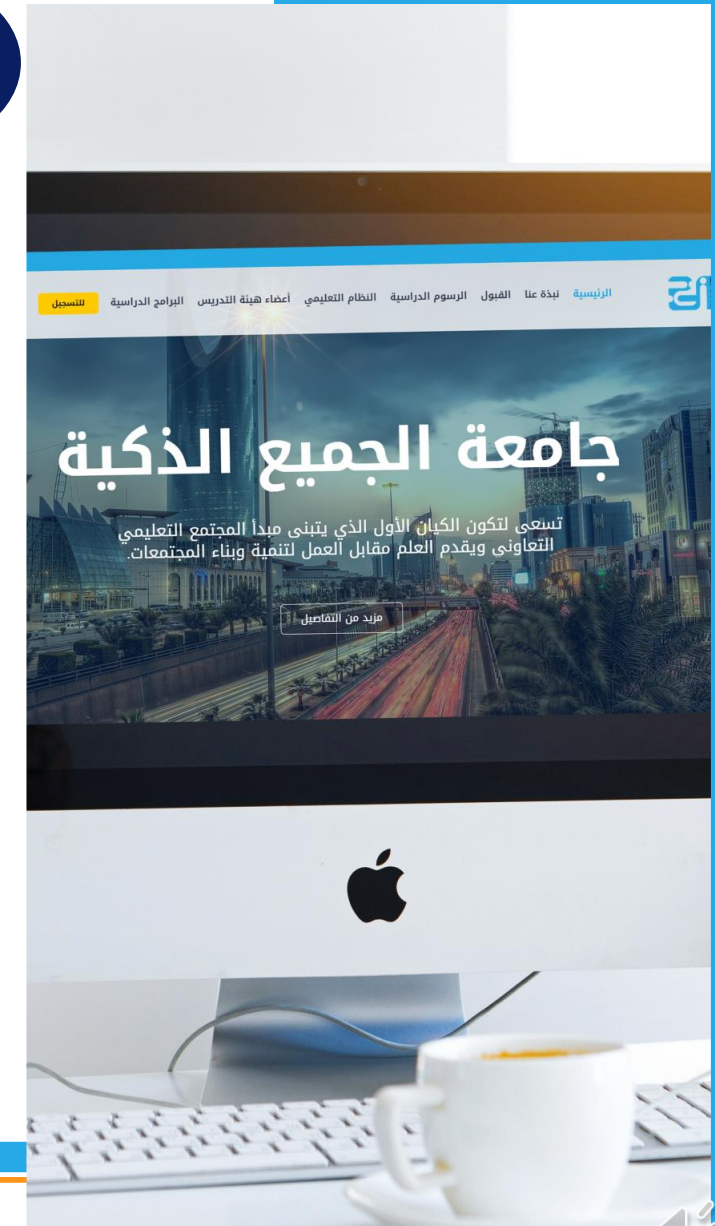


- **IECookiesView**

IECookiesView is a forensic utility that is used to display the details of all cookies that are stored by Internet Explorer. It provides the capability to sort cookies according to name and date. Additionally, it provides a search function that can find a cookie in the list by just specifying the name of a website.

- **IE History Viewer**

Any URL that is typed into the address bar or any link that is followed in Internet Explorer automatically causes the address to be stored in the history index file. The IE History Viewer parses all data from the history file, and prints the list of all visited URLs. This application provides the ability to save the list of addresses as a text, HTML, or XML file.



- Netstat -ano

Collect information about the network

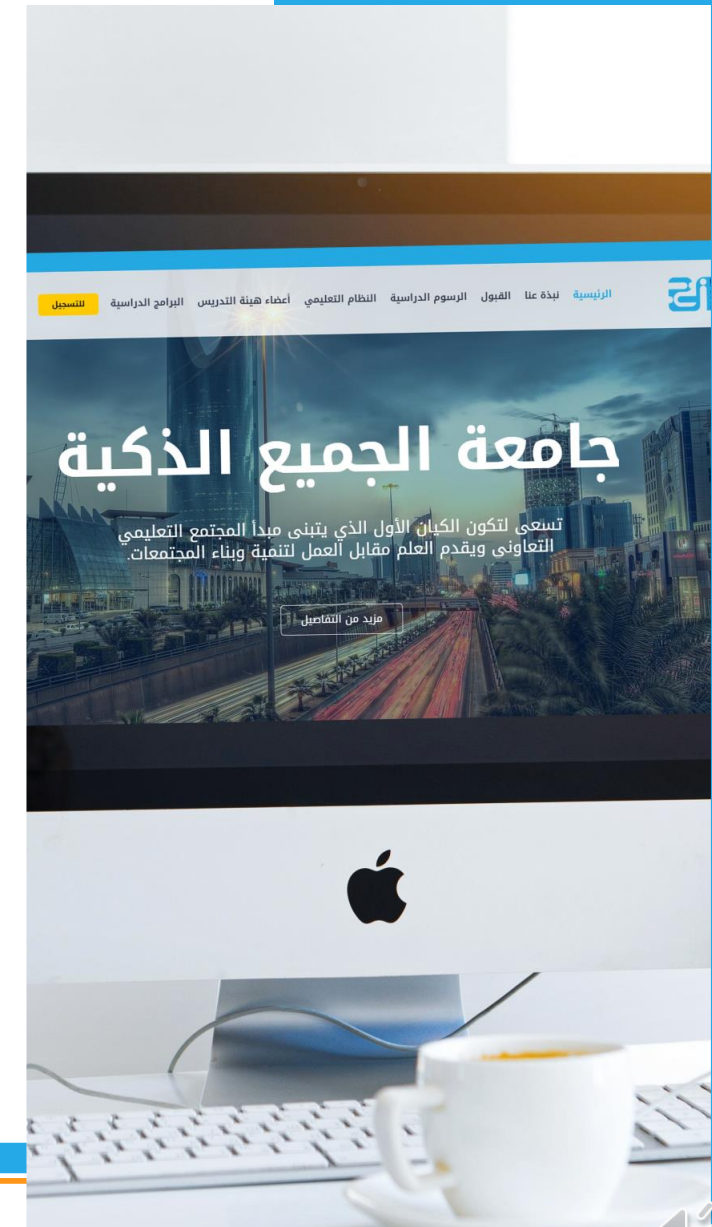
- Ipconfig

Know IP address and DHCP

```
C:\Users\Nermin>netstat
```

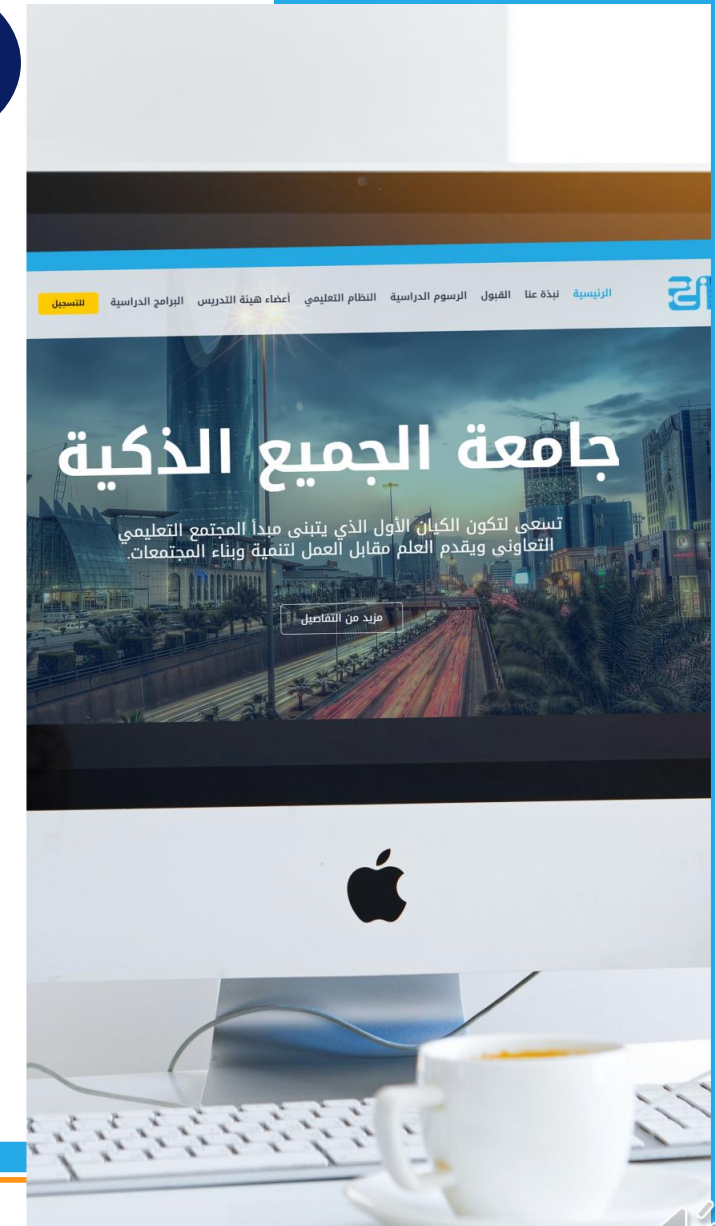
Active Connections

Proto	Local Address	Foreign Address	State
TCP	127.0.0.1:49673	DESKTOP-UAC9DLD:49674	ESTABLISHED
TCP	127.0.0.1:49674	DESKTOP-UAC9DLD:49673	ESTABLISHED
TCP	127.0.0.1:49677	DESKTOP-UAC9DLD:60115	ESTABLISHED
TCP	127.0.0.1:49677	DESKTOP-UAC9DLD:60116	ESTABLISHED
TCP	127.0.0.1:49678	DESKTOP-UAC9DLD:49679	ESTABLISHED
TCP	127.0.0.1:49679	DESKTOP-UAC9DLD:49678	ESTABLISHED
TCP	127.0.0.1:59988	DESKTOP-UAC9DLD:59989	ESTABLISHED
TCP	127.0.0.1:59989	DESKTOP-UAC9DLD:59988	ESTABLISHED
TCP	127.0.0.1:60115	DESKTOP-UAC9DLD:49677	ESTABLISHED
TCP	127.0.0.1:60116	DESKTOP-UAC9DLD:49677	ESTABLISHED



What Is Virtual Memory?

- In order to copy virtual memory into RAM, the operating system divides virtual memory into pages.
- Each page contains a fixed number of addresses that are stored on disk until called by the operating system.
- When pages are called by the operating system they are copied from disk memory to RAM, a process which translates virtual addresses into real addresses.
- This process is known as mapping. The process of copying virtual pages from disk to main memory is known as paging or swapping.



Lecture 5

What Is Virtual Memory?

System Scanner

System scanner (available from www.codeproject.com/w2k/system_scanner.asp) is designed as a replacement to the Task manager

The screenshot displays the 'System Scanner' application window. It features a table of running processes with columns for Process name, Thread count, Process path, and Process ID. A 'Virtual memory map' dialog box is open in the foreground, showing a 'Draw map' button and a grid representing memory usage.

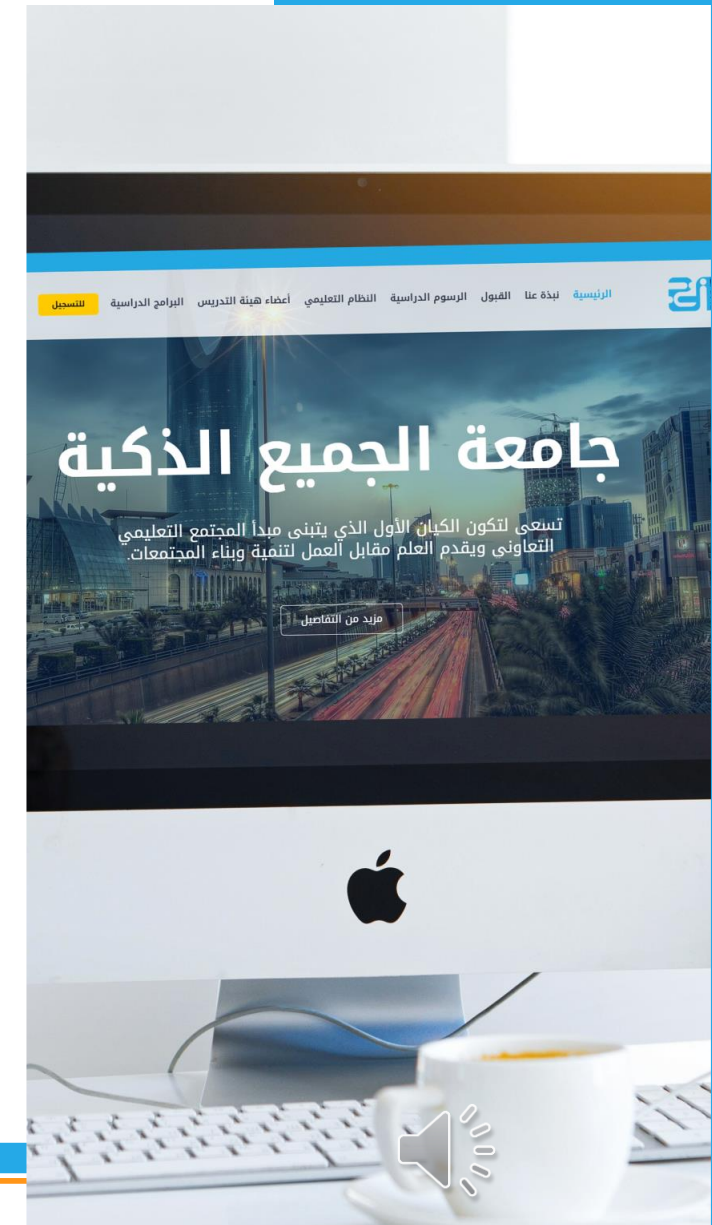
Process name	Thread count	Process path	Process ID
Scanner.exe	1	C:\Documents and Settings\220\Desktop\Scanner.exe	3168
cmd.exe	1	C:\WINDOWS\system32\cmd.exe	2728
natspeak.exe	38	C:\Program Files\Nuance\NaturallySpeaking9\Program\natspeak.exe	1852
WISPTI5.EXE	6	C:\WINDOWS\system32\WISPTI5.EXE	3704
WINWORD.EXE	10	C:\Program Files\Microsoft Office\Office12\WINWORD.EXE	3092
J2GDllCmd.exe	1	C:\Program Files\PaperMaster Pro 7.0\J2GDllCmd.exe	2668
pnagent.exe	4	C:\Program Files\Citrix\ICA Client\pnagent.exe	2716
PersTray.exe	1	C:\Program Files\PerSono\perstray.exe	2708
vc6tray.exe	1	C:\Program Files\Virtual CD v6\System\VC6Tray.exe	504
iexplore.exe	36	C:\Program Files\Internet Explorer\IEXPLORE.EXE	3976
rapimgr.exe	6	C:\PROGRA~1\MI3AA1~1\rapimgr.exe	3624
ctfmon.exe	1	C:\WINDOWS\system32\ctfmon.exe	3436
wcescomm.exe	4	C:\Program Files\Microsoft ActiveSync\wcescomm.exe	3452
SDTrayApp.exe	7	C:\Program Files\Spyware Doctor\SDTrayApp.exe	
proquota.exe	2	C:\WINDOWS\system32\proquota.exe	
opwareSE2.exe	1	C:\Program Files\ScanSoft\OpwareSE2.exe	
VC6Play.exe	7	C:\Program Files\HHVcdV6Sys\VC6Play.exe	
winampa.exe	1	C:\Program Files\Media\Winampa.exe	
rundll32.exe	4	C:\WINDOWS\system32\rundll32.exe	
PccNTMon.exe	5	C:\Program Files\Trend Micro\PccNTMon.exe	
DVDLauncher.exe	2	C:\Program Files\CyberLink\Power2Go\DVDLauncher.exe	
ico.exe	1	C:\WINDOWS\system32\ICO.exe	
issch.exe	1	C:\Program Files\Common Files\Java\jre1.6\issch.exe	
jusched.exe	1	C:\Program Files\Java\jre1.6\jusched.exe	
stsysstra.exe	4	C:\WINDOWS\stsysstra.exe	
rundll32.exe	1	C:\WINDOWS\system32\rundll32.exe	
WLTRAY.EXE	6	C:\WINDOWS\system32\WLTRAY.EXE	
explorer.exe	13	C:\WINDOWS\Explorer.EXE	
wmiprvse.exe	8	C:\WINDOWS\system32\wbem\wmiprvse.exe	
Tablet.exe	8	C:\WINDOWS\system32\Tablet.exe	
TabUserW.exe	2	C:\WINDOWS\system32\TabUserW.exe	
wmiprvse.exe	6	C:\WINDOWS\system32\wbem\wmiprvse.exe	
alg.exe	6	C:\WINDOWS\System32\alg.exe	
CK2E21.EXE	1	C:\TMP\CK2E21.EXE	

Number of running processes: 67

Lecture 5

Print Spooling

This process occurs when a computer prints files in a Windows environment. When a user sends a print command from a computer to the printer, the print spooling process creates a “print job” to some files that remain in the queue unless the print operation is completed successfully.

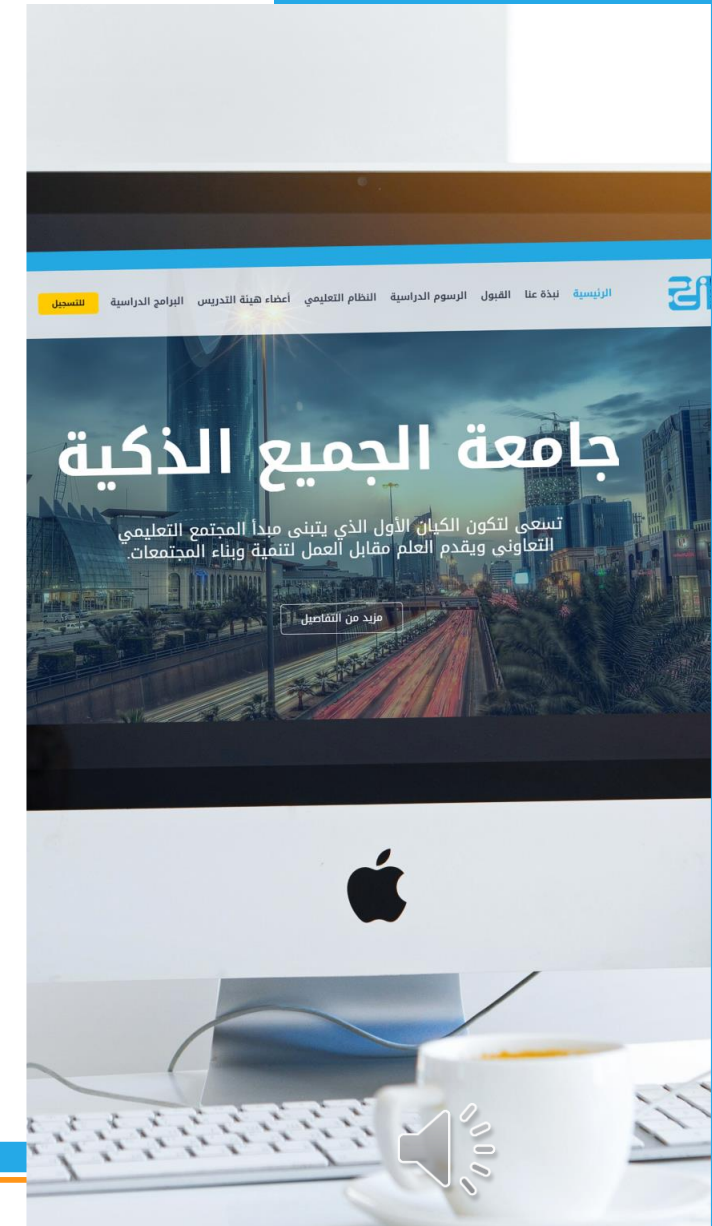


C:\windows\system32\spool\printer\

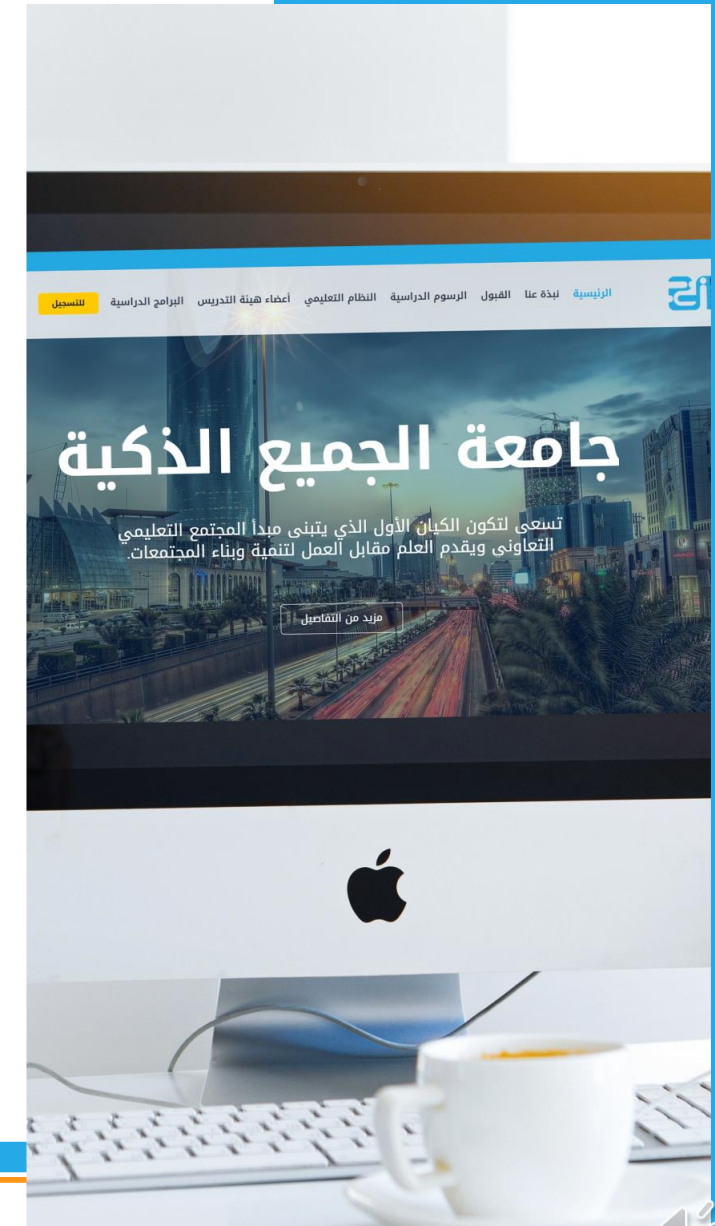
SPL: files are created in the printer spooler on your computer when you send documents for printing and are used to store the contents of the documents.

SHD files contain details for the print job.

SHD file is a 'shadow' file that contains information about the print job including owner, the printer, the name of the file printed and the printing method (EMF or RAW)

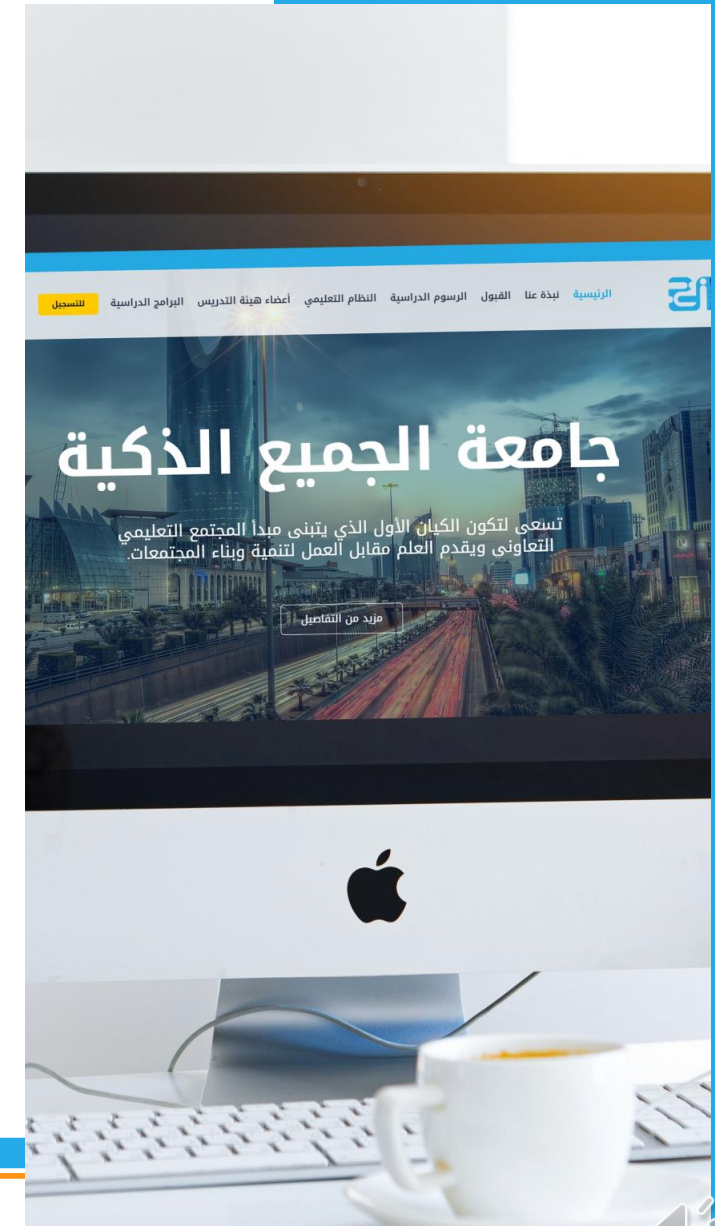


- SPL and SHD files are stored in the "Printers" spooler folder on your hard disk.
- In RAW format, the .SPL file contains the data to be printed
- In EMF format, the .SPL file contains the name of the file printed, the method and a list of files that contain the data to be printed
- .SHD, .SPL files are deleted after the print job completes

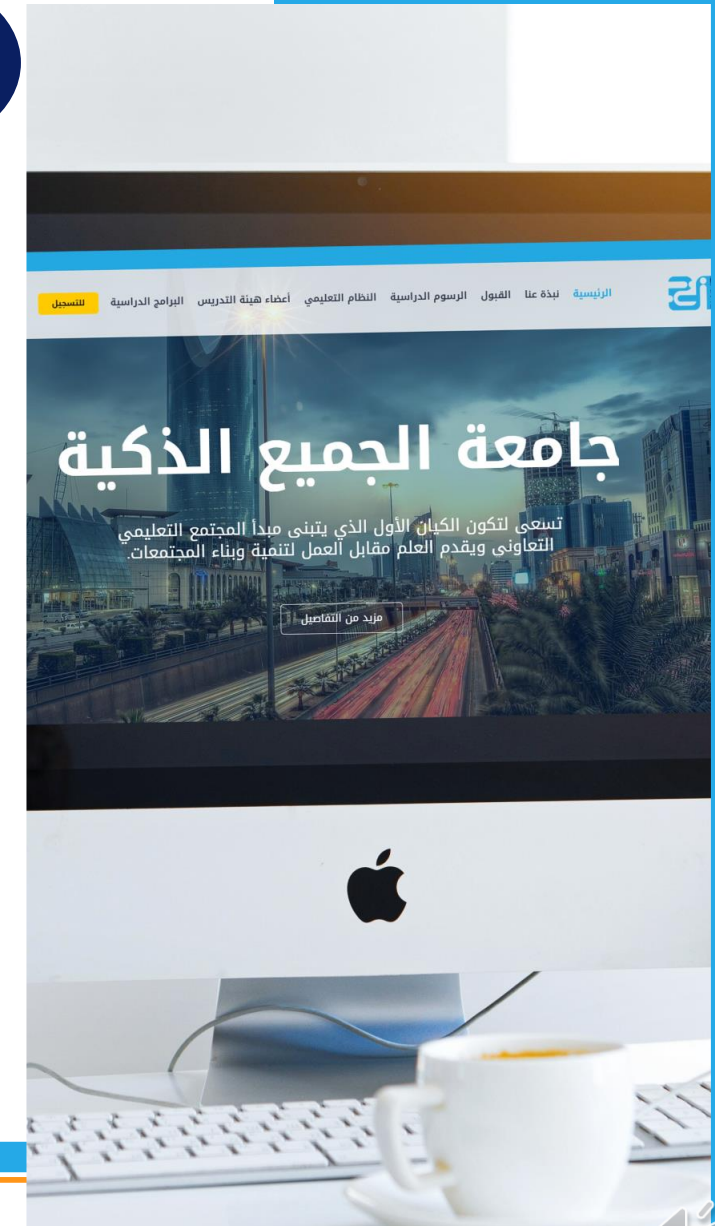


Lecture 3

Linux Forensic



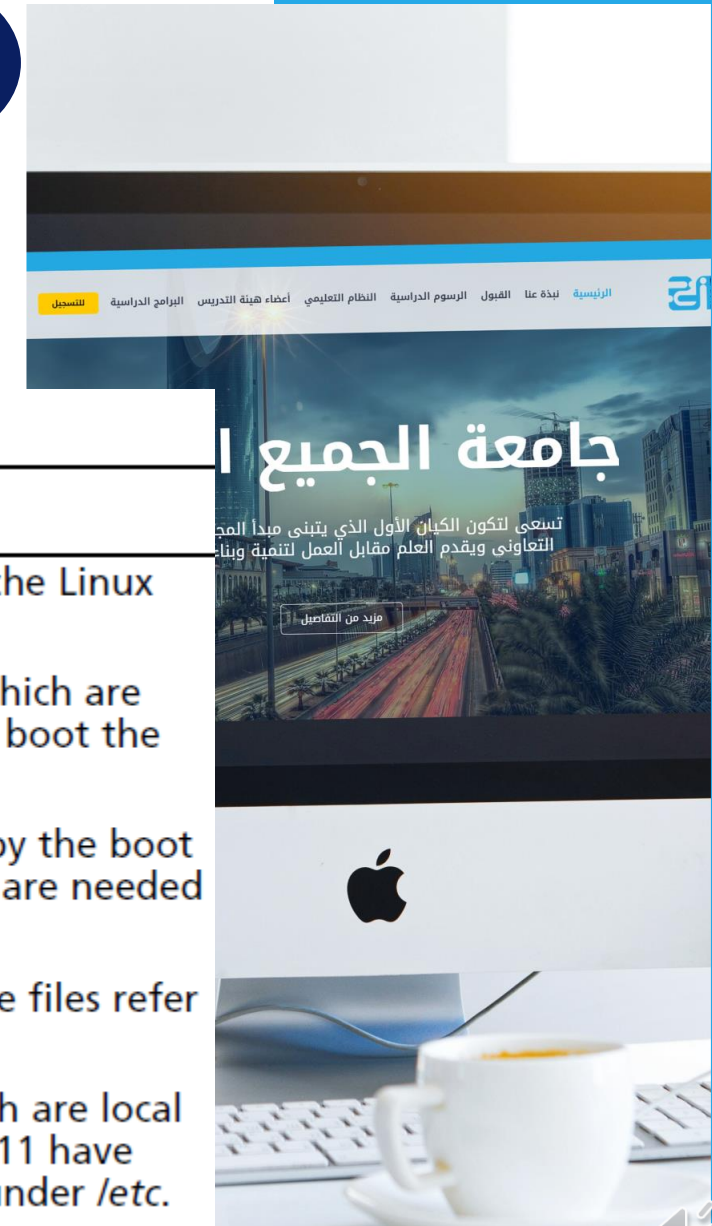
- Linux treats all **devices as a file**. As such, an entry is created in the file system for each hardware device recognized by the operating system.
- For instance, if a standard IDE hard drive is connected to the system, it will be listed under `/dev/hdx`.



The majority of Linux distributions have a very similar directory structure

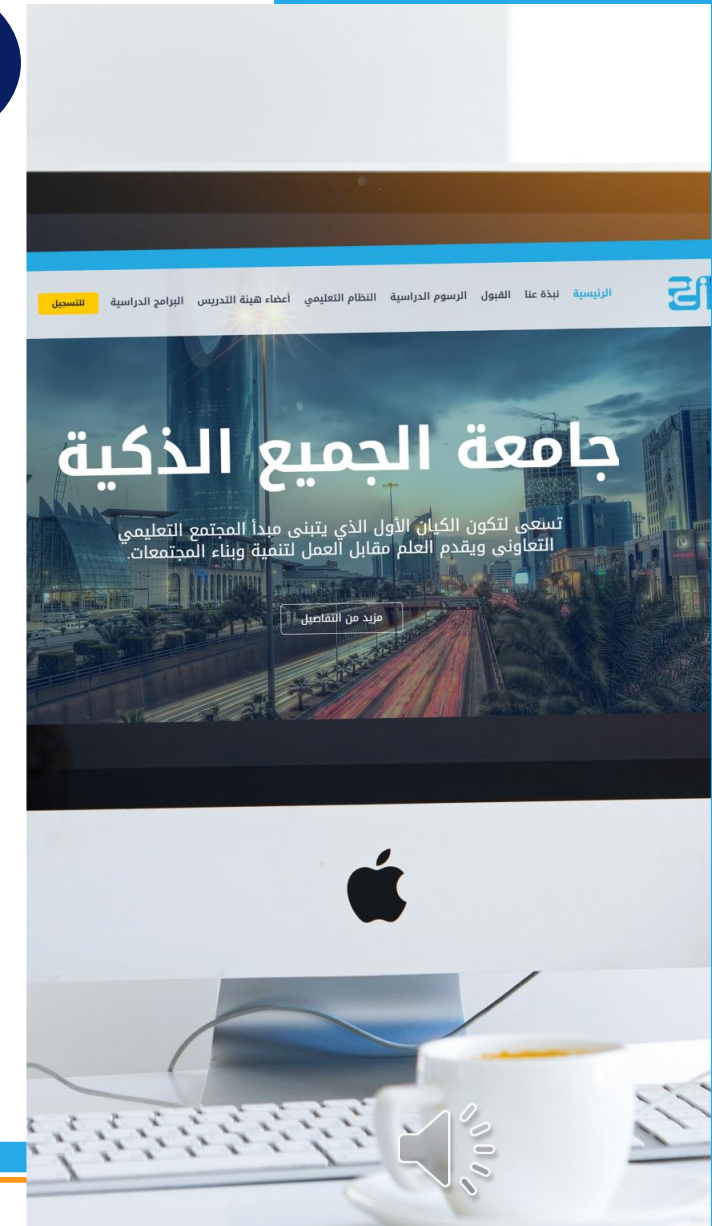
The Major Linux Directories and Their Functions

Linux directory path	Description of the Linux directory
/	The root directory is the lowest level directory in the Linux file system.
/bin	The bin directory contains executable programs which are needed in single user mode. These programs help boot the system or repair it.
/boot	The boot directory contains a static foals knitted by the boot loader. This directory should hold only files which are needed during the boot process.
/dev	This directory contains special or device files. These files refer to physical devices.
/etc	The etc directory contains consideration files which are local to the machine. Certain larger packages such as X11 have their own subdirectories with consideration files under /etc.



Linux includes several simple utilities to make imaging and basic analysis of suspect disks and drives simpler. These include:

- `dd` : Command used to copy from an input file or device to an output file or device.
- `dcfldd` : A more advanced variant of `dd` that shows the progress while imaging.
- `sfdisk/fdisk` : Used to determine the structure of a disk.



- md5sum and sha1sum: Create and store an MD5 or SHA hash of a file or list of files (including devices).
- file : Reads file header information in an attempt to ascertain its type, regardless of name or extension.
- xxd : Command line hexdump tool.

