

Lab:
Process Management



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26 January 2024

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Lab 3: Process Management

Part A: Windows Processes

1. Working in your lab groups, open the Windows VM on your respective computers and perform the following steps.
 - a. Open Notepad.
 - b. Start the Task Manager and select the **Processes** tab.
 - c. Verify that the Notepad app is displayed in the list.
 - d. Select the **Details** tab and sort the processes by Image Name.
 - e. What is the Process ID and User of the Notepad process? (1 mark)

Answer: 6116

Note: Type directly into the space provided and use the highlight function or change the font color of your answers. If the answer is different for each computer in the group, write down each group member's name and their computer's information.

- Many other processes are displayed, and most of these are services. Research and briefly describe Windows services. (1 mark)

Answer: (dllhost.exe: Manages Operating system services), (audiogd.exe: Manages Audio), (explorer.exe, dwm.exe, csrss.exe: These manage graphics)

- For each of the following processes, identify the user of each process, and then research and briefly describe their function.

- System Idle (2 marks)

Answer: Indicates unused cpu resources

- Winlogon (2 marks)

Answer: Manages windows logon and logoff

- Explorer (2 marks)

Answer:

Provides gui

Part B: Windows Process Information

A process requires system resources for execution. Resource Monitor (perfmon.exe) is a Windows utility that displays real-time information about the use of hardware (CPU, memory, disk and network) and software (handles and modules).

- If you haven't already done so, open Notepad.
- Open **Task Manager**, click the **Performance** tab and click the link on the bottom of the window to open **Resource Monitor**. How many active threads are there for the notepad process? (1 mark)

Answer: 4

3. Click the **Overview** tab and check the checkbox beside the **Notepad** image.
4. Type some text in Notepad and save the file on your desktop (use any name). How many threads are now used by Notepad? (1 mark)

Answer: 14

5. Select the **CPU** tab. Note that resources used by a process are accessed using a **handle**. List the types of handles used by Notepad (Hint: Find the dropdown list below the process list). (1 mark)

Answer:

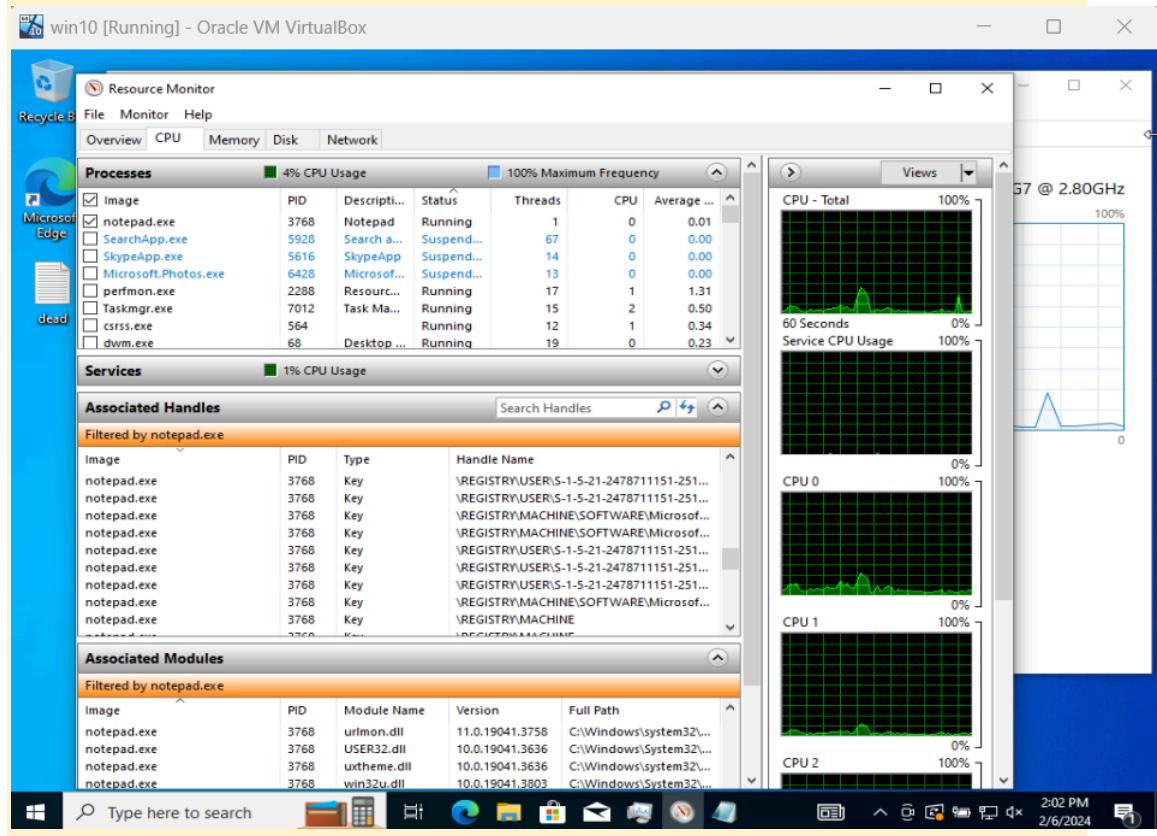
Associated Handles			
Filtered by notepad.exe			
Image	PID	Type	Handle Name
notepad.exe	3768	ALPC Port	\BaseNamedObjects\[CoreUI]-PID(3768)-Tl...
notepad.exe	3768	ALPC Port	\RPC Control\OLE1E271B306478A50AD8DF...
notepad.exe	3768	Desktop	\Default
notepad.exe	3768	Directory	\Sessions\1\BaseNamedObjects
notepad.exe	3768	Directory	\KnownDIs
notepad.exe	3768	Event	\KernelObjects\MaximumCommitCondition
notepad.exe	3768	File	\Device\DeviceApI
notepad.exe	3768	File	C:\Windows\System32\en-US\propsys.dll...
notepad.exe	3768	File	C:\Windows\WinSxS\amd64_microsoft.win...
notepad.exe	3768	File	C:\Windows\WinSxS\amd64_microsoft.win...

6. Sections of *system* code needed by a process may be stored in dynamic link libraries (.dll) of code, which are listed in the **Associated Modules** dropdown box. What is the PID of the modules used by the Notepad process? (1 mark)

Answer: 3768

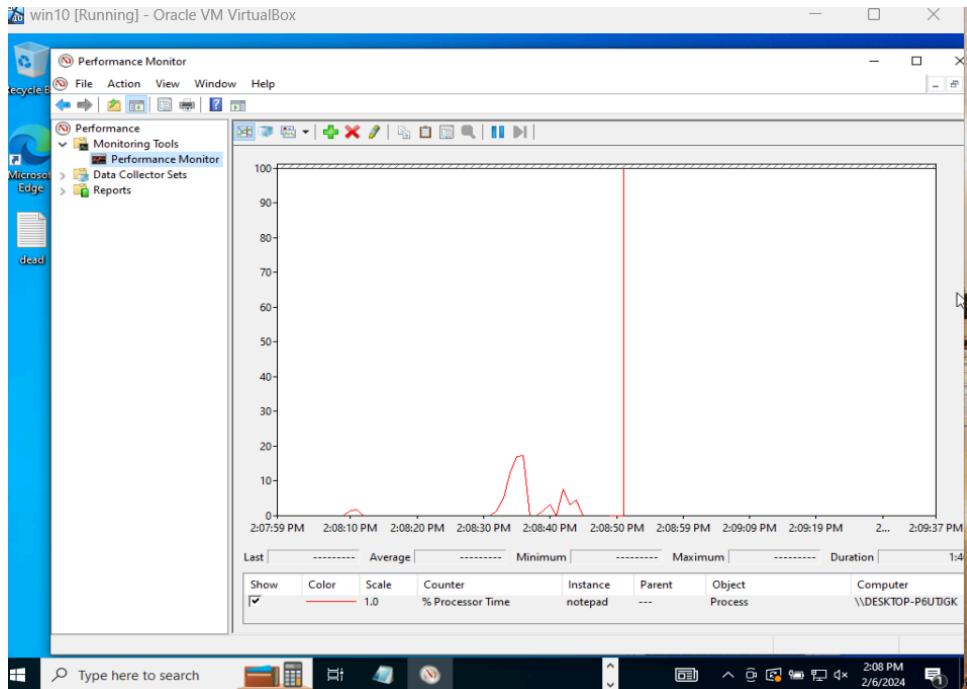
7. Compare the PID of the modules to the PID of the notepad process itself. Why is the modules' PID the same as the Notepad process? (Hint: Look at the memory usage of the notepad process). What's the difference between shareable and private? (2 marks)

Answer: The modules listed with the same PID as the Notepad process are components that are loaded and used by Notepad in its operation. These modules share the same PID because they are part of the Notepad process's memory space. Shareable memory refers to parts of the program that can be used by other processes at the same time. Private memory is like a personal notebook, used only by the program that created it and not accessible to others.



8. Search for and run Performance Monitor.

9. Right-click the graph and select Remove All Counters.
10. Click the green + sign to add a counter.
11. Select the **Process > %Processor Time counter**, select the instance notepad, and then click the **Add>>** button and click **OK** to view the graph.



- a. Where is the value on the graph? (1 mark)

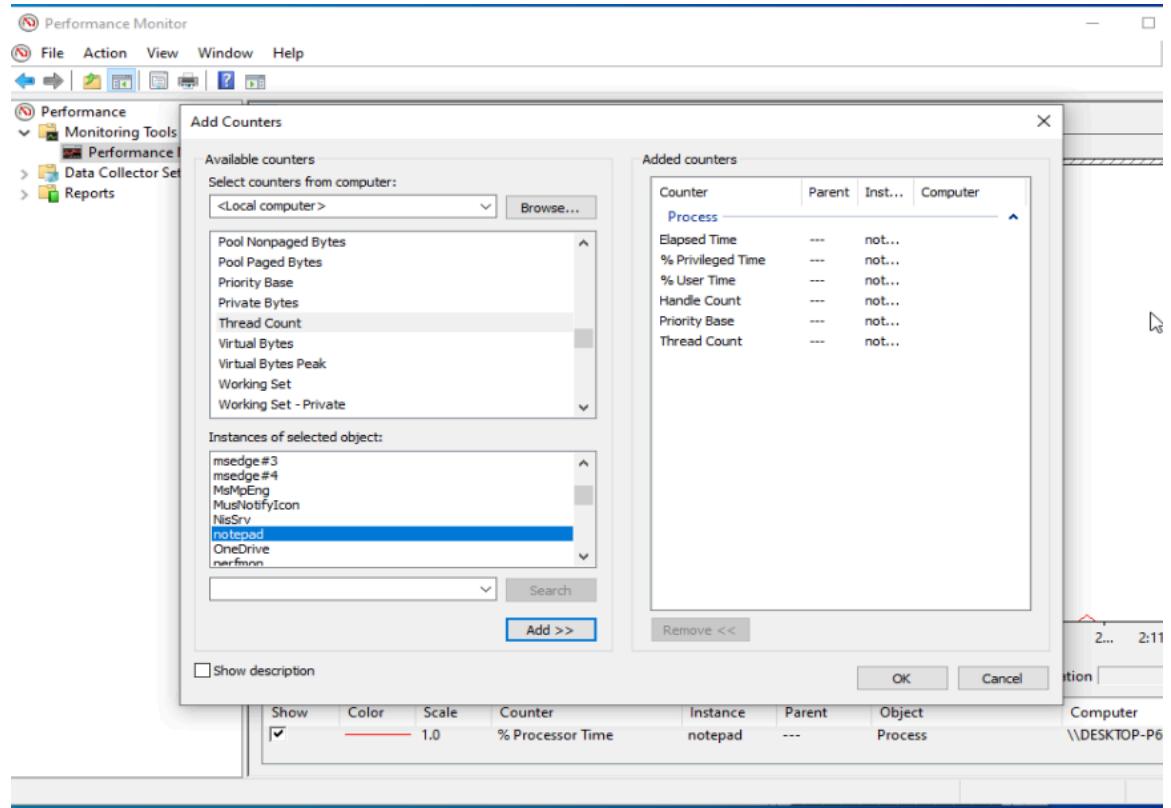
Answer: The value on the graph, which represents the "% Processor Time"

- b. How can you make the value move? (1 mark)

Answer: Using notepad made the value move and spike

12. Each time a counter is selected in the *Add Counter* menu, view its description by checking the **Show Description** checkbox.

13. Add the following counters for the notepad instance. Briefly describe what each counter means.



- a. Elapsed Time (1 mark)

Answer: The total time since the process started.

- b. Privileged Time (1 mark)

Answer: The time the process has spent executing code in kernel mode.

- c. User Time (1 mark)

Answer: The time the process has spent executing code in user mode.

d. Handle Count (1 mark)

Answer: The number of objects handles the process is using.

e. Priority Base (1 mark)

Answer: The base priority level assigned to the process.

f. Thread Count (1 mark)

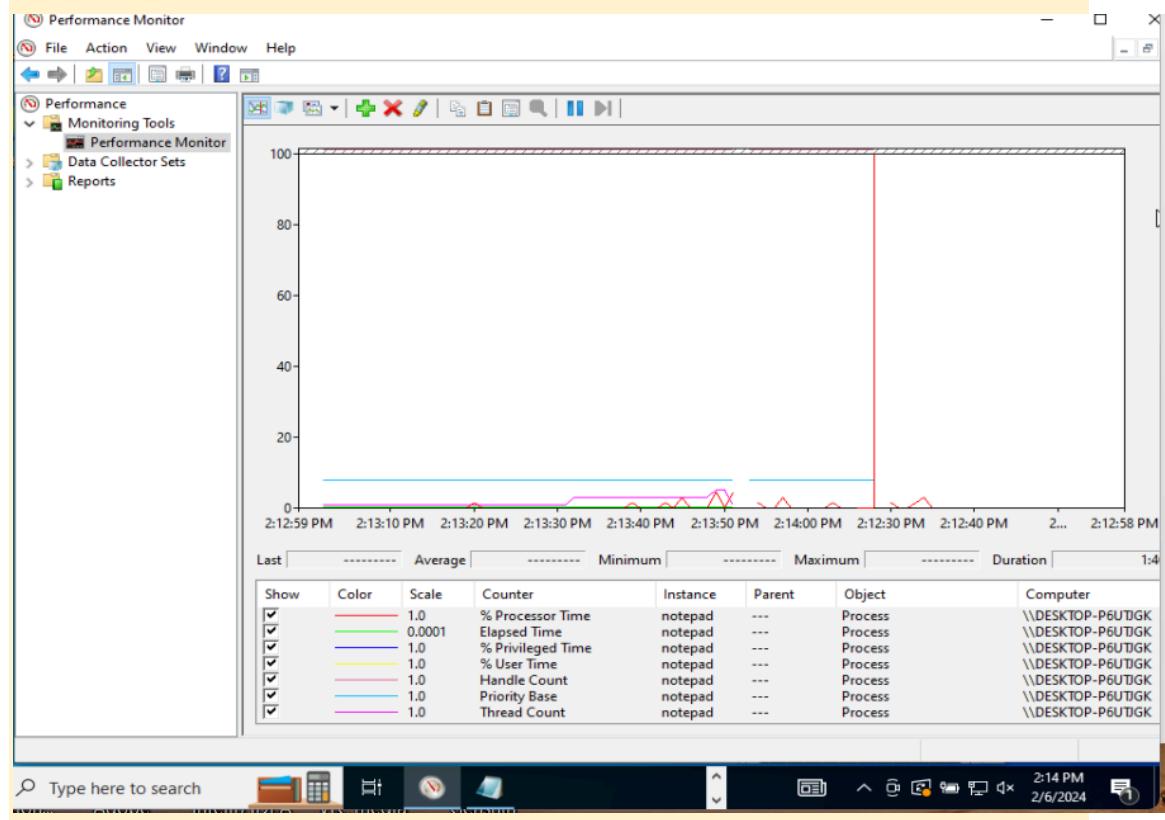
Answer: The number of threads the process is using.

14. What is the difference between privileged and user mode? (1 mark)

Answer: Privileged (kernel) mode allows unrestricted access to all system resources and hardware, used by the OS kernel for critical operations. User mode restricts application access to system resources and hardware, ensuring system stability and security by isolating application operations from core system functions.

15. Ensure that all the counters you added previously are active, and then perform some actions in Notepad. Take a screenshot of the graph in Performance Monitor (perfmon) and attach it here. (1 mark)

Answer:



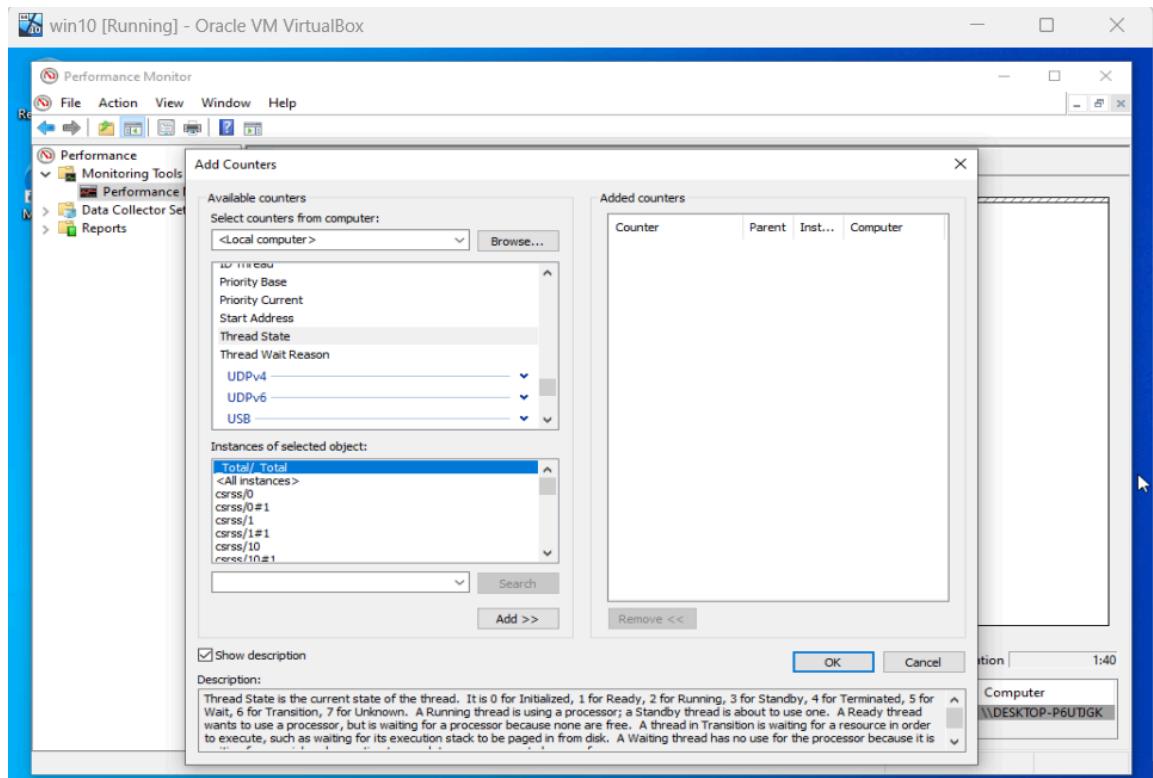
16. What is the purpose of having two separate modes of operation (i.e., privileged/kernel and user modes)? (1 mark)

Answer: The purpose of separating into privileged/kernel and user modes is to enhance system security and stability. This separation ensures that only the operating system's kernel has direct access to hardware and critical system resources, while user applications operate in a restricted environment. It prevents applications from performing operations that could harm the system's integrity or security, reducing the risk of accidental or malicious damage.

Part C: Thread Scheduling

The Thread Scheduling utility can be useful when you're debugging a multithreaded application and you're unsure about the state of the threads running in the process.

1. Shut down the VM and change the number of processors to 1 CPU (for this part of the lab only).
2. Restart the VM.
3. Start a Notepad instance and open Performance Monitor.
4. Right-click the graph and select **Properties**.
5. Click the **Graph** tab, change the view to **Histogram bar** and change the vertical scale maximum to **7**. Click **OK**.
6. Click the **+** button on the toolbar to bring up the *Add Counters* dialog box.
7. Select the **Thread > Thread State** counter, and then check the **Show Description** checkbox to see the description of the thread state values.



8. Record down the thread state definition and the different state values. (2 marks)

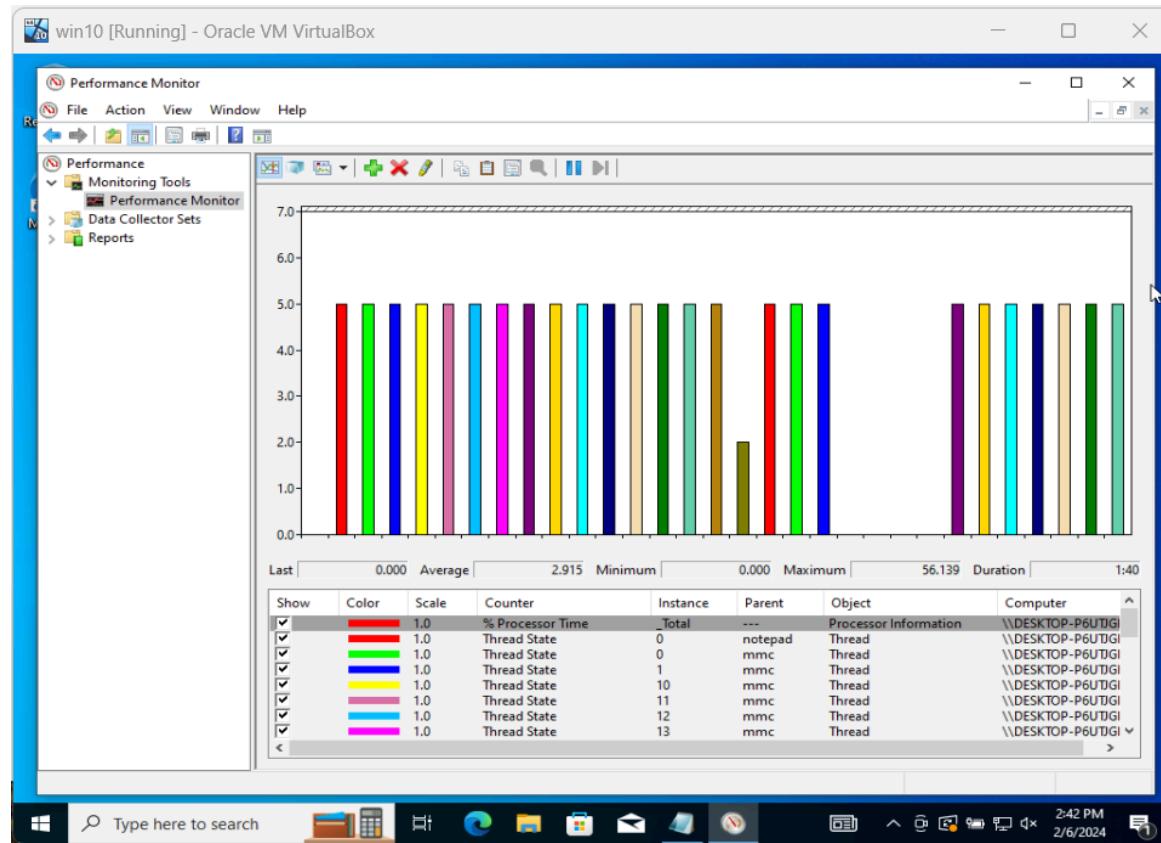
Answer:

0 for Initialized,
1 for Ready,
2 for Running,
3 for Standby,
4 for Terminated,
5 for Wait,
6 for Transition,
7 for Unknown.

A Running thread is using a processor; a Standby thread is about to use one. A Ready thread wants to use a processor, but is waiting for a processor because none are free. A thread in Transition is waiting for a resource in order to execute, such as waiting for its execution stack to be paged in from disk. A Waiting thread has no use for the processor because it is waiting for a peripheral operation to complete or for a resource to become free.

9. In the **Instances of selected object** dropdown box, select **<All instances>** and click on **Search**. The list of instances will be updated. Scroll down until you see the **notepad** process (notepad/0). Select it and click the **Add** button.
10. In the **Instances** list, scroll back to the **MMC** process (Microsoft Management Console process running the System Monitor) and select all the threads (mmc/0, mmc/1, and so on), and then add them to the chart by clicking the **Add** button.

11. Close the *Add Counters* box by clicking **OK**.



12. You should see the state of the Notepad thread. What is the state of Notepad? Why? (2 marks)

Answer: 5.0, The thread is ready to run but waiting for CPU availability.

Note: Notice that one MMC thread is in the running state (number 2). This is the thread that's querying the thread states, so it's always displayed in the running state.

13. Can Notepad be in running state? (1 mark)

Answer: Yes if it is taking in letters(processing and imaging) and saving a file

14. How would you transition Notepad into running state? (1 mark)

Answer: Write things

15. Can you see Notepad in the running state with your current setup? Why or why not? (2 marks)

Answer: Whether or not you can see Notepad in the running state with your current setup depends on the tools and permissions you have. If you are using a tool like Windows Task Manager, Process Explorer, or Performance Monitor with sufficient privileges, you can observe Notepad's threads and potentially see them in the running state when you perform actions in Notepad. However, these threads may only run briefly before transitioning to a wait state, especially if Notepad is waiting for further user input or other events. The visibility of these state changes also depends on the refresh rate of the monitoring tool and the timing of the actions performed in Notepad.

16. If you're not using a VM – What is the maximum number of processes you would be able to see in the running state at one time? Why? (2 marks)

Answer: The maximum number of processes you can see in the running state at any one time on a non-virtualized machine (i.e., not using a VM) directly depends on the number of CPU cores available on the system. This is because each core of a CPU can execute one thread (basic unit of process execution) at a time in a truly concurrent manner.

17. Change the VM back to use multiple CPUs for better performance.

Single-core CPU: On a single-core CPU, you would typically be able to see one process in the running state at any given instant because there's only one core available to execute threads.

Multi-core CPU: On a multi-core CPU, the maximum number of processes that can be in the running state simultaneously equals the number of cores. For example, a quad-core CPU could theoretically have four processes running at the same time, one on each core.

Part D: Process Explorer

All the system utilities discussed so far have their purposes and can be used when no external tools are present. Process Explorer (procexp) is a freeware task manager and system monitor for Microsoft Windows created by SysInternals, which has been acquired by Microsoft and rebranded as Windows Sysinternals. It provides the functionality of Windows Task Manager along with a rich set of features for collecting information about processes running on the user's system (Wikipedia, 2023).

1. Download [Sysinternals Suite](https://learn.microsoft.com/en-us/sysinternals/downloads/) (<https://learn.microsoft.com/en-us/sysinternals/downloads/>).
2. Before you extract the tools from the zip file, remove the marker that tells Windows to treat the content of the file as coming from the internet and untrusted. This will remove the security warnings and content errors when you run any of the tools or view the help files.
 - a. Right-click the **SysinternalsSuite.zip** file in folder you downloaded in the previous step and select **Properties**.
 - b. Click the **General** tab, select the **Unblock** checkbox and click **OK**.
3. Extract the tools from the zipped file to a location you can easily remember, because you'll use these tools in other labs in this course.
4. Open the **Sysinternals** folder and run **procexp.exe**.

The main window displays the process list arranged in a tree view showing parent/child process relationships. If you don't have administrator privileges, you won't see all the processes in the system. (The "user" in the VM is an admin.)

5. Use the Help (F1) to find out how to split the main window into an upper and lower pane.

- a. What is shown on the lower pane? What else can be shown there? (2 marks)

Answer: Lower Pane Content: The lower pane in Process Explorer can display two types of information depending on the mode selected: handles or DLLs (dynamic link libraries) and mapped files. This view provides detailed insights into which resources (such as files, registry keys, or other objects) are associated with a process or which DLLs a process has loaded.

Additional Display Options: Besides handles or DLLs, the lower pane can show detailed properties of the selected process, including the paths to the executable file, loaded modules, and open handles. This feature aids in diagnosing issues or identifying potential malware by examining the resources a process is using.

- b. What do the mini graphs on the top show (from left to right)? (1 mark)

Answer: The mini graphs at the top of Process Explorer display real-time system performance metrics. Typically, these graphs include CPU usage, memory usage, and possibly disk and network activity, providing a quick visual overview of the system's performance health.

6. One of the first things you'll notice in the process list is its use of colour. Row colours distinguish different types or states of processes. Go to **Options > Configure Colors** to learn what each color represents.

Note: Even though you can customize the colours, it's not recommended because many IT professionals rely on the default colours to differentiate the processes and to recognize suspicious activities.

7. Start a console window and launch Notepad from the command line by typing **notepad**.
8. View the new processes in Process Explorer.

9. Right-click the notepad process and open the **Properties** dialog box. What is the parent process of notepad? Why? (2 marks)

Answer: Parent Process: When you launch Notepad from a console window (e.g., cmd.exe or PowerShell), the console process that executes the command to start Notepad becomes its parent process. This hierarchical relationship is standard in operating systems where processes launched from another process inherit it as their parent. The reason is based on the process creation mechanism in Windows, where any process started from within another inherits the initiating (or calling) process as its parent.

10. Select the **Threads** tab and look for an error message regarding Dbghelp.dll.

This is one of Microsoft's debug engines used for loading symbol files and resolving memory addresses to names. To fully trace and understand what the kernel is doing under the hood, you'll need to configure the symbols.

- a. Google **Microsoft debugging tools** or go to <https://developer.microsoft.com/en-us/windows/downloads/windows-10-sdk>.
- b. Download the standalone SDK.
- c. Install only the *Debugging Tools for Windows*.
- d. Open the Sysinternals' *Process Explorer*, go to Options > Configure **Symbols** and point the Dbghelp.dll path to the debugging tools you just installed at:

C:\Program Files (x86)\Windows Kits\10\Debuggers\x64\dbghelp.dll

Use the Microsoft public symbols at:

srv*c:\symbols*<https://msdl.microsoft.com/download/symbols>

11. Reopen Notepad Properties and view the threads tab again.

a. What does the context switches value represent? (1 mark)

Answer: This value represents the number of times the thread has been switched in or out of the CPU. A context switch occurs when the operating system changes the CPU's focus from one thread to another, allowing multiple processes to share the CPU efficiently. High numbers of context switches might indicate that the thread is frequently yielding the processor, either because it's waiting on resources or due to the system's multitasking strategy.

b. What does the cycles values represent? (1 mark)

Answer: The cycles value represents the total number of CPU cycles that the thread has consumed. This metric gives an insight into how much processor time the thread has used, which can help in identifying resource-intensive threads within a process. It's a useful measure for performance analysis and optimization efforts.

Part E: Linux Process Information

1. View the file `/proc/stat`, and then briefly explain each of the following.

a. cpu (1 mark)

Answer: Shows the time the system has spent in various modes (user, system, idle, etc.) for all CPUs collectively.

b. ctxt (1 mark)

Answer: The number of context switches that have occurred system-wide.

c. processes (1 mark)

Answer: Total number of processes created since the system boot.

d. procs_running (1 mark)

Answer: The number of processes currently running (actively scheduled on a CPU).

e. procs_blocked (1 mark)

Answer: The number of processes currently blocked, waiting for I/O to complete.

2. The `ps` command displays process's status. Use the `ps` command without options, and then list and interpret the process's attributes (use man for details about `ps`). (2 marks)

Answer: Running `ps` without options displays processes associated with the current terminal. Attributes typically include PID (Process ID), TTY (terminal associated with the process), TIME (CPU time taken by the process), and CMD (the command that started the process).

```
jean-pierre@MyBaby:~$ ps
  PID TTY          TIME CMD
 2398 pts/0        00:00:00 bash
 2413 pts/0        00:00:00 ps
jean-pierre@MyBaby:~$
```

3. Which `ps` command identifies only state, PID and command name of all processes? (Hint: Use the `-o` option.) (1 mark)

Answer: The command `ps -eo state, pid, cmd` lists processes with their state, PID, and command name.

4. Use `man ps` to identify the process state codes associated with the following process states.

a. D – (1 mark)

Answer: Uninterruptible sleep (usually IO)

b. R – (1 mark)

Answer: Running or runnable (on run queue)

c. T – (1 mark)

Answer: Stopped by job control signal

d. X – (1 mark)

Answer: Dead (should never be seen)

e. Z – (1 mark)

Answer: Defunct ("zombie") process, terminated but not reaped by its parent

```
D  uninterruptible sleep (usually IO)
I  Idle kernel thread
R  running or runnable (on run queue)
S  interruptible sleep (waiting for an event to complete)
T  stopped by job control signal
t  stopped by debugger during the tracing
W  paging (not valid since the 2.6.xx kernel)
X  dead (should never be seen)
Z  defunct ("zombie") process, terminated but not reaped by
   its parent
```

5. What is the difference between a zombie process and an orphan process? (2 marks)

A zombie process has completed execution but still has an entry in the process table to report to its parent process. It's in a "terminated state."

An orphan process is a running process whose parent has terminated. These are adopted by init (PID 1), which will clean them up.

6. The command `top` displays a summary of system information, and it dynamically shows the processes that currently have the highest priorities. Run `top` and record the following information.

- a. Total number of processes (tasks): (1 mark)

Answer: 176

- b. Number of running processes: (1 mark)

Answer: 1

- c. Number of sleeping processes: (1 mark)

Answer: 175

- d. PID of the process `top`: (1 mark)

Answer: 2479

7. Press the letter `q` to quit `top`.
8. Many processes were displayed, and many of those are daemons. Research and briefly describe Linux daemons. (1 mark)

Answer: Linux daemons are integral background processes that begin running when the system boots up and continue until it shuts down. They perform various autonomous tasks without requiring user intervention.

9. Another name for a Linux thread is a lightweight process (LWP). In most systems, there is no difference between a thread and a LWP.
10. Use `ps -el` to display status of all process threads. Find one command that started more than one thread (one PID repeated with different TIDs), and record the command, its PID and the TID of two of the threads: (1 mark)

Answer: This command lists all threads of all processes. A process with more than one thread will have the same PID but different TID (thread IDs) for each thread. This command does not list the PID and TID together

F	S	UID	PID	PPID	C	PRI	NI	ADDR	SZ	WCHAN	TTY	TIME	CMD
4	S	0	1	0	0	80	0	-	25931	-	?	00:00:06	systemd
1	S	0	2	0	0	80	0	-	0	-	?	00:00:00	kthreadd
1	I	0	3	2	0	60	-20	-	0	-	?	00:00:00	rcu_gp
1	I	0	4	2	0	60	-20	-	0	-	?	00:00:00	rcu_par_gp
1	I	0	5	2	0	60	-20	-	0	-	?	00:00:00	slub_flush
1	I	0	6	2	0	60	-20	-	0	-	?	00:00:00	netns
1	I	0	8	2	0	60	-20	-	0	-	?	00:00:00	kworker/0:
1	I	0	10	2	0	80	0	-	0	-	?	00:00:02	kworker/u4
1	I	0	11	2	0	60	-20	-	0	-	?	00:00:00	mm_percpu_
1	I	0	12	2	0	80	0	-	0	-	?	00:00:00	rcu_tasks_
1	I	0	13	2	0	80	0	-	0	-	?	00:00:00	rcu_tasks_
1	I	0	14	2	0	80	0	-	0	-	?	00:00:00	rcu_tasks_
1	S	0	15	2	0	80	0	-	0	-	?	00:00:00	ksoftirqd/
1	I	0	16	2	0	80	0	-	0	-	?	00:00:01	rcu_preemp
1	S	0	17	2	0	-40	-	-	0	-	?	00:00:00	migration/
1	S	0	18	2	0	9	-	-	0	-	?	00:00:00	idle_injec
1	S	0	19	2	0	80	0	-	0	-	?	00:00:00	cpuhp/0
1	S	0	20	2	0	80	0	-	0	-	?	00:00:00	cpuhp/1
1	S	0	21	2	0	9	-	-	0	-	?	00:00:00	idle_injec
1	S	0	22	2	0	-40	-	-	0	-	?	00:00:00	migration/
1	S	0	23	2	0	80	0	-	0	-	?	00:00:00	ksoftirqd/

Part F: Linux Process Management

Linux inter-process communication is based on signals, which are codes for well-defined messages sent to a process. The `kill` command sends a signal to a process. This command name is poor, because various signals can be sent, not just a `SIGKILL` signal.

1. Using the `kill -l` command, identify the code for each of the following terms, and then research and briefly describe the meaning of each.

```
jean-pierre@MyBaby: ~ kill -l
 1) SIGHUP      2) SIGINT      3) SIGQUIT      4) SIGILL      5) SIGTRAP
 6) SIGABRT     7) SIGBUS      8) SIGFPE       9) SIGKILL     10) SIGUSR1
 11) SIGSEGV    12) SIGUSR2     13) SIGPIPE     14) SIGALRM     15) SIGTERM
 16) SIGSTKFLT   17) SIGCHLD     18) SIGCONT     19) SIGSTOP     20) SIGTSTP
 21) SIGTTIN    22) SIGTTOU     23) SIGURG      24) SIGXCPU     25) SIGXFSZ
 26) SIGVTALRM   27) SIGPROF     28) SIGWINCH    29) SIGIO       30) SIGPWR
 31) SIGSYS     34) SIGRTMIN    35) SIGRTMIN+1  36) SIGRTMIN+2  37) SIGRTMIN+3
 38) SIGRTMIN+4  39) SIGRTMIN+5  40) SIGRTMIN+6  41) SIGRTMIN+7  42) SIGRTMIN+8
 43) SIGRTMIN+9  44) SIGRTMIN+10 45) SIGRTMIN+11 46) SIGRTMIN+12 47) SIGRTMIN+13
 48) SIGRTMIN+14 49) SIGRTMIN+15 50) SIGRTMAX-14 51) SIGRTMAX-13 52) SIGRTMAX-12
 53) SIGRTMAX-11 54) SIGRTMAX-10 55) SIGRTMAX-9  56) SIGRTMAX-8  57) SIGRTMAX-7
 58) SIGRTMAX-6  59) SIGRTMAX-5  60) SIGRTMAX-4  61) SIGRTMAX-3  62) SIGRTMAX-2
 63) SIGRTMAX-1  64) SIGRTMAX
```

- a. `SIGKILL`: (2 marks)

Answer: Immediately terminates the process without cleanup.

- b. `SIGTERM`: (2 marks)

Answer: Gracefully terminates the process, allowing cleanup.

- c. `SIGSTOP`: (2 marks)

Answer: Pauses the process, cannot be ignored.

2. Run `man ps`, and then press CTRL-Z. What is the state of the process? (1 mark)

Answer: [1]+ stopped man ps

It's in a stopped state

CTRL-Z moved the `man` process to the background. It no longer controls the terminal window.

3. Run the `jobs` command. What is the purpose of this command? (1 mark)

Answer: The `jobs` command provides the user with the status of these background and stopped jobs, along with their job number.

4. Run `fg`. What happens? Why? (1 mark)

Answer: It brought back the `man ps` command which had previously been stopped. `fg` command is specifically designed to change a job's state from stopped to running and to move it from the background to the foreground, allowing you to interact with it directly.

5. Press CTRL-Z again to suspend the `man ps` process.

6. Run `man proc`, suspend the process using CTRL-Z and run `jobs` again.

You should now see two suspended `man` processes.

7. What command can you use to bring the `man ps` process to the foreground? (1 mark)

```
[1]- Stopped man ps
[2]+ Stopped man proc
jean-pierre@MyBaby:~$
```

Answer: fg %1

8. Press the `qps` key to exit the `man ps` command.
9. Send the default kill signal (SIGTERM) to the `man proc` process using `kill PID_of_man`.
10. Run `ps`. Why is the process still listed? (Hint: the signal is NOT being ignored!) (1 mark)

```
try: sudo apt install <deb name>
jean-pierre@MyBaby:~$ kill %2

[2]+  Stopped                  man proc
jean-pierre@MyBaby:~$ ps
  PID TTY          TIME CMD
 2398 pts/0        00:00:00 bash
 2738 pts/0        00:00:00 ps
[2]+  Terminated                 man proc
jean-pierre@MyBaby:~$ █
```

Answer: I just used the `kill %2` since I did not see the PID

It's listed one final time in the output of the `ps` command because this is the state of processes at the moment you executed `ps`. The `ps` command is showing you the state of processes just before it was updated to reflect the termination of the `man proc` process.

11. Send the force kill signal (SIGKILL) to the `man process` using `kill -9 PID_of_man`.
12. Run `ps`, and then compare the results to the previous step. Explain what has occurred. (1 mark)

```
jean-pierre@MyBaby:~$ man proc

[2]+  Stopped                  man proc
jean-pierre@MyBaby:~$ jobs
[1]-  Stopped                  man ps
[2]+  Stopped                  man proc
jean-pierre@MyBaby:~$ fg %1
man ps
jean-pierre@MyBaby:~$ kill -9 PID_of_man
bash: kill: PID_of_man: arguments must be process or job IDs
jean-pierre@MyBaby:~$ kill -9 %2

[2]+  Stopped                  man proc
jean-pierre@MyBaby:~$ ps
  PID TTY      TIME CMD
 2398 pts/0    00:00:00 bash
 2788 pts/0    00:00:00 ps
[2]+  Killed                  man proc
jean-pierre@MyBaby:~$ █
```

Answer: It says killed this time instead of terminated. I feel like I may have used a shortcut I wasnt supposed to use.

References

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