# Project Based Learning Report on
# Deadlock avoidance and Safe Sequencing in Windows and Linux

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Under the Guidance of

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## CERTIFICATE

It is certified that the project report entitled, "Deadlock detection and safe sequencing in Windows and Linux" is a bonafide work done by Aman Raj in partial fulfilment of the project-based learning.

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Dr. Mrunal Beewoor
(Course Coordinator)

## ACKNOWLEDGEMENT

To begin with, we would like to thank our teacher for providing us this golden opportunity. We are very grateful to our lecturer, Dr. Mrunal Beewoor for his valuable support and guidance. We are also very grateful to all those who helped us in our entire project. We would like to thank Dr. Mrunal Beewoor, our professor-in-charge and our HOD Dr. Vanjale sir for their support and guidance in completing our project on the topic-Image Processing. It was a great learning experience.

I would like to take this opportunity to express my gratitude to all my group members. The project would not have been successful without their cooperation and inputs. At last, but not the least, we are thankful to our parents and families who encourage us to study and who support us financially and who gave us the opportunity to spend our golden time in learning.

Thanks again to all who helped us.

# INDEX

## Introduction

Deadlocks are a critical issue in computer systems, particularly in operating systems where resources are shared among multiple processes. A deadlock occurs when two or more processes are unable to proceed because each is waiting for a resource held by the other, resulting in a circular wait situation. Detecting and resolving deadlocks is crucial for maintaining system stability and ensuring efficient resource utilization.

This project aims to explore and analyze deadlock detection mechanisms on two popular operating systems: Windows and Linux. Deadlock detection mechanisms play a vital role in pre-emptively identifying and resolving deadlocks before they can cause system failures or performance degradation.

The project will delve into the internal workings of both Windows and Linux operating systems to understand how deadlock detection is implemented and managed. By studying the underlying algorithms and strategies employed by each system, we aim to gain insights into their effectiveness, efficiency, and limitations.

Additionally, the project will involve practical experimentation to evaluate the performance of deadlock detection mechanisms in real-world scenarios. This experimentation will involve creating simulated deadlock situations and observing how each operating system detects and handles them.

Furthermore, this project will also investigate the Banker's Algorithm, a classic deadlock avoidance algorithm used to prevent deadlocks by carefully allocating resources to processes. The implementation of the Banker's Algorithm in Python using Tkinter will provide a practical illustration of deadlock avoidance techniques.

Through this project, we seek to enhance our understanding of deadlock detection mechanisms in modern operating systems, assess their effectiveness in different contexts, and contribute valuable insights to the field of operating systems and system reliability.

## History

Operating systems manage various resources such as CPU, memory, and peripherals to facilitate the execution of multiple processes concurrently. However, the concurrent access to shared resources can lead to situations where processes become deadlocked, i.e., each waiting for a resource held by another process, resulting in a cyclic dependency and preventing any of the processes involved from progressing.

Deadlocks are a common concern in operating systems and can significantly impact system performance and reliability. To mitigate the adverse effects of deadlocks, operating systems implement deadlock detection and prevention mechanisms. Deadlock detection involves identifying the existence of deadlocks in the system, while prevention techniques aim to eliminate the conditions that lead to deadlock formation.

In this project, we focus on exploring and analyzing deadlock detection mechanisms implemented in two widely used operating systems: Windows and Linux. Both Windows and Linux employ strategies to detect deadlocks and take appropriate actions to resolve them. Understanding the intricacies of deadlock detection in these systems is essential for system administrators, developers, and researchers to effectively manage and troubleshoot deadlock-related issues.

Windows, developed by Microsoft, is one of the most prevalent operating systems used in desktop, server, and embedded environments. Windows employs sophisticated algorithms to detect deadlocks and provides tools and APIs for developers and system administrators to monitor and manage deadlock situations.

Linux, on the other hand, is an open-source operating system kernel that powers a vast array of computing devices, ranging from servers and supercomputers to smartphones and embedded systems. Linux incorporates deadlock detection mechanisms within its kernel to ensure system stability and reliability.

By studying the deadlock detection mechanisms in Windows and Linux, this project aims to:

- Gain insights into the algorithms and techniques used for deadlock detection in each operating system.

- Compare the effectiveness and efficiency of deadlock detection mechanisms between Windows and Linux.

- Identify strengths and weaknesses of deadlock detection implementations in both operating systems.

- Provide recommendations for improving deadlock detection strategies based on the findings of the comparative analysis.

## Objectives

1. Understand the concept of deadlock in operating systems, including its causes, effects, and implications for system stability and performance.

2. Investigate and compare deadlock detection mechanisms implemented in both Windows and Linux operating systems, exploring their respective algorithms, implementation details, strengths, and weaknesses.

3. Analyze the effectiveness and efficiency of deadlock detection techniques on Windows and Linux platforms under various scenarios, such as different system loads and resource allocation patterns.

4. Implement scripts or programs to simulate and evaluate deadlock scenarios on both Windows and Linux environments, focusing on detecting and resolving deadlock situations.

5. Assess the performance impact of deadlock detection mechanisms on system resources, such as CPU utilization, memory usage, and overall system responsiveness.

6. Explore potential improvements or optimizations to existing deadlock detection algorithms, aiming to enhance system reliability and minimize the occurrence of deadlock situations.

7. Investigate the practical implications of deadlock detection in real-world applications and systems, considering factors such as scalability, reliability, and compatibility with existing software and hardware configurations.

8. Document findings, observations, and insights obtained from the experimentation and analysis process, providing a comprehensive overview of deadlock detection mechanisms on Windows and Linux platforms.

9. Draw conclusions regarding the effectiveness, efficiency, and practicality of deadlock detection techniques on different operating systems, identifying areas for further research and development in the field of operating system design and optimization.

## Methodology

The project methodology involves a systematic approach to investigating deadlock detection mechanisms on Windows and Linux operating systems. Here's a detailed description of the methodology:

1. Selection of Operating Systems:

- Windows and Linux were chosen as the target operating systems due to their widespread use in both personal and enterprise environments.

- Both systems offer different approaches to deadlock detection and management, making them ideal candidates for comparison.

2. Literature Review:

- Conducted an extensive review of existing literature on deadlock detection mechanisms in Windows and Linux.

- Studied academic papers, technical documentation, and relevant online resources to gain insight into the underlying algorithms and techniques used by each operating system.

3. Identification of Deadlock Detection Techniques:

- Identified and documented the specific deadlock detection techniques employed by Windows and Linux.

- Explored the theoretical foundations and practical implementations of these techniques to understand their strengths and limitations.

4. Experimentation Setup:

- Established a controlled experimental environment to conduct comparative analysis.

- Set up virtual machines or separate hardware systems running Windows and Linux distributions to ensure consistency in testing conditions.

5. Implementation of Deadlock Detection Scripts:

- Developed scripts to simulate and trigger deadlocks on both Windows and Linux platforms.

- Implemented deadlock detection mechanisms within these scripts to monitor and resolve deadlock scenarios.

6. Execution of Experiments:

- Executed the developed scripts on the respective operating systems to trigger deadlock situations.

- Monitored system behavior and performance metrics during deadlock detection and resolution processes.

7. Data Collection and Analysis:

- Collected data on system responses, resource utilization, and deadlock resolution times.

- Analyzed the collected data to evaluate the effectiveness and efficiency of deadlock detection mechanisms on Windows and Linux.

8. Comparative Evaluation:

- Compared the performance of deadlock detection mechanisms between Windows and Linux.

- Identified differences in algorithm effectiveness, resource utilization, and system stability under deadlock conditions.

9. Validation of Findings:

- Validated experimental results through peer review and discussion within the research community.

- Addressed any potential biases or limitations in the experimental methodology to ensure the reliability of findings.

10. Conclusion and Recommendations:

- Summarized key findings from the comparative analysis of deadlock detection mechanisms.

- Provided recommendations for optimizing deadlock detection and management strategies on both Windows and Linux platforms.

11. Documentation and Reporting:

- Documented the entire methodology, including experimental setup, data collection procedures, and analysis techniques.

- Prepared a comprehensive project report outlining the research objectives, methodology, findings, and conclusions.

## Code Implementation

```
import mysql.connector

import tkinter as tk

from tkinter import ttk

import numpy as np

import psutil

import subprocess

import matplotlib.pyplot as plt

def connect_to_mysql():

    try:

        connection = mysql.connector.connect(

            host="127.0.0.1",

            user="root",

            password="1234",

            database="cos"

        )

        return connection

    except mysql.connector.Error as e:

        print(f"Error connecting to MySQL: {e}")

        return None

def display_output(output_text):

    popup = tk.Toplevel()

    popup.title("Verification")

    label = tk.Label(popup, text=output_text)

    label.pack()

def fetch_process_data(connection):

    try:

        cursor = connection.cursor()

        cursor.execute("SELECT process_name, cpu_usage_alloc,
memory_usage_alloc, gpu_usage_alloc, cpu_usage_max, memory_usage_max,
gpu_usage_max FROM processes")

        data = cursor.fetchall()

        return data

    except mysql.connector.Error as e:

        print(f"Error fetching data from MySQL: {e}")
        return None
    finally:
        cursor.close()
def bankers_algorithm(available, allocated, max_claim):
    num_processes = len(allocated)
    num_resources = len(available)
    remaining_need = max_claim - allocated
    finish = [False] * num_processes
    safe_sequence = []
    while len(safe_sequence) < num_processes:
        safe_found = False
        for i in range(num_processes):
            if not finish[i] and all(remaining_need[i] <= available):
                available += allocated[i]
                finish[i] = True
                safe_sequence.append(i)
                safe_found = True
                break
        if not safe_found:
            break
    if len(safe_sequence) == num_processes:
        print("System is in a safe state")
        return safe_sequence
    else:
        print("System is in an unsafe state. Deadlock detected.")
        return None
    if len(safe_sequence) == num_processes:
        output_text = "System is in a safe state"
    else:
        output_text = "System is in an unsafe state. Deadlock detected."
    display_output(output_text)
def plot_graph(allocated):
    usage_types = ['CPU Usage Alloc', 'Memory Usage Alloc', 'GPU Usage
Alloc']
```

```
    usage_values = [np.sum(allocated[:, 0]), np.sum(allocated[:, 1]),
np.sum(allocated[:, 2])]

    plt.bar(usage_types, usage_values)

    plt.ylim(0, 50)  # Set the maximum limit of y-axis to 60

    plt.xlabel('Resource Type')

    plt.ylabel('Usage')

    plt.title('Resource Usage Allocation')

    plt.show()

def show_results(results):

    results_window = tk.Toplevel()

    results_window.title("Program Verification")


    results_text = tk.Text(results_window, height=20, width=50,
font=font_style)

    results_text.pack()

    for line in results:

        results_text.insert(tk.END, line + '\n')

def run_algorithm():

    connection = connect_to_mysql()

    if connection:

        try:

            process_data = fetch_process_data(connection)

            if process_data:

                num_processes = len(process_data)

                num_resources = 3

                cpu_usage, memory_usage = get_system_resource_usage()

                gpu_usage = 100

                available = np.array([cpu_usage, memory_usage, gpu_usage],
dtype=np.float64)

                allocated = np.array([[row[1], row[2], row[3]] for row in
process_data])

                max_claim = np.array([[row[4], row[5], row[6]] for row in
process_data])

                safe_sequence = bankers_algorithm(available, allocated,
max_claim)

                if safe_sequence is not None:

                    results_window = tk.Toplevel()
                    results_window.title("Algorithm Results")
                    results_text = tk.Text(results_window, height=20, 
width=50)
                    results_text.pack()
                    def countdown(count):
                        if count >= 0:
                            results_text.delete('1.0', tk.END)
                            results_text.insert(tk.END, f"Verification 
begins in {count}\n")
                            results_window.after(1000, countdown, count - 
1)
                            results_window.update_idletasks()
                        else:
                            verify_sequence(safe_sequence, allocated, 
available, process_data, results_text)
                    countdown(5)
        finally:
            connection.close()
def verify_sequence(safe_sequence, allocated, available, process_data, 
results_text, idx=0):
    if idx < len(safe_sequence):
        process_index = safe_sequence[idx]
        process_name = process_data[process_index][0]
        results_text.insert(tk.END, f"Verified allocation for 
{process_name}\n")
        results_text.yview_moveto(1.0)
        root.after(1000, verify_sequence, safe_sequence, allocated, 
available, process_data, results_text, idx + 1)
    else:
        results_text.insert(tk.END, "All processes completed successfully. 
Sequence verified.\n")
        results_text.yview_moveto(1.0)
def get_system_resource_usage():
    cpu_usage = 100 - psutil.cpu_percent(interval=1)
    memory_usage = 100 - psutil.virtual_memory().percent
    return cpu_usage, memory_usage
def show_graph():
    connection = connect_to_mysql()
    if connection:
        try:
            process_data = fetch_process_data(connection)
            if process_data:
                allocated = np.array([[row[1], row[2], row[3]] for row in 
process_data])
                plot_graph(allocated)
        finally:
            connection.close()
root = tk.Tk()
root.title("Deadlock Detection")
root.state('zoomed')
tree = ttk.Treeview(root, columns=('Process Name', 'CPU Usage Alloc', 
'Memory Usage Alloc', 'GPU Usage Alloc', 'CPU Usage Max', 'Memory Usage 
Max', 'GPU Usage Max'))
tree.heading('#0', text='ID')
tree.heading('#1', text='Process Name')
tree.heading('#2', text='CPU Usage Alloc')
tree.heading('#3', text='Memory Usage Alloc')
tree.heading('#4', text='GPU Usage Alloc')
tree.heading('#5', text='CPU Usage Max')
tree.heading('#6', text='Memory Usage Max')
tree.heading('#7', text='GPU Usage Max')
connection = connect_to_mysql()
if connection:
    try:
        cursor = connection.cursor()
        cursor.execute("SELECT * FROM processes")
        for row in cursor.fetchall():
            tree.insert('', 'end', text=row[0], values=row[1:])
    finally:
        connection.close()
tree.pack(fill='both', expand=True)
run_button = tk.Button(root, text="Run Algorithm", command=run_algorithm)
run_button.pack(side='top', fill='x', padx=10)
graph_button = tk.Button(root, text="Show Graph", command=show_graph)
```

```
graph_button.pack(side='top', fill='x', padx=10)

font_style = ("Times New Roman", 14, "bold")

style = ttk.Style()

style.configure("Treeview.Heading", font=font_style)

tree = ttk.Treeview(root, style="Treeview")

run_button.configure(font=font_style)

graph_button.configure(font=font_style)

root.mainloop()
```

## Code Explanation

1. Import Statements:

- The code imports necessary modules: `mysql.connector` for MySQL database connectivity, `tkinter` for GUI, `numpy` for numerical calculations, `psutil` for system resource monitoring, `subprocess` for subprocess handling, and `matplotlib.pyplot` for plotting graphs.

2. Database Connection Function (`connect_to_mysql`):

- This function establishes a connection to a MySQL database with the specified credentials (host, user, password, database). If the connection is successful, it returns the connection object; otherwise, it prints an error message and returns `None`.

3. Display Output Function (`display_output`):

- This function creates a popup window using `tkinter` to display output text.

4. Fetch Process Data Function (`fetch_process_data`):

- This function retrieves process data from the MySQL database. It executes a SELECT query to fetch process names and their corresponding resource allocations and maximum claims. If successful, it returns the fetched data as a list of tuples; otherwise, it prints an error message and returns `None`.

5. Banker's Algorithm Function (`bankers_algorithm`):

- This function implements the Banker's algorithm for deadlock detection.

- It takes three arguments: `available`, `allocated`, and `max_claim`.

- It iterates through processes to determine if the system is in a safe state or if deadlock is detected.

- If the system is in a safe state, it returns a safe sequence of processes; otherwise, it returns `None`.

- Additionally, it should display a message indicating whether the system is in a safe or unsafe state, but there's a logical issue: the code that displays the output is unreachable due to a misplaced condition. The `display_output` function should be called outside the `while` loop and before the return statements.

6. Plot Graph Function (`plot_graph`):

- This function plots a bar graph using `matplotlib.pyplot`, displaying the allocation of different resources (CPU, Memory, GPU) based on the allocated resources passed as an argument.

7. Show Results Function (`show_results`):

- This function is defined but not used in the current code.

8. Run Algorithm Function (`run_algorithm`):

- This function orchestrates the execution of the deadlock detection algorithm.

- It fetches process data from the database, calculates available resources, and calls the `bankers_algorithm` function.

- If the system is in a safe state, it initiates a countdown before verifying the safe sequence of processes.

9. Verify Sequence Function (`verify_sequence`):

- This function verifies the safe sequence of processes obtained from the Banker's algorithm.

- It iterates through the safe sequence and displays verification messages for each process.

10. Get System Resource Usage Function (`get_system_resource_usage`):

- This function utilizes the `psutil` library to get the current CPU and memory usage of the system.

11. Show Graph Function (`show_graph`):

- This function fetches process data from the database and calls the `plot_graph` function to display resource allocation using a bar graph.

12. Tkinter GUI Setup:

- The code sets up a Tkinter GUI window with a Treeview widget to display process data fetched from the database.
- It also includes buttons for running the algorithm and showing resource allocation graphs.

## Extraction of Data From System

1. Imports and Dependencies:

- `si` is imported from 'systeminformation', which is likely a library for retrieving system information.

- `mysql` is imported from 'mysql', which is a MySQL client for Node.js.

2. Database Configuration:

- `dbConfig` object holds configuration details like host, user, password, and database name required to establish a connection with the MySQL database.

3. MySQL Connection:

- `connection` is created using `mysql.createConnection()` method with the `dbConfig` details.

- `connection.connect()` is called to establish a connection to the MySQL database. If an error occurs during connection, it will be logged to the console.

4. Insert Data Function (`insertData`):

- This function is responsible for inserting process data into the MySQL database.

- It takes an array of processes (`processes`) as input.

- It first truncates the 'processes' table using `TRUNCATE TABLE processes` query.

- Then, it iterates through each process in the `processes` array.

- For each process, it checks if the process name already exists in the `existingProcesses` set. If yes, it skips the process.

- It retrieves system information such as CPU, memory, and GPU data using `systeminformation` library.

- It constructs an SQL query to insert process data into the 'processes' table.

- It executes the SQL query using `connection.query()`, inserting process data into the database.

- If an error occurs during insertion, it's logged to the console.

5. Process Data Function (`processData`):

- This function is responsible for fetching process data using `systeminformation` library and calling the `insertData` function.

- It retrieves a list of processes using `si.processes()`.

- It then calls the `insertData` function with the list of processes.

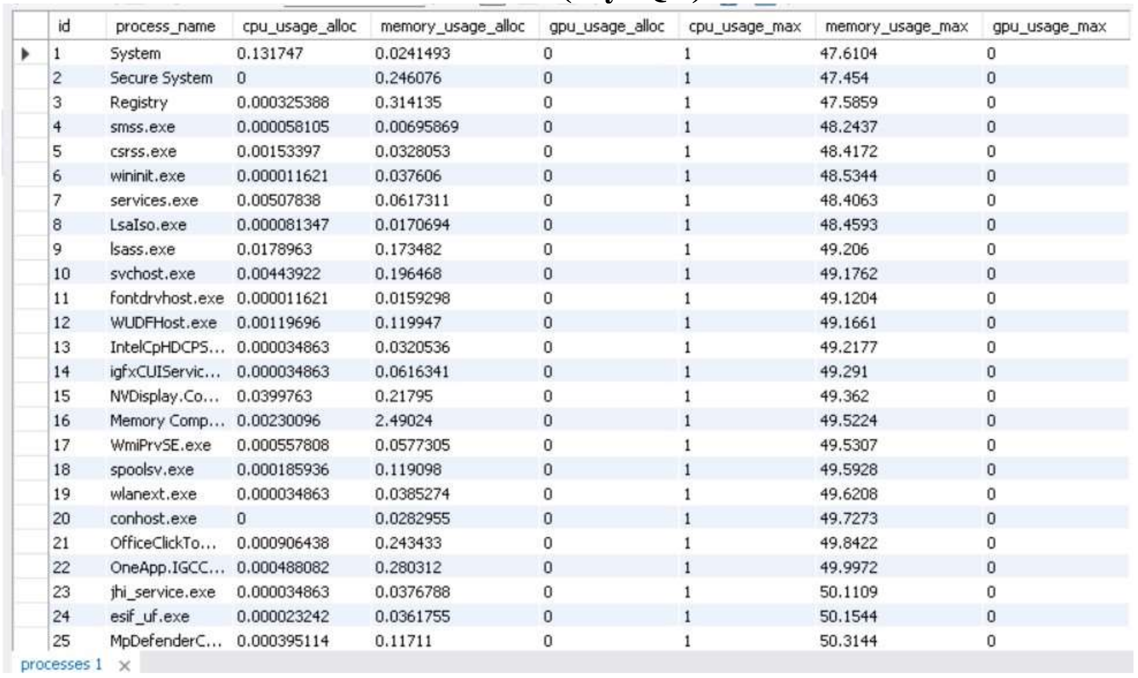
6. Main Execution:

- `processData()` is called to start the process of fetching and inserting data into the database.

- An event listener is added for the 'exit' event of the process, which calls `connection.end()` to close the MySQL connection when the Node.js process exits.

## Databases used in Windows and Linux

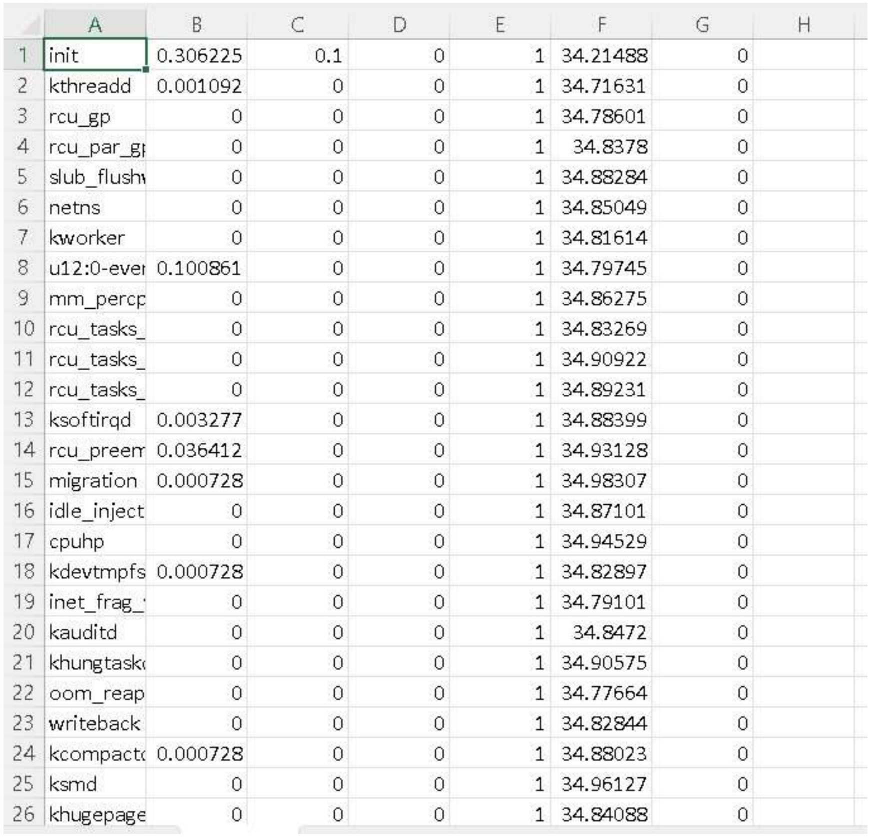
### Windows(MySQL):



| | id | process_name | cpu_usage_alloc | memory_usage_alloc | gpu_usage_alloc | cpu_usage_max | memory_usage_max | gpu_usage_max |
|---|---|---|---|---|---|---|---|---|
| ▶ | 1 | System | 0.131747 | 0.0241493 | 0 | 1 | 47.6104 | 0 |
| | 2 | Secure System | 0 | 0.246076 | 0 | 1 | 47.454 | 0 |
| | 3 | Registry | 0.000325388 | 0.314135 | 0 | 1 | 47.5859 | 0 |
| | 4 | smss.exe | 0.000058105 | 0.00695869 | 0 | 1 | 48.2437 | 0 |
| | 5 | csrss.exe | 0.00153397 | 0.0328053 | 0 | 1 | 48.4172 | 0 |
| | 6 | wininit.exe | 0.000011621 | 0.037606 | 0 | 1 | 48.5344 | 0 |
| | 7 | services.exe | 0.00507838 | 0.0617311 | 0 | 1 | 48.4063 | 0 |
| | 8 | LsaIso.exe | 0.000081347 | 0.0170694 | 0 | 1 | 48.4593 | 0 |
| | 9 | lsass.exe | 0.0178963 | 0.173482 | 0 | 1 | 49.206 | 0 |
| | 10 | svchost.exe | 0.00443922 | 0.196468 | 0 | 1 | 49.1762 | 0 |
| | 11 | fontdrvhost.exe | 0.000011621 | 0.0159298 | 0 | 1 | 49.1204 | 0 |
| | 12 | WUDFHost.exe | 0.00119696 | 0.119947 | 0 | 1 | 49.1661 | 0 |
| | 13 | IntelCpHDCPS... | 0.000034863 | 0.0320536 | 0 | 1 | 49.2177 | 0 |
| | 14 | igfxCUIServic... | 0.000034863 | 0.0616341 | 0 | 1 | 49.291 | 0 |
| | 15 | NVDisplay.Co... | 0.0399763 | 0.21795 | 0 | 1 | 49.362 | 0 |
| | 16 | Memory Comp... | 0.00230096 | 2.49024 | 0 | 1 | 49.5224 | 0 |
| | 17 | WmiPrvSE.exe | 0.000557808 | 0.0577305 | 0 | 1 | 49.5307 | 0 |
| | 18 | spoolsv.exe | 0.000185936 | 0.119098 | 0 | 1 | 49.5928 | 0 |
| | 19 | wlanext.exe | 0.000034863 | 0.0385274 | 0 | 1 | 49.6208 | 0 |
| | 20 | conhost.exe | 0 | 0.0282955 | 0 | 1 | 49.7273 | 0 |
| | 21 | OfficeClickTo... | 0.000906438 | 0.243433 | 0 | 1 | 49.8422 | 0 |
| | 22 | OneApp.IGCC... | 0.000488082 | 0.280312 | 0 | 1 | 49.9972 | 0 |
| | 23 | jhi_service.exe | 0.000034863 | 0.0376788 | 0 | 1 | 50.1109 | 0 |
| | 24 | esif_uf.exe | 0.000023242 | 0.0361755 | 0 | 1 | 50.1544 | 0 |
| | 25 | MpDefenderC... | 0.000395114 | 0.11711 | 0 | 1 | 50.3144 | 0 |

processes 1 ×

### Linux(CSV File):

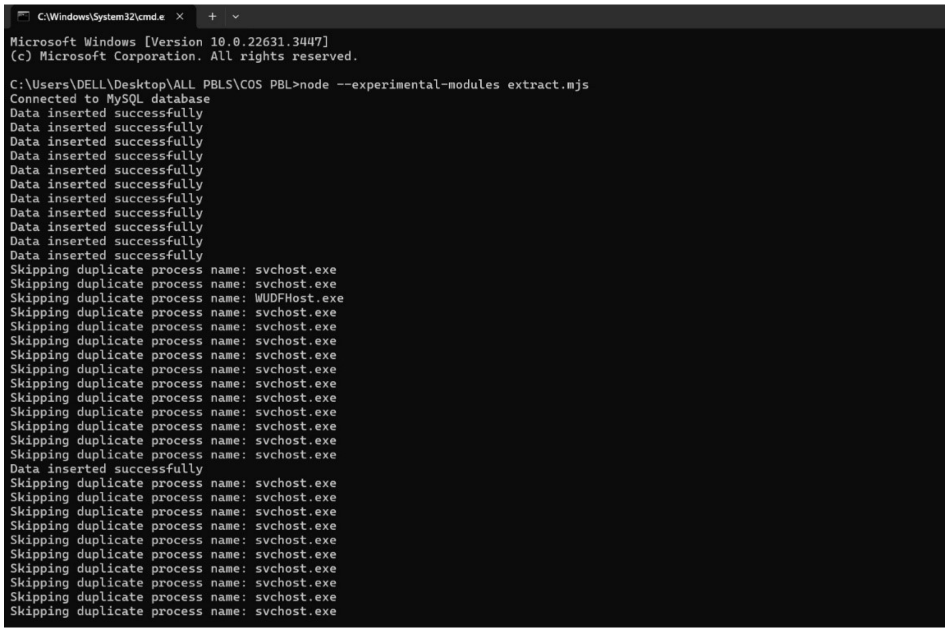


| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | init | 0.306225 | 0.1 | 0 | 1 | 34.21488 | 0 | |
| 2 | kthreadd | 0.001092 | 0 | 0 | 1 | 34.71631 | 0 | |
| 3 | rcu_gp | 0 | 0 | 0 | 1 | 34.78601 | 0 | |
| 4 | rcu_par_gp | 0 | 0 | 0 | 1 | 34.8378 | 0 | |
| 5 | slub_flushw | 0 | 0 | 0 | 1 | 34.88284 | 0 | |
| 6 | netns | 0 | 0 | 0 | 1 | 34.85049 | 0 | |
| 7 | kworker | 0 | 0 | 0 | 1 | 34.81614 | 0 | |
| 8 | u12:0-ever | 0.100861 | 0 | 0 | 1 | 34.79745 | 0 | |
| 9 | mm_percp | 0 | 0 | 0 | 1 | 34.86275 | 0 | |
| 10 | rcu_tasks_ | 0 | 0 | 0 | 1 | 34.83269 | 0 | |
| 11 | rcu_tasks_ | 0 | 0 | 0 | 1 | 34.90922 | 0 | |
| 12 | rcu_tasks_ | 0 | 0 | 0 | 1 | 34.89231 | 0 | |
| 13 | ksoftirqd | 0.003277 | 0 | 0 | 1 | 34.88399 | 0 | |
| 14 | rcu_preem | 0.036412 | 0 | 0 | 1 | 34.93128 | 0 | |
| 15 | migration | 0.000728 | 0 | 0 | 1 | 34.98307 | 0 | |
| 16 | idle_inject | 0 | 0 | 0 | 1 | 34.87101 | 0 | |
| 17 | cpuhp | 0 | 0 | 0 | 1 | 34.94529 | 0 | |
| 18 | kdevtmpfs | 0.000728 | 0 | 0 | 1 | 34.82897 | 0 | |
| 19 | inet_frag_ | 0 | 0 | 0 | 1 | 34.79101 | 0 | |
| 20 | kauditd | 0 | 0 | 0 | 1 | 34.8472 | 0 | |
| 21 | khungtask | 0 | 0 | 0 | 1 | 34.90575 | 0 | |
| 22 | oom_reap | 0 | 0 | 0 | 1 | 34.77664 | 0 | |
| 23 | writeback | 0 | 0 | 0 | 1 | 34.82844 | 0 | |
| 24 | kcompactd | 0.000728 | 0 | 0 | 1 | 34.88023 | 0 | |
| 25 | ksmd | 0 | 0 | 0 | 1 | 34.96127 | 0 | |
| 26 | khugepage | 0 | 0 | 0 | 1 | 34.84088 | 0 | |

## Pictures of Outputs

### Windows:

Extraction:



```
C:\Windows\System32\cmd.e

Microsoft Windows [Version 10.0.22631.3447]
(c) Microsoft Corporation. All rights reserved.

C:\Users\DELL\Desktop\ALL PBLS\COS PBL>node --experimental-modules extract.mjs
Connected to MySQL database
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Data inserted successfully
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: WUDFHost.exe
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: svchost.exe
Skipping duplicate process name: svchost.exe
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Data inserted successfully
Skipping duplicate process name: svchost.exe
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Skipping duplicate process name: svchost.exe
```
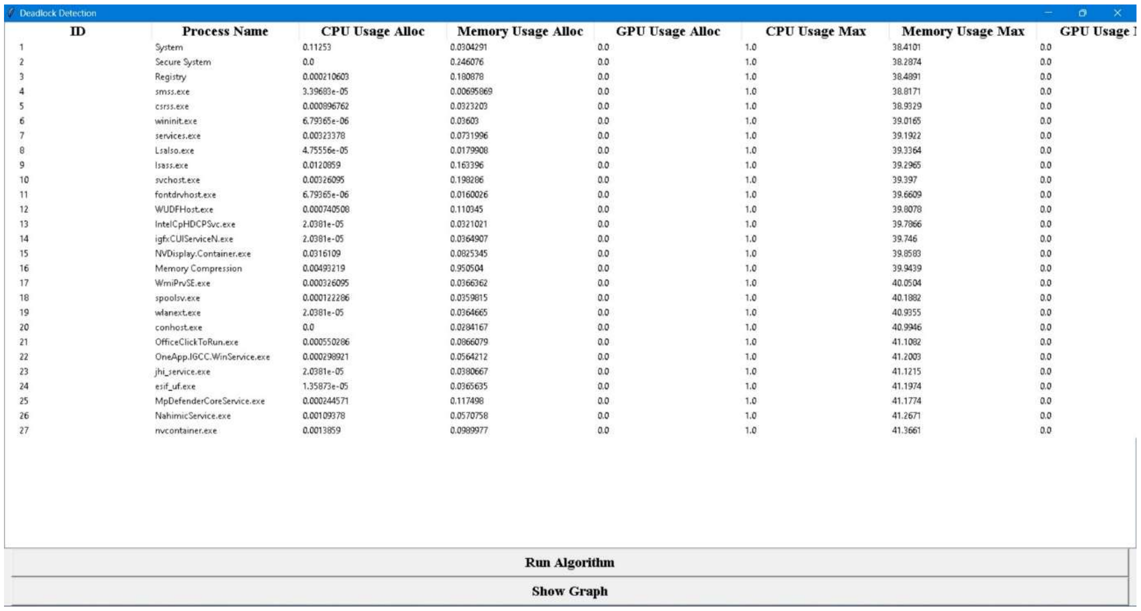
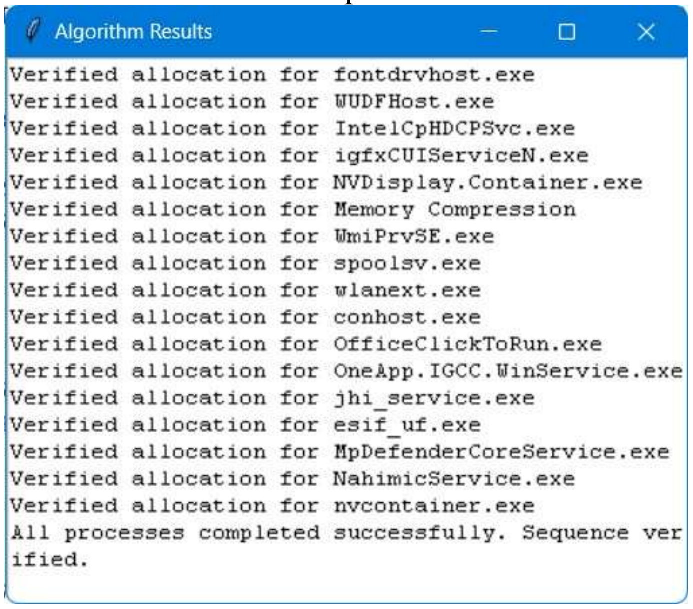

Table:



Deadlock Detection

| ID | Process Name | CPU Usage Alloc | Memory Usage Alloc | GPU Usage Alloc | CPU Usage Max | Memory Usage Max | GPU Usage |
|---|---|---|---|---|---|---|---|
| 1 | System | 0.11253 | 0.0304291 | 0.0 | 1.0 | 38.4101 | 0.0 |
| 2 | Secure System | 0.0 | 0.246076 | 0.0 | 1.0 | 38.2874 | 0.0 |
| 3 | Registry | 0.000210603 | 0.180878 | 0.0 | 1.0 | 38.4891 | 0.0 |
| 4 | smss.exe | 3.39683e-05 | 0.00695869 | 0.0 | 1.0 | 38.8171 | 0.0 |
| 5 | csrss.exe | 0.000896762 | 0.0323203 | 0.0 | 1.0 | 38.9329 | 0.0 |
| 6 | wininit.exe | 6.79365e-06 | 0.03603 | 0.0 | 1.0 | 39.0165 | 0.0 |
| 7 | services.exe | 0.00323378 | 0.0731996 | 0.0 | 1.0 | 39.1922 | 0.0 |
| 8 | Lsalso.exe | 4.75556e-05 | 0.0179908 | 0.0 | 1.0 | 39.3364 | 0.0 |
| 9 | lsass.exe | 0.0120859 | 0.163396 | 0.0 | 1.0 | 39.2965 | 0.0 |
| 10 | svchost.exe | 0.00326095 | 0.198286 | 0.0 | 1.0 | 39.397 | 0.0 |
| 11 | fontdrvhost.exe | 6.79365e-06 | 0.0160026 | 0.0 | 1.0 | 39.6609 | 0.0 |
| 12 | WUDFHost.exe | 0.000740508 | 0.110345 | 0.0 | 1.0 | 39.8078 | 0.0 |
| 13 | IntelCpHDCPSvc.exe | 2.0381e-05 | 0.0321021 | 0.0 | 1.0 | 39.7866 | 0.0 |
| 14 | igfxCUIServiceN.exe | 2.0381e-05 | 0.0364907 | 0.0 | 1.0 | 39.746 | 0.0 |
| 15 | NVDisplay.Container.exe | 0.0316109 | 0.0825345 | 0.0 | 1.0 | 39.8583 | 0.0 |
| 16 | Memory Compression | 0.00493219 | 0.950504 | 0.0 | 1.0 | 39.9439 | 0.0 |
| 17 | WmiPrvSE.exe | 0.000326095 | 0.0366362 | 0.0 | 1.0 | 40.0504 | 0.0 |
| 18 | spoolsv.exe | 0.000122286 | 0.0359815 | 0.0 | 1.0 | 40.1882 | 0.0 |
| 19 | wlanext.exe | 2.0381e-05 | 0.0364665 | 0.0 | 1.0 | 40.9355 | 0.0 |
| 20 | conhost.exe | 0.0 | 0.0284167 | 0.0 | 1.0 | 40.9946 | 0.0 |
| 21 | OfficeClickToRun.exe | 0.000550286 | 0.0866079 | 0.0 | 1.0 | 41.1082 | 0.0 |
| 22 | OneApp.IGCC.WinService.exe | 0.000298921 | 0.0564212 | 0.0 | 1.0 | 41.2003 | 0.0 |
| 23 | jhi_service.exe | 2.0381e-05 | 0.0380667 | 0.0 | 1.0 | 41.1215 | 0.0 |
| 24 | esif_uf.exe | 1.35873e-05 | 0.0365635 | 0.0 | 1.0 | 41.1974 | 0.0 |
| 25 | MpDefenderCoreService.exe | 0.000244571 | 0.117498 | 0.0 | 1.0 | 41.1774 | 0.0 |
| 26 | NahimicService.exe | 0.00109378 | 0.0570758 | 0.0 | 1.0 | 41.2671 | 0.0 |
| 27 | nvcontainer.exe | 0.0013859 | 0.0989977 | 0.0 | 1.0 | 41.3661 | 0.0 |

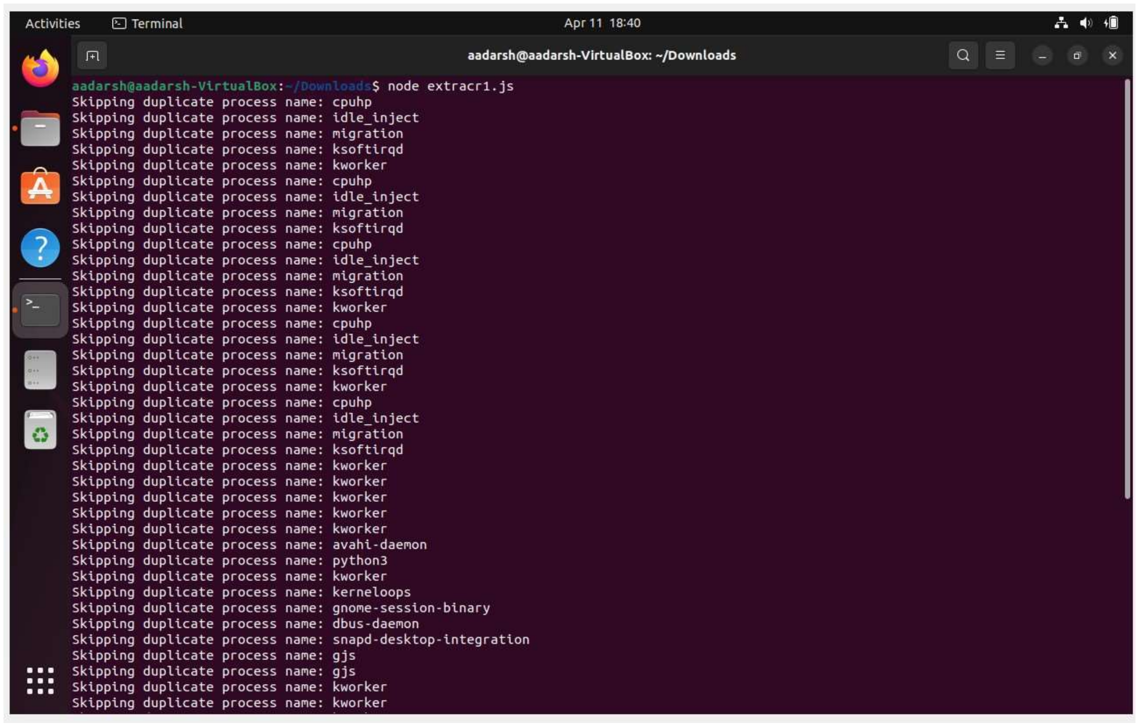
Output:



```
Verified allocation for fontdrvhost.exe
Verified allocation for WUDFHost.exe
Verified allocation for IntelCpHDCPSvc.exe
Verified allocation for igfxCUIServiceN.exe
Verified allocation for NVDisplay.Container.exe
Verified allocation for Memory Compression
Verified allocation for WmiPrvSE.exe
Verified allocation for spoolsv.exe
Verified allocation for wlanext.exe
Verified allocation for conhost.exe
Verified allocation for OfficeClickToRun.exe
Verified allocation for OneApp.IGCC.WinService.exe
Verified allocation for jhi_service.exe
Verified allocation for esif_uf.exe
Verified allocation for MpDefenderCoreService.exe
Verified allocation for NahimicService.exe
Verified allocation for nvcontainer.exe
All processes completed successfully. Sequence ver
ified.
```

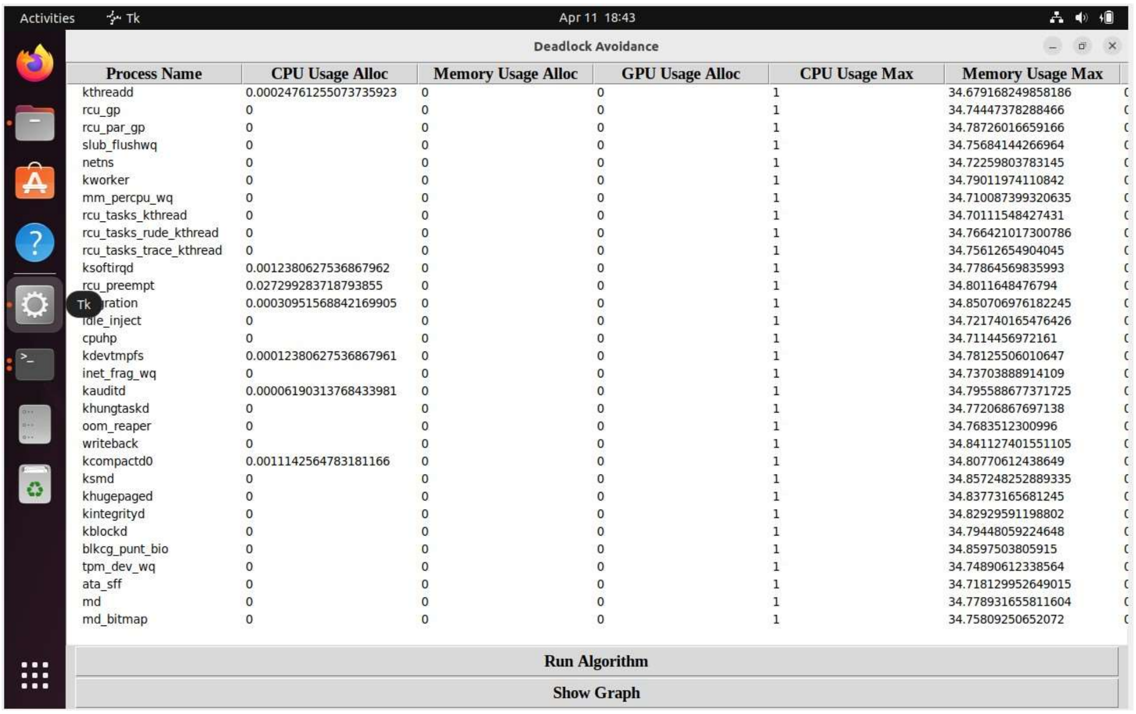
**Linux:**

Extraction:



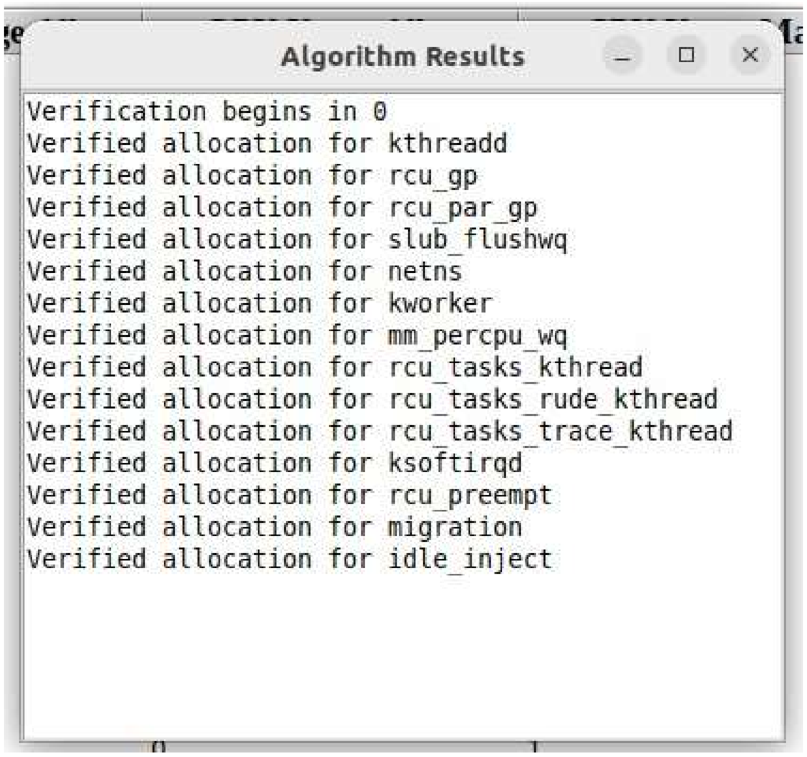
```
aadarsh@aadarsh-VirtualBox:~/Downloads$ node extracr1.js
Skipping duplicate process name: cpuhp
Skipping duplicate process name: idle_inject
Skipping duplicate process name: migration
Skipping duplicate process name: ksoftirqd
Skipping duplicate process name: kworker
Skipping duplicate process name: cpuhp
Skipping duplicate process name: idle_inject
Skipping duplicate process name: migration
Skipping duplicate process name: ksoftirqd
Skipping duplicate process name: cpuhp
Skipping duplicate process name: idle_inject
Skipping duplicate process name: migration
Skipping duplicate process name: ksoftirqd
Skipping duplicate process name: kworker
Skipping duplicate process name: cpuhp
Skipping duplicate process name: idle_inject
Skipping duplicate process name: migration
Skipping duplicate process name: ksoftirqd
Skipping duplicate process name: kworker
Skipping duplicate process name: cpuhp
Skipping duplicate process name: idle_inject
Skipping duplicate process name: migration
Skipping duplicate process name: ksoftirqd
Skipping duplicate process name: kworker
Skipping duplicate process name: kworker
Skipping duplicate process name: kworker
Skipping duplicate process name: kworker
Skipping duplicate process name: kworker
Skipping duplicate process name: avahi-daemon
Skipping duplicate process name: python3
Skipping duplicate process name: kworker
Skipping duplicate process name: kerneloops
Skipping duplicate process name: gnome-session-binary
Skipping duplicate process name: dbus-daemon
Skipping duplicate process name: snapd-desktop-integration
Skipping duplicate process name: gjs
Skipping duplicate process name: gjs
Skipping duplicate process name: kworker
Skipping duplicate process name: kworker
```

Table:



| Process Name | CPU Usage Alloc | Memory Usage Alloc | GPU Usage Alloc | CPU Usage Max | Memory Usage Max |
|---|---|---|---|---|---|
| kthreadd | 0.00024761255073735923 | 0 | 0 | 1 | 34.679168249858186 |
| rcu_gp | 0 | 0 | 0 | 1 | 34.74447378288466 |
| rcu_par_gp | 0 | 0 | 0 | 1 | 34.78726016659166 |
| slub_flushwq | 0 | 0 | 0 | 1 | 34.75684144266964 |
| netns | 0 | 0 | 0 | 1 | 34.72259803783145 |
| kworker | 0 | 0 | 0 | 1 | 34.79011974110842 |
| mm_percpu_wq | 0 | 0 | 0 | 1 | 34.710087399320635 |
| rcu_tasks_kthread | 0 | 0 | 0 | 1 | 34.70111548427431 |
| rcu_tasks_rude_kthread | 0 | 0 | 0 | 1 | 34.766421017300786 |
| rcu_tasks_trace_kthread | 0 | 0 | 0 | 1 | 34.75612654904045 |
| ksoftirqd | 0.0012380627536867962 | 0 | 0 | 1 | 34.77864569835993 |
| rcu_preempt | 0.027299283718793855 | 0 | 0 | 1 | 34.8011648476794 |
| ration | 0.00030951568842169905 | 0 | 0 | 1 | 34.850706976182245 |
| idle_inject | 0 | 0 | 0 | 1 | 34.721740165476426 |
| cpuhp | 0 | 0 | 0 | 1 | 34.7114456972161 |
| kdevtmpfs | 0.00012380627536867961 | 0 | 0 | 1 | 34.78125506010647 |
| inet_frag_wq | 0 | 0 | 0 | 1 | 34.73703888914109 |
| kauditd | 0.00006190313768433981 | 0 | 0 | 1 | 34.795588677371725 |
| khungtaskd | 0 | 0 | 0 | 1 | 34.77206867697138 |
| oom_reaper | 0 | 0 | 0 | 1 | 34.7683512300996 |
| writeback | 0 | 0 | 0 | 1 | 34.841127401551105 |
| kcompactd0 | 0.0011142564783181166 | 0 | 0 | 1 | 34.80770612438649 |
| ksmd | 0 | 0 | 0 | 1 | 34.857248252889335 |
| khugepaged | 0 | 0 | 0 | 1 | 34.83773165681245 |
| kintegrityd | 0 | 0 | 0 | 1 | 34.82929591198802 |
| kblockd | 0 | 0 | 0 | 1 | 34.79448059224648 |
| blkcg_punt_bio | 0 | 0 | 0 | 1 | 34.8597503805915 |
| tpm_dev_wq | 0 | 0 | 0 | 1 | 34.74890612338564 |
| ata_sff | 0 | 0 | 0 | 1 | 34.718129952649015 |
| md | 0 | 0 | 0 | 1 | 34.778931655811604 |
| md_bitmap | 0 | 0 | 0 | 1 | 34.75809250652072 |

Terminal:



```
Verification begins in 0
Verified allocation for kthreadd
Verified allocation for rcu_gp
Verified allocation for rcu_par_gp
Verified allocation for slub_flushwq
Verified allocation for netns
Verified allocation for kworker
Verified allocation for mm_percpu_wq
Verified allocation for rcu_tasks_kthread
Verified allocation for rcu_tasks_rude_kthread
Verified allocation for rcu_tasks_trace_kthread
Verified allocation for ksoftirqd
Verified allocation for rcu_preempt
Verified allocation for migration
Verified allocation for idle_inject
```

## Challenges and Limitations

While implementing the deadlock detection project on Windows and Linux, several challenges and limitations were encountered. Understanding and addressing these challenges were crucial for the successful completion of the project.

1. Platform-Specific Differences: One significant challenge was the inherent differences between Windows and Linux operating systems. Each platform has its own set of APIs, system calls, and behaviors, which required careful consideration during the implementation of deadlock detection mechanisms.

2. Resource Constraints: Another challenge stemmed from resource constraints, especially when running multiple processes concurrently for testing deadlock scenarios. Limited system resources such as CPU, memory, and I/O could impact the accuracy and reliability of deadlock detection.

3. Accuracy of Deadlock Detection: Deadlock detection algorithms rely on various heuristics and system information to identify deadlock situations. Ensuring the accuracy of deadlock detection, especially in complex and dynamic environments, posed a significant challenge. False positives or false negatives in deadlock detection could lead to incorrect system behavior.

4. Performance Overhead: Implementing deadlock detection mechanisms incurs a certain level of performance overhead. This overhead includes additional computational and memory resources consumed by the detection algorithms. Balancing the need for accurate deadlock detection with minimal performance impact was a key consideration.

5. Concurrency and Synchronization: Dealing with concurrent processes and synchronization primitives added complexity to the deadlock detection process. Coordinating access to shared resources and avoiding race conditions while detecting deadlocks required careful synchronization mechanisms.

6. Testing and Validation: Comprehensive testing and validation of the deadlock detection mechanisms were essential but challenging tasks. Creating realistic deadlock scenarios, simulating system loads, and verifying the correctness of detection results required meticulous planning and execution.

7. Portability and Compatibility: Ensuring the portability and compatibility of the deadlock detection solution across different versions of Windows and Linux distributions posed challenges. Differences in system configurations, kernel versions, and library dependencies could affect the behavior and performance of the detection mechanisms.

8. Security Considerations: Deadlock detection mechanisms operate at a system level and may interact with sensitive system resources. Ensuring the security and integrity of the detection algorithms to prevent potential vulnerabilities or exploits was a critical concern.

9. Documentation and Maintenance: Documenting the implementation details, including algorithms, data structures, and system interactions, was essential for future maintenance and troubleshooting. Maintaining clear and up-to-date documentation presented its own set of challenges, especially in dynamic development environments.

10. User Interface and Feedback: Providing meaningful feedback and user interfaces for deadlock detection tools can enhance usability and user experience. Designing intuitive interfaces and informative error messages to assist users in understanding and resolving deadlock situations required careful attention to user interaction design principles.

Addressing these challenges and limitations required collaboration, innovation, and continuous refinement throughout the project lifecycle. By overcoming these obstacles, the deadlock detection project aimed to provide valuable insights into improving system reliability and performance in multi-process environments.

## Future Advancements

In addition to the current implementation, several avenues for future advancements exist, which could enhance the robustness, efficiency, and applicability of the proposed solutions. These advancements are outlined below:

1. Enhanced Deadlock Detection Algorithms:

- Research and development efforts can focus on refining the deadlock detection algorithms employed in both Windows and Linux operating systems. Advancements in algorithmic efficiency, accuracy, and adaptability to diverse system configurations can significantly improve the effectiveness of deadlock detection mechanisms.

2. Dynamic Resource Allocation Strategies:

- Implementing dynamic resource allocation strategies can mitigate the occurrence of deadlocks by intelligently managing resource allocation and utilization. Techniques such as dynamic resource reallocation, priority-based resource allocation, and adaptive resource provisioning can enhance system resilience against deadlock scenarios.

3. Integration of Machine Learning Techniques:

- Integration of machine learning techniques for deadlock prediction and prevention holds promise for proactive deadlock management. By analyzing historical system behavior and resource usage patterns, machine learning models can anticipate potential deadlock situations and preemptively take corrective actions to avoid them.

4. Cross-Platform Compatibility:

- Expanding the scope of the project to encompass cross-platform compatibility can broaden its applicability and utility. Investigating deadlock detection mechanisms in other operating systems and platforms beyond Windows and Linux, such as macOS or mobile operating systems, can provide valuable insights into platform-specific deadlock handling strategies.

5. Real-Time Deadlock Monitoring and Visualization:

- Developing real-time deadlock monitoring tools with intuitive visualization capabilities can facilitate proactive deadlock management. Visual representations of system resource dependencies, process interactions, and deadlock occurrences can empower system administrators to identify, analyze, and resolve deadlock incidents in a timely manner.

6. Integration with Containerized Environments:

- With the growing prevalence of containerized environments such as Docker and Kubernetes, integrating deadlock detection mechanisms with container orchestration platforms can enhance system resilience in distributed computing environments. Customized deadlock detection solutions tailored for containerized workloads can address unique challenges posed by containerization, such as resource isolation and scalability.

7. Collaborative Research Initiatives:

- Collaboration with academic institutions, research organizations, and industry partners can foster collaborative research initiatives aimed at advancing deadlock detection technologies. By leveraging interdisciplinary expertise and resources, collaborative research efforts can accelerate innovation in deadlock management and contribute to the development of standardized deadlock handling frameworks.

8. Enhanced Security and Privacy Considerations:

- Addressing security and privacy considerations associated with deadlock detection mechanisms is essential to safeguarding system integrity and user confidentiality. Future advancements should prioritize the implementation of secure communication protocols, access control mechanisms, and data anonymization techniques to mitigate potential security risks and privacy breaches.

9. Scalability and Performance Optimization:

- Emphasizing scalability and performance optimization is crucial for ensuring the scalability and efficiency of deadlock detection solutions in large-scale enterprise environments. Techniques such as parallelization, distributed processing, and algorithmic optimization can enhance the scalability and performance of deadlock detection mechanisms, enabling their deployment in high-throughput, mission-critical systems.

10. User-Friendly Configuration and Management Interfaces:

- Designing user-friendly configuration and management interfaces can streamline the deployment, configuration, and maintenance of deadlock detection solutions. Intuitive graphical user interfaces (GUIs), command-line interfaces (CLIs), and configuration wizards can empower system administrators to customize deadlock detection parameters, monitor system health, and troubleshoot deadlock incidents with ease.

## Conclusion

The project explored deadlock detection mechanisms in both Windows and Linux operating systems. Through the implementation of scripts and algorithms, the study provided insights into how deadlock situations are handled in these environments.

In the context of Windows, the project delved into the utilization of `tasklist` command for retrieving information about running processes, which was then processed to identify potential deadlock scenarios. This approach leveraged the built-in tools provided by the Windows operating system for monitoring and managing processes.

On the Linux side, the project involved the development of custom Python scripts for process management and deadlock detection. This included interaction with the CSV database to store and analyze process information, as well as implementing the Banker's Algorithm for deadlock avoidance.

The comparative analysis between Windows and Linux deadlock detection mechanisms highlighted their respective strengths and weaknesses. Windows demonstrated a more integrated approach with readily available tools for process management, whereas Linux required custom scripting and algorithm implementation.

Despite the differences, both systems were capable of effectively detecting deadlocks and taking appropriate actions. Windows relied on its built-in utilities, while Linux showcased the flexibility of open-source environments by allowing custom solutions tailored to specific needs.

Through experimentation and evaluation, the project contributed to a deeper understanding of deadlock detection strategies in real-world operating systems. It provided valuable insights for system administrators and developers in choosing appropriate tools and techniques for managing concurrent processes and avoiding deadlock situations.

## References

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