Laboratory 7

Title of the Laboratory Exercise: Programs for deadlock avoidance algorithm

1. Introduction and Purpose of Experiment

   Deadlocks can be avoided if certain information is available in advance. By solving these problems students will become familiar to avoid deadlock in advance with the available resource information

2. Aim and Objectives

   Aim

   - To develop Bankers algorithm for multiple resources for deadlock avoidance

   Objectives

   At the end of this lab, the student will be able to

   - Verify a problem to check that whether deadlock will happen or not for the given resources
   - Implement the banker's algorithm for multiple resources

3. Experimental Procedure

   i. Analyse the problem statement

   ii. Design an algorithm for the given problem statement and develop a flowchart/pseudo-code

   iii. Implement the algorithm in C language

   iv. Compile the C program

   v. Test the implemented program

   vi. Document the Results

   vii. Analyse and discuss the outcomes of your experiment

4. Questions

   Implement a Bankers algorithm for deadlock avoidance

5. Calculations/Computations/Algorithms

STEP 1: Start

STEP 2: initialize requestMatrix, finished (array), availCopy(array) and count ← 0

STEP 3: for every row in request matrix, do

3.1: for every col in row, do

3.1.1: requestMatrix[row][col] = maxRequired[row][col] – currentAlloc[row][col]

STEP 4: availCopy = copy of availableVector

STEP 5: while count is less than number of processes, do

5.1: isSafe ← false

5.2: for every process p, do

5.2.1: if p is not finished, do

5.2.1.1: if p can be completed with current available resources, free resources, add p to sequence, mark as finished, isSafe ← true

5.3: if isSafe is false, return false

STEP 6: return true

STEP 7: Stop

6. Presentation of Results

```c
#include <stdio.h>
#include <stdbool.h>

#define NUM_PROCESSES 5
#define NUM_RESOURCE_CLASSES 3

bool isStateSafe(int[], int[], int[][NUM_RESOURCE_CLASSES], int[][NUM_RESOURCE_CLASSES], in
t[]);

int main(int argc, char *argv[])
{
    // defining variable to store the process ids
    int processes[] = {0, 1, 2, 3, 4};

    // Available instances of resources
    int avail[] = {3, 3, 2};
```

```
    // Maximum R that can be allocated
    // to processes
    int maxm[][NUM_RESOURCE_CLASSES] = {{7, 5, 3},
                                        {3, 2, 2},
                                        {9, 0, 2},
                                        {2, 2, 2},
                                        {4, 3, 3}};

    // Resources allocated to processes
    int allot[][NUM_RESOURCE_CLASSES] = {{0, 1, 0},
                                         {2, 0, 0},
                                         {3, 0, 2},
                                         {2, 1, 1},
                                         {0, 0, 2}};

    // declaring variable to store processes sequence
    int seq[NUM_PROCESSES];

    bool res = isStateSafe(processes, avail, maxm, allot, seq);

    if (res)
    {
        printf("This state is safe. The sequence that leads to completetion of all processe
s is:\n");
        for (int i = 0; i < NUM_PROCESSES; i++)
            printf("%d ", seq[i]);
        printf("\n");
    }
}

/**
 * Checks if the given state is a safe state or not.
 * @param processes the process ids.
 * @param availableVector the vector containing the amount of resources available per class
.
 * @param maxRequired contains the maximum number of resources required to complete
 * (for each process).
 * @param currentAlloc contains the number of resources held by each process.
 * @param seq to store the sequence of processes that need to be executed that lead to
 * completion.
 * @return true, if state is safe, false otherwise.
 */
bool isStateSafe(int processes[], int availableVector[], int maxRequired[][NUM_RESOURCE_CLA
SSES],
                 int currentAlloc[][NUM_RESOURCE_CLASSES], int seq[])
{

    // declaring request matrix
    int requestMatrix[NUM_PROCESSES][NUM_RESOURCE_CLASSES];
    // initializing all processes as not finished
    bool finished[NUM_PROCESSES] = {0};
    // variable to store copy of availableVector
    int availCopy[NUM_RESOURCE_CLASSES];
    // variable to keep track of loop
    int count = 0;

    // finding the request matrix
    for (int i = 0; i < NUM_PROCESSES; i++)
        for (int j = 0; j < NUM_RESOURCE_CLASSES; j++)
            requestMatrix[i][j] = maxRequired[i][j] - currentAlloc[i][j];

    // creating copy
    for (int i = 0; i < NUM_RESOURCE_CLASSES; i++)
        availCopy[i] = availableVector[i];

    // while all processes are not finished
    while (count < NUM_PROCESSES)
    {
        bool isSafe = false;
```

```
        // for every process, do
        for (int i = 0; i < NUM_PROCESSES; i++)
        {
            // if process is not finished, do
            if (finished[i] == 0)
            {
                int j;
                // checking if process i can be completed with the
                // available resources
                for (j = 0; j < NUM_RESOURCE_CLASSES; j++)
                    if (requestMatrix[i][j] > availCopy[j])
                        // process cannot be completed, break out of loop
                        break;

                // if it was able to be completed, do
                if (j == NUM_RESOURCE_CLASSES)
                {
                    // freeing resources
                    for (int k = 0; k < NUM_RESOURCE_CLASSES; k++)
                        availCopy[k] += currentAlloc[i][k];

                    // adding process to sequence
                    seq[count++] = processes[i];

                    // marking process as finished
                    finished[i] = 1;

                    // a safe state is found
                    isSafe = true;
                }
            }
        }

        // if no safe state was found, return false
        if (isSafe == false)
            return false;
    }

    return true;
}
```

Figure 1 : Source Code

```
/mnt/d/RUAS-sem-05/OS/lab7 main*
❯ gcc lab7.c

/mnt/d/RUAS-sem-05/OS/lab7 main*
❯ ./a.out
This state is safe. The sequence that leads to completetion of all processes is:
1 3 4 0 2

/mnt/d/RUAS-sem-05/OS/lab7 main*
❯
```

Figure 2: Execution

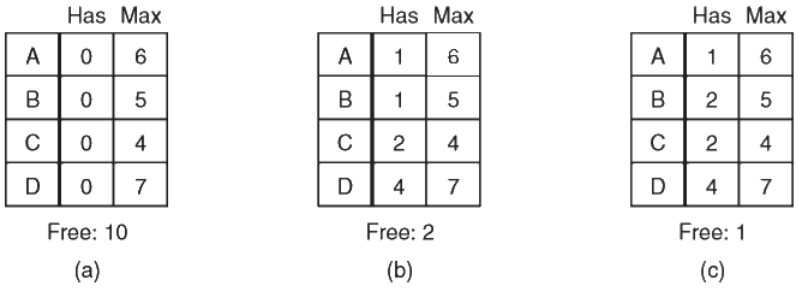
7. Analysis and Discussions

The banker's algorithm is a scheduling algorithm that can avoid deadlocks.

- It considers each request as it occurs.
- If granting the request leads to a safe state (ie., a state where even if one process asks for all the available resources, it can complete its execution), it grants it.
- If granting the request leads to unsafe state, it does not grant it.

Assume that there are four processes, *A, B, C* and *D*, and a single resource of 32 instances in total.

- Process *A* required 6 instances to complete.
- Process *B* required 5 instances to complete.
- Process *C* required 4 instances to complete.
- Process *D* required 7 instances to complete.



	Has	Max
A	0	6
B	0	5
C	0	4
D	0	7

Free: 10

(a)

	Has	Max
A	1	6
B	1	5
C	2	4
D	4	7

Free: 2

(b)

	Has	Max
A	1	6
B	2	5
C	2	4
D	4	7

Free: 1

(c)

Figure. Three resource allocation states: (a) Safe. (b) Safe. (c) Unsafe.

The following allocation:

- 1 to *A*,
- 1 to *B*,
- 2 to *C*, and
- 4 to *D*

is safe, since using the remaining 2 instances, process *C* can finish execution. However, the allocation,

- 1 to *A*,
- 2 to *B*,
- 2 to *C*, and
- 4 to *D*

is unsafe, as using the 1 remaining instance, no process can be completed.

The banker's algorithm for a single resource can be generalized to handle multiple resources. The generalized version closely resembles the deadlock detection with multiple resources of each type algorithm.

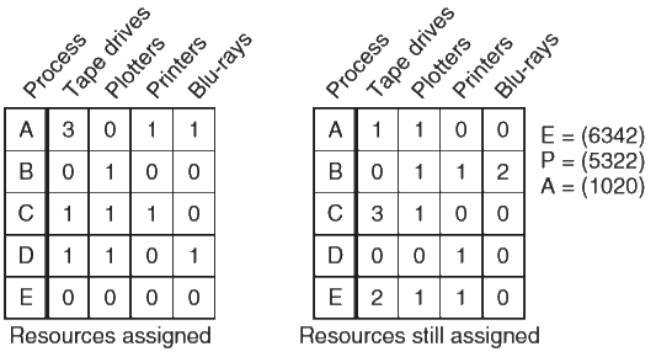


Figure. The banker's algorithm with multiple resources.

The matrix on the left is the current allocation matrix, and the matrix on the right is the request matrix. *E* is the existing resource vector, *P* is the processed resources (resources that are assigned), and *A* is the available resource vector.

Like the Banker's algorithm for a single resource, a request for a resource will be granted only if granting it leads to a safe state.

8. Conclusions

Banker's algorithm is an algorithm that is used to avoid deadlocks. This algorithm was introduced by Dijkstra. This algorithm can be used only if the number of resources that a process needs is known beforehand. This is usually not the case, as a process does not always know when it will need a resource.

9. Comments

    1. Limitations of Experiments

    The algorithm can only be used if the number of resources that are required by a process is known beforehand, that is, the maximum allocation matrix is known before the process starts execution.

    2. Limitations of Results

    The program has a time complexity of roughly $O(pr)$ where p is the number of processes, and r is the number of resources classes. Performing this algorithm every time a resource is requested can be expensive.

    3. Learning happened

    The Banker's algorithm for multiple resources was learned.