The National Institute of Engineering, Mysuru
Department of Computer Science and Engineering

Operating System tutorials (CS5C02) – 2021-22

To the Course Instructor

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Operating System Report

Title: Page replacement and Scheduling Algorithms

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FIFO (First In First Out page replacement algorithm)

Introduction

- In operating systems that use paging for memory management, page replacement algorithm are needed to decide which page needed to be replaced when new page comes in. Whenever a new page is referred and not present in memory, page fault occurs and Operating System replaces one of the existing pages with newly needed page. Different page replacement algorithms suggest different ways to decide which page to replace. The target for all algorithms is to reduce number of page faults.
- First In First Out (**FIFO**) page replacement algorithm is the simplest page replacement algorithm. In this algorithm, operating system keeps track of all pages in the memory in a queue, oldest page is in the front of the queue. When a page needs to be replaced page in the front of the queue is selected for removal.

How it works !

- Operating system keeps track of all the pages in a queue
- If a page is already present in set, it’s a hit and there will be no change in the queue. If the page in the string is not present, it’s a page fault.
- If set holds less pages than capacity, insert page into the set one by one until all page requests are processed. Simultaneously maintain the pages in the queue to perform FIFO and increment page faults. If current page is already present, it does nothing.
- If the queue is full, remove the first page from the queue, replace that first page with current page in the string and store it back in the queue.
- Then page faults are incremented.

Implementation

```
1- Start traversing the pages.
 i) If set holds less pages than capacity.
   a) Insert page into the set one by one until
      the size  of set reaches capacity or all
      page requests are processed.
   b) Simultaneously maintain the pages in the
      queue to perform FIFO.
   c) Increment page fault
 ii) Else
   If current page is present in set, do nothing.
```

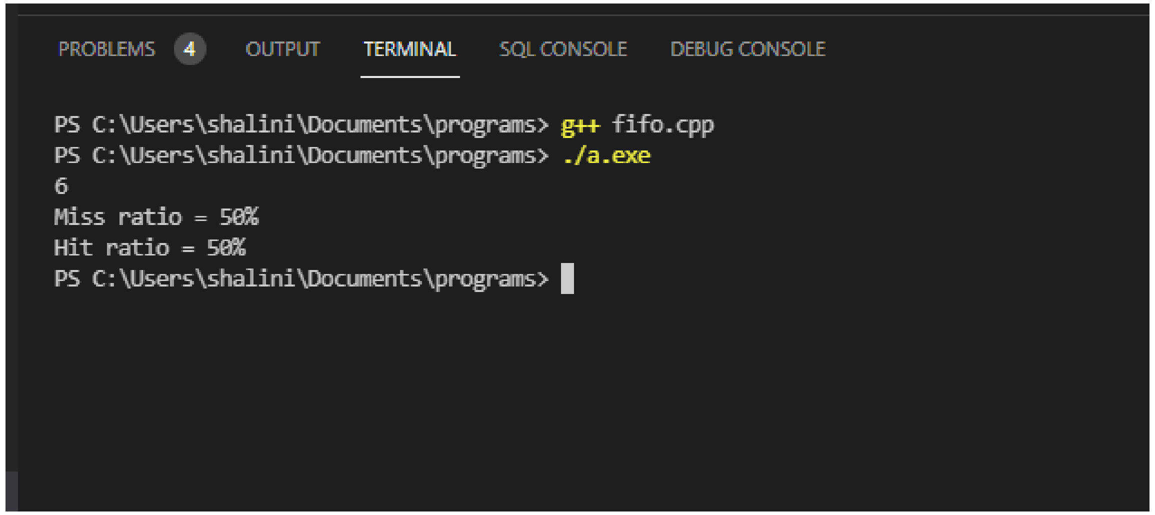
```
Else
    a) Remove the first page from the queue
       as it was the first to be entered in
       the memory
    b) Replace the first page in the queue with
       the current page in the string.
    c) Store current page in the queue.
    d) Increment page faults.

2. Return page faults.
```

Program

```
#include<bits/stdc++.h>
using namespace std;

// Function to find page faults using FIFO
int pageFaults(int pages[], int n, int capacity)
{
    /* To represent set of current pages. We use an unordered_set so
      that we quickly check if a page is present in set or not */
    unordered_set<int> s;

    // To store the pages in FIFO manner
    queue<int> indexes;

    // Start from initial page
    int page_faults = 0;
```

```
for (int i=0; i<n; i++)
    {
        // Check if the set can hold more pages
        if (s.size() < capacity)
        {
            /* Insert it into set if not present already which
               represents page fault */
            if (s.find(pages[i])==s.end())
            {
                // Insert the current page into the set
                s.insert(pages[i]);

                // increment page fault
                page_faults++;

                // Push the current page into the queue
                indexes.push(pages[i]);
            }
        }
        /* If the set is full then need to perform FIFO i.e. remove the first page of the queue from set
          and queue both and insert the current page */
        else
        {
            // Check if current page is not already present in the set
            if (s.find(pages[i]) == s.end())
            {
                // Store the first page in the queue to be used to find and erase the page from the set
                int val = indexes.front();

                // Pop the first page from the queue
                indexes.pop();

                // Remove the indexes page from the set
                s.erase(val);

                // insert the current page in the set
                s.insert(pages[i]);

                // push the current page into the queue
                indexes.push(pages[i]);

                // Increment page faults
                page_faults++;
            }
        }
    }
    return page_faults;
}
```

```cpp
int main()
{
    int pages[] = {7, 0, 1, 2, 0, 3, 0, 4,
                   2, 3, 0, 3, 2};
    int n = sizeof(pages)/sizeof(pages[0]);
    int capacity = 4;
    float miss_per, hit_per;
    cout << pageFaults(pages, n, capacity);
    miss_per = ((pageFaults(pages, n, capacity)*1.0)/n)*100;
    hit_per = 100 - miss_per;
    cout<<"\nMiss ratio = "<<miss_per<<"%";
    cout<<"\nHit ratio = "<<hit_per<<"%";
    return 0;
}
```



```
PS C:\Users\shalini\Documents\programs> g++ fifo.cpp
PS C:\Users\shalini\Documents\programs> ./a.exe
6
Miss ratio = 50%
Hit ratio = 50%
PS C:\Users\shalini\Documents\programs>
```

- **Advantages:**
- It is easy to understand and implement.
- The number of operations is limited in a queue makes the implementation simple.
- **Disadvantages:**
- It does not consider the priority or burst time of the processes.
- When the number of incoming pages is large, it might not provide excellent performance.
- When we increase the number of frames or capacity to store pages in the queue, it should give us less number of page faults.
- Sometimes FIFO may behave abnormally, and it may increase the number of page faults. This behavior of FIFO is called Belady’s anomaly.
- In FIFO, the system should keep track of all the frames. Sometimes it results in slow process execution.

RR (Round Robin CPU scheduling algorithm)

Introduction:

- A Process Scheduler schedules different processes to be assigned to the CPU based on particular scheduling algorithms. These algorithms are either non-preemptive or preemptive. Non-preemptive algorithms are designed so that once a process enters the running state, it cannot be preempted until it completes its allotted time, whereas the preemptive scheduling is based on priority where a scheduler may preempt a low priority running process anytime when a high priority process enters into a ready state.
- A round-robin **scheduling algorithm** is used to schedule the process fairly for each job a time slot or quantum and the interrupting the job if it is not completed by then the job come after the other job which is arrived in the quantum time that makes these scheduling fairly. Round-robin is cyclic in nature, so starvation doesn’t occur. Round-robin is a variant of first come, first served scheduling. No priority, special importance is given to any process or task. RR scheduling is also known as Time slicing scheduling

How it works !

1. Take the process which occurs first and start executing the process(for quantum time only).
2. Check if any other process request has arrived. If a process request arrives during the quantum time in which another process is executing, then add the new process to the Ready queue
3. After the quantum time has passed, check for any processes in the Ready queue. If the ready queue is empty then continue the current process. If the queue not empty and the current process is not complete, then add the current process to the end of the ready queue.
4. Take the first process from the Ready queue and start executing it (same rules)
5. Repeat all steps above from 2-5
6. If the process is complete and the ready queue is empty then the task is complete

Implementation

1. Declare arrival[], burst[], wait[], turn[] arrays and initialize them. Also declare a timer variable and initialize it to zero. To sustain the original burst array create another array (temp_burst[]) and copy all the values of burst array in it.
2. To keep a check we create another array of bool type which keeps the record of whether a process is completed or not. we also need to maintain a queue array which contains the process indicies (initially the array is filled with 0).
3. Now we increment the timer variable until the first process arrives and when it does, we add the process index to the queue array
4. Now we execute the first process until the time quanta and during that time quanta, we check whether any other process has arrived or not and if it has then we add the index in the queue (by calling the fxn. queueUpdation()).
5. Now, after doing the above steps if a process has finished, we store its exit time and execute the next process in the queue array. Else, we move the currently executed process at the end of the queue (by calling another fxn. queueMaintainence()) when the time slice expires.
6. The above steps are then repeated until all the processes have been completely executed. If a scenario arises where there are some processes left but they have not arrived yet, then we shall wait and the CPU will remain idle during this interval.

Program

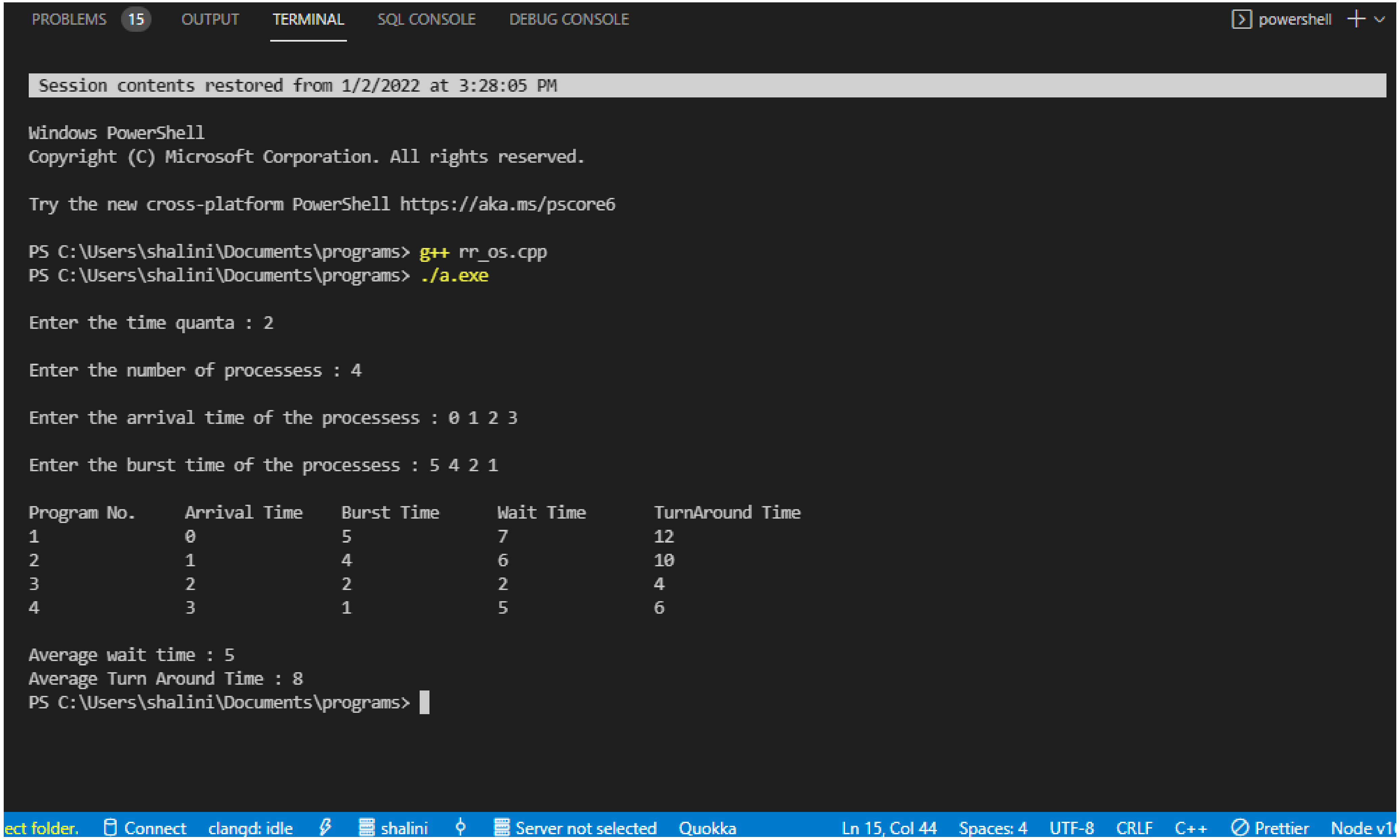
```
#include <iostream>
using namespace std;
void queueUpdation(int queue[],int timer,int arrival[],int n, int maxProccessIndex){
    int zeroIndex;
    for(int i = 0; i < n; i++){
        if(queue[i] == 0){
            zeroIndex = i;
            break;
        }
    }
    queue[zeroIndex] = maxProccessIndex + 1;
}


void queueMaintainence(int queue[], int n){
    for(int i = 0; (i < n-1) && (queue[i+1] != 0) ; i++){
        int temp = queue[i];
        queue[i] = queue[i+1];
        queue[i+1] = temp;
    }
}
```

```
void checkNewArrival(int timer, int arrival[], int n, int maxProccessIndex,int queue[]){
    if(timer <= arrival[n-1]){
       bool newArrival = false;
       for(int j = (maxProccessIndex+1); j < n; j++){
             if(arrival[j] <= timer){
              if(maxProccessIndex < j){
                 maxProccessIndex = j;
                 newArrival = true;
              }
           }
       }
       //adds the incoming process to the ready queue (if any arrives)
       if(newArrival)
          queueUpdation(queue,timer,arrival,n, maxProccessIndex);
    }
}

//Driver Code
int main(){
    int n,tq, timer = 0, maxProccessIndex = 0;
    float avgWait = 0, avgTT = 0;
    cout << "\nEnter the time quanta : ";
    cin>>tq;
    cout << "\nEnter the number of processess : ";
    cin>>n;
    int arrival[n], burst[n], wait[n], turn[n], queue[n], temp_burst[n];
    bool complete[n];
```

```
cout << "\nEnter the arrival time of the processess : ";
    for(int i = 0; i < n; i++)
        cin>>arrival[i];

    cout << "\nEnter the burst time of the processess : ";
    for(int i = 0; i < n; i++){
        cin>>burst[i];
        temp_burst[i] = burst[i];
    }


for(int i = 0; i < n; i++){    //Initializing the queue and complete array
        complete[i] = false;
        queue[i] = 0;
    }
    while(timer < arrival[0])    //Incrementing Timer until the first process arrives
        timer++;
    queue[0] = 1;

    while(true){
        bool flag = true;
        for(int i = 0; i < n; i++){
            if(temp_burst[i] != 0){
                flag = false;
                break;
            }
        }
        if(flag)
            break;
```

```
for(int i = 0; (i < n) && (queue[i] != 0); i++){
    int ctr = 0;
    while((ctr < tq) && (temp_burst[queue[0]-1] > 0)){
        temp_burst[queue[0]-1] -= 1;
        timer += 1;
        ctr++;


        //Checking and Updating the ready queue until all the processes arrive
        checkNewArrival(timer, arrival, n, maxProccessIndex, queue);
    }
    //If a process is completed then store its exit time and mark it as completed
    if((temp_burst[queue[0]-1] == 0) && (complete[queue[0]-1] == false)){
        //turn array currently stores the completion time
        turn[queue[0]-1] = timer;
        complete[queue[0]-1] = true;
    }

      //checks whether or not CPU is idle
bool idle = true;
            if(queue[n-1] == 0){
                for(int i = 0; i < n && queue[i] != 0; i++){
                    if(complete[queue[i]-1] == false){
                        idle = false;
                    }
                }
            }
            else
                idle = false;


            if(idle){
                timer++;
                checkNewArrival(timer, arrival, n, maxProccessIndex, queue);
            }

            //Maintaining the entries of processes after each premption in the ready Queue
            queueMaintainence(queue,n);
        }
    }
```

```
 for(int i = 0; i < n; i++){
        turn[i] = turn[i] - arrival[i];
        wait[i] = turn[i] - burst[i];
    }


    cout << "\nProgram No.\tArrival Time\tBurst Time\tWait Time\tTurnAround Time"
         << endl;
    for(int i = 0; i < n; i++){
        cout<<i+1<<"\t\t"<<arrival[i]<<"\t\t"
          <<burst[i]<<"\t\t"<<wait[i]<<"\t\t"<<turn[i]<<endl;
    }
    for(int i =0; i< n; i++){
        avgWait += wait[i];
        avgTT += turn[i];
    }
    cout<<"\nAverage wait time : "<<(avgWait/n)
      <<"\nAverage Turn Around Time : "<<(avgTT/n);


    return 0;

}
```



```
Session contents restored from 1/2/2022 at 3:28:05 PM

Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\shalini\Documents\programs> g++ rr_os.cpp
PS C:\Users\shalini\Documents\programs> ./a.exe

Enter the time quanta : 2

Enter the number of processess : 4

Enter the arrival time of the processess : 0 1 2 3

Enter the burst time of the processess : 5 4 2 1

Program No.     Arrival Time    Burst Time      Wait Time       TurnAround Time
1               0               5               7               12
2               1               4               6               10
3               2               2               2               4
4               3               1               5               6

Average wait time : 5
Average Turn Around Time : 8
PS C:\Users\shalini\Documents\programs>
```

Advantages:

- Every process gets an equal share of the CPU.
- RR is cyclic in nature, so there is no starvation.

Disadvantages:

- Setting the quantum too short, increases the overhead and lowers the CPU efficiency, but setting it too long may cause poor response to short processes.
- Average waiting time under the RR policy is often long.