CSE2005 – OPERATING SYSTEMS

A Modified Scheduling Algorithm for Real Time Systems

16BEC0098 – Pranoy Dev

School of Computer Science and Engineering, VIT University

ABSTRACT

Currently prevalent round robin CPU scheduling algorithms are not applicable in real time operating systems because of their large waiting time, large turnaround time, large response time, high context switch rates and less throughput. The primary aim of this paper is to come up with a method for round robin CPU scheduling which enhances the CPU performance in a real time operating system. The proposed algorithm for real time systems is a hybrid of priority and round-robin scheduling algorithms. It combines the merits of round robin, like elimination of starvation, and priority scheduling. The proposed algorithm also deals with aging by assigning variable priorities to the processes. Thus the algorithm corrects all the limitations of RR CPU scheduling algorithm. We will also present a comparative analysis of our new algorithm with the existing algorithms like priority and round robin on the basis of average turnaround time, average waiting time, varying time quantum and number of context switches.

I. Introduction:

In computer science, scheduling is the process by which processes are given access to system resources like processor cycles, communications bandwidth. Hence, there arises the need for a scheduling algorithm [5] for the computer systems to perform multitasking and multiplexing.

Scheduling is a fundamental operating system function that determines which process run, when there are multiple run able processes. CPU scheduling is important because it impacts resource utilization and other performance parameters. There exists a number of CPU scheduling algorithms [1, 2] like First Come First Serve, Shortest Job First Scheduling, Round Robin scheduling, Priority Scheduling etc, but due to a number of disadvantages these are rarely used in real time operating systems except Round Robin scheduling.

A number of assumptions are considered in CPU scheduling which are as follows [19, 20]:

1. Job pool consists of run able processes waiting for the CPU.

2. All processes are independent and compete for resources.

3. The job of the scheduler is to distribute the limited resources of CPU to the different processes fairly and in a way that optimizes some performance criteria.

The scheduler [6] is the component of the kernel that selects which process to run next. Operating systems may feature up to three distinct types of schedulers, a long term scheduler, a mid-term or medium term scheduler and a short-term scheduler. The long term scheduler or job scheduler selects processes from the job pool and loads them into memory for execution. The short term scheduler, or CPU scheduler selects from among the processes that are ready to execute, and allocates CPU to one of them. The medium term scheduler removes processes from memory and reduces the degree of multiprogramming results in the scheme of swapping. Swapping is the scheme which is performed by dispatcher which is the module that gives control of the CPU to the process selected by the short-term scheduler [7].

The CPU scheduling also plays an important role in the real time operating system which always has a time constraint on computations. A real time system is the one whose applications are mission-critical, where real-time tasks should be scheduled to be completed before their deadlines [8, 9]. Most real-time systems control unpredictable environments and may need operating systems that can handle unknown and changing tasks. So, not only a dynamic task scheduling is required, but both system hardware and software must adapt to unforeseen configurations [10].

There are two main types of real-time systems [16]: Hard Real-Time System, Firm or Soft Real-Time System. In Hard Real-Time System, it requires that fixed deadlines must be met otherwise disastrous situation may arise whereas in Soft Real-Time System, missing an occasional deadline is undesirable, but nevertheless tolerable. System in which performance is degraded but not destroyed by failure to meet response time constraints is called soft real time systems.

In real time systems each task should be invoked after the ready time and must be completed before its deadline [12, 13, 14], an attempt has been made to satisfy these constraints. Simple round robin architecture [11] is not suitable to implement in Soft real time due to more number of context switches, longer waiting and response times. This in turn leads to low throughput in the system. If a real-time process having relatively larger CPU burst it will leads to the problem of starvation .Priority scheduling may be a better option for real-time scheduling but it will face the similar problem i.e. low priority processes will always starve.

II. SCHEDULING OBJECTIVES

A system architect must consider various elements in constructing a scheduling algorithm, for example, kind of frameworks utilized and client necessities. Relying upon the system, the client and designer may anticipate that the schedulers will [3]:

- Maximize throughput: A scheduling algorithm ought to be equipped for adjusting the greatest number of jobs per unit of time.
- Avoid inconclusive blocking or starvation: A job ought not sit tight for unbounded time before or while process service.
- Minimize overhead: Overhead causes wastage of assets. Be that as it may, when we utilize system resources viably, then general system execution enhances extraordinarily.
- Enforcement of priorities: if system allocates priorities to forms, the booking system ought to support the higher-need forms.
- Attain balance between response, utilization: the scheduling algorithm must keep resources occupied
- Support jobs which show desirable behavior.
- Corrupt gracefully under huge load.

A system might finish these objectives in many ways. The scheduler can stall indefinite blocking of jobs via aging. Scheduler increments throughput by favoring processes whose requests can be satisfied quickly, or whose completion cause other processes to run.

III. SCHEDULING CRITERIA

CPU scheduling algorithms maybe such which have different properties, and the choice of one particular algorithm might favor one category of processes over other. Choosing an algorithm for a particular situation, we must cater to properties of various algorithms. The scheduling criteria include the following:

- Context Switch: A context switch is process of storing and restoring context (state) of a preempted process, so that execution may be resumed from same point at a later stage. Context switching involves a lot of computation, lead to wastage of time and memory, which in turn increases the overhead of scheduler, hence operating system’s design, is to optimize only these switches.
- Throughput: it is the number of processes completed per unit time. It is slow in round robin scheduling implementation. Context switching and throughput are inversely proportional.
- CPU Utilization: Tells the business of the CPU. One needs to maximize CPU utilization.

- Turnaround Time: Total time spent to complete the job. The time interval from the time of submission of a job to its completion is the turnaround time. Total turnaround time is the sum of the times spent waiting to get into memory, waiting time in the ready queue, execution time on the CPU and doing I/O.
- Waiting Time: Time a job has been stalled in ready queue. The CPU scheduling algorithm does not affect the amount of time during which a process executes or does input-output; it affects only the amount of time that a process spends waiting in ready queue.
- Response Time: in real time systems, turnaround time may not be best measure. Often, a job can provide with some output fairly early and continue computing new results while previous results are being produced to the user. Thus, it is the time from the submission of a request until the first response is produced that means time when the task is submitted until the first response is received. Thus, the response time should be less.

Hence a good scheduling algorithm for real time and time sharing system must have: -

- less context switches.
- high CPU utilization.
- high throughput.
- Less turnaround time.
- Less waiting time.

ROUND ROBIN SCHEDULING ALGORITHM

The round robin algorithm was designed mainly for time-shared systems not for real time systems. Time slice or time quantum is defined in case of RR algorithm, which refers to duration for which the process is allocated to the CPU and executed.[1]

The processes which have to be executed are kept in a circular queue which has a head and a tail. The CPU scheduler will go around the queue, allocating the CPU to each process for a

time interval of one quantum but the problem is that all the processes are arranged in FCFS (First Come First Serve) manner.

Arriving processes are then added to the tail of the queue. [1]

The CPU scheduler will then select the Process Control Block from the head of the ready queue. This is a disadvantage in RR algorithm since all processes are basically given the same priority. Round robin also favours the process with short CPU burst and penalizes long ones.

Disadvantages:

The disadvantages of round robin CPU scheduling algorithm which affects execution process time shared system are as follows-

1. Larger waiting, response time and high rates of context switching.
   Since Real-time programs must guarantee response within specified time constraints therefore larger waiting, response time and high rates of context switching affect the system's performance and delay the results. [3], [4]
2. Low throughput
   Throughput is defined as number of process completed per time unit. If round robin is implemented in soft real time systems throughput will be low which leads to severe degradation of system performance because of high context switching. If the number of context switches is low then the throughput will be high. Context switch and throughput are inversely proportional to each other. [3]
   With these observations it is found that the existing simple round robin architecture is not suitable for real time

PRIORITY SCHEDULING ALGORITHM

The operating system assigns a fixed priority number to every process, and the scheduler then arranges the processes in the ready queue in order of their priority. These processes are then allocated to the CPU one by one. Lower priority processes get interrupted by incoming higher priority processes. [4]

Waiting time and response time in this algorithm depend on the priority of the processes. Higher priority processes have smaller waiting and response times. Deadlines can be easily met by giving higher priority to the earlier deadline processes.

Disadvantage:

Starvation of lower priority processes is possible if large number of higher priority processes keep arriving continuously.

Therefore a combination of the above two algorithms will be needed to make an algorithm fit for real time systems.[1]

Our Contribution:

We have tried to come up with a modified round robin scheduling algorithm which works on a dynamic time quantum, which changes after every round of execution. This will help in reducing the average waiting time, average turnaround time and reduce the number of context switch.

Our Proposed algorithm:

We calculate a intelligent time slice (ITS) is calculated based on the priority, shortest CPU burst time and context switch. We have a pre defined time slice which is the Original time slice (OTS), if the process needs special consideration, the priority component (PC) is assigned to 0 or 1 according to the pre defined priority by the user. We define a Shortness component (SC) which is the difference between the burst time of the current process and its previous process. If the difference is negative, we make SC as 1 else 0. To calculate CSC i.e Context switch component we add PC,SC and OTP and the resulting sum is subtracted from the burst time of the process. If the result obtained is less than the OTS, we consider it as CSC. Adding all the calculated components we get our ITS.

Our time quantum varies from TQ_i to TQ_n, where i is the round number.

Algorithm

1. Sort the processes according to priority as well as shortness and assign a new priority to each process which is the sum of the original priority and shortness rank.

2. Calculate priority component. If there are n processes, for a process i in n

PCi=0 if its new priority is > 2n/3 (Not Important)

PCi=1 if its new priority is > n/3 (Moderately Important)

PCi=2 if its new priority is >= 1 (Important)

3. Calculate shortness component. If there are n processes, for a process i in n

SCi=0 if the (Burst Time)i>(Burst Time)i-1 (Longer)

SCi=1 if the (Burst Time)i<=(Burst Time)i-1 (Shorter)

4. Calculate the intelligent time slice (ITS) for each process as the sum of the initial time slice, burst time, priority component and shortness component.

5. Repeat Step 6 until all processes are completed.

6. If the Round number(j) is 1, calculate time quantum as

TQj,i=ITSi if SCi=1

TQj,i=ITSi/2 if SCi=0

If the Round number(j) is not 1, calculate time quantum as

TQj,i=TQj-1,i * 2 if SCi=1

TQj,i=TQj-1,i * 1.5 if SCi=0

7. Calculate average waiting time and average turnaround time.

Code:

```
#include<iostream>
#include<math.h>
#include<iomanip>
 using namespace
std;
```

```
int main() {     int n;     cout<<"\nEnter the number of processes:
";     cin>>n;     int
bt[n],p[n],s[n],wt[n],tat[n],ts,its[n],tq[n][n],rbt[n],ord[n];
for(int i=0; i<n; i++)
    {         wt[i]=tat[i]=0;
s[i]=1;         for(int j=0;
j<n; j++)
tq[i][j]=0;
    }     cout<<"\nEnter the initial time
slice: ";     cin>>ts;     for(int i=0; i<n;
i++)
    {         ord[i]=i+1;         cout<<"\nEnter burst time for
process "<<i+1<<": ";         cin>>bt[i];
cout<<"\nEnter the priority of the process "<<i+1<<": ";
cin>>p[i];
    }     int flag=0,j=0;
for(int i=0; i<n-1; i++)
for(int j=0; j<n-1; j++)
if(bt[j]>bt[j-1])
            {
                int t=bt[j];
bt[j]=bt[j+1];
bt[j+1]=t;
t=p[j];
p[j]=p[j+1];
p[j+1]=t;
t=ord[j];
```

```
ord[j]=ord[j+1];
ord[j+1]=t;             }
for(int i=0; i<n; i++)
p[i]+=i;     for(int i=0; i<n-
1; i++)         for(int j=0;
j<n-1; j++)
if(p[j]>p[j+1])             {
int t=bt[j];
bt[j]=bt[j+1];
bt[j+1]=t;
t=p[j];
p[j]=p[j+1];
p[j+1]=t;
t=ord[j];
ord[j]=ord[j+1];
ord[j+1]=t;             }
for(int i=0; i<n; i++)
rbt[i]=bt[i];     while(!flag)
{         for(int i=0; i<n;
i++)
        {             if(p[i]>0.67*n) p[i]=0;
else if(p[i]>0.33*n) p[i]=1;             else
p[i]=2;             if(i!=0)
if((bt[i]-bt[i-1])>0)                    s[i]=0;
its[i]=ts+bt[i]+s[i]+p[i];             if(j==0)
{                 if(s[i]==1)
tq[j][i]=its[i];                 else
```

```
tq[j][i]=ceil(0.5*(float)its[i]);
if(rbt[i]<tq[j][i])
tq[j][i]=rbt[i];                rbt[i]=rbt[i]-
tq[j][i];
            }             else
{                 if(rbt[i]<=0)
tq[j][i]=0;                 else
if(s[i]==1)
tq[j][i]=2*tq[j-1][i];
else
tq[j][i]=1.5*tq[j-1][i];
if(rbt[i]<tq[j][i])
tq[j][i]=rbt[i];
rbt[i]=rbt[i]-tq[j][i];
            }         }
j++;         flag=-1;
for(int i=0; i<n; i++)
if(rbt[i]>0)
flag=0;
    }     cout<<"\n\nProcess no.:\n";     for(int i=0; i<n;
i++)         cout<<setw(5)<<ord[i];     cout<<"\n\nBurst
Times for the processes:\n";     for(int i=0; i<n; i++)
cout<<setw(5)<<bt[i];     cout<<"\n\nIntelligent Time Slices
for the processes:\n";     for(int i=0; i<n; i++)
cout<<setw(5)<<its[i];     cout<<"\n\nDynamic Time Quantums
for the processes:\n";     for(int x=0; x<j; x++)
```

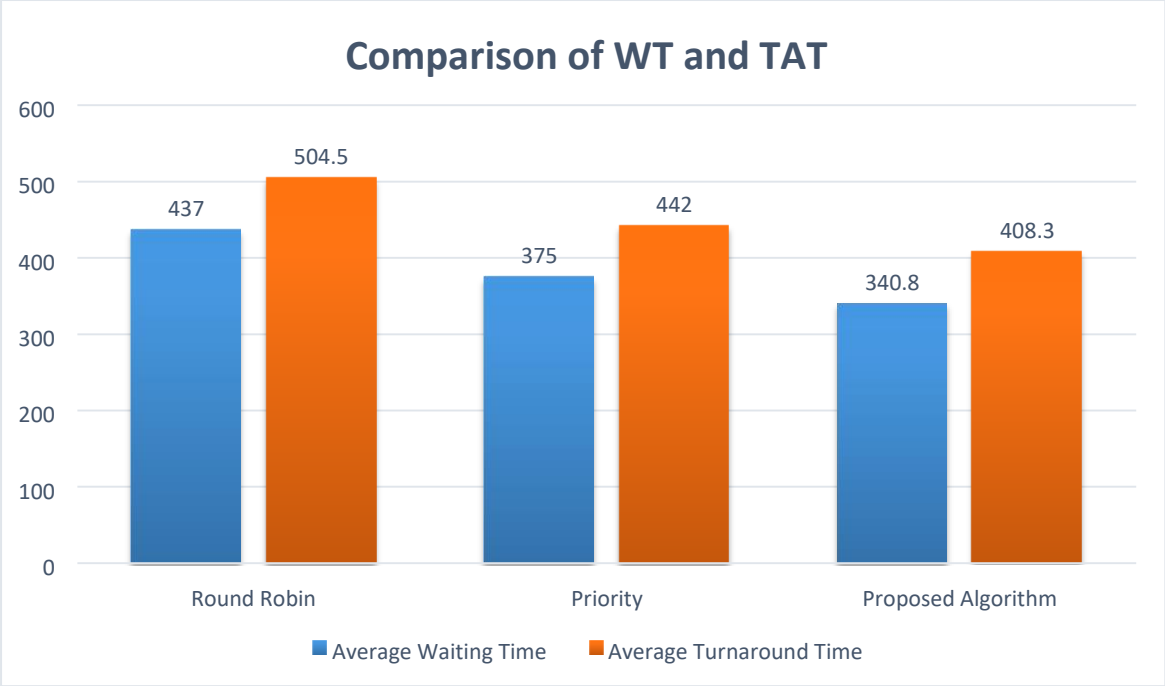
```
    {         cout<<"Round "<<x+1<<":
"<<endl;          for(int y=0; y<n; y++)
cout<<setw(5)<<tq[x][y];
cout<<endl;
    }     for(int x=0;
x<n; x++)
    {         flag=-1;
for(int y=0; y<j; y++)
        {             for(int
z=0; z<n; z++)
            {                 if(z!=x)
wt[x]+=tq[y][z];                  else
if(z==x&&tq[y+1][z]==0)
                {
flag=0;
break;
                }
}
tat[x]+=tq[y][x];
if(flag==0)
break;         }
tat[x]+=wt[x];
    }     cout<<"\nWaiting time for the
processes:\n";     for(int i=0; i<n; i++)
cout<<setw(5)<<wt[i];     cout<<"\n\nTurnaround time
for the processes:\n";     for(int i=0; i<n; i++)
cout<<setw(5)<<tat[i];
```

```
    float avwt=0,avtat=0;
for(int i=0; i<n; i++)
    {
avwt+=wt[i];
avtat+=tat[i];
    }     avwt/=n;     avtat/=n;
cout<<"\n\nAverage waiting time: "<<avwt<<endl;
cout<<"\nAverage turnaround time: "<<avtat<<endl;
}
```

Comparison:

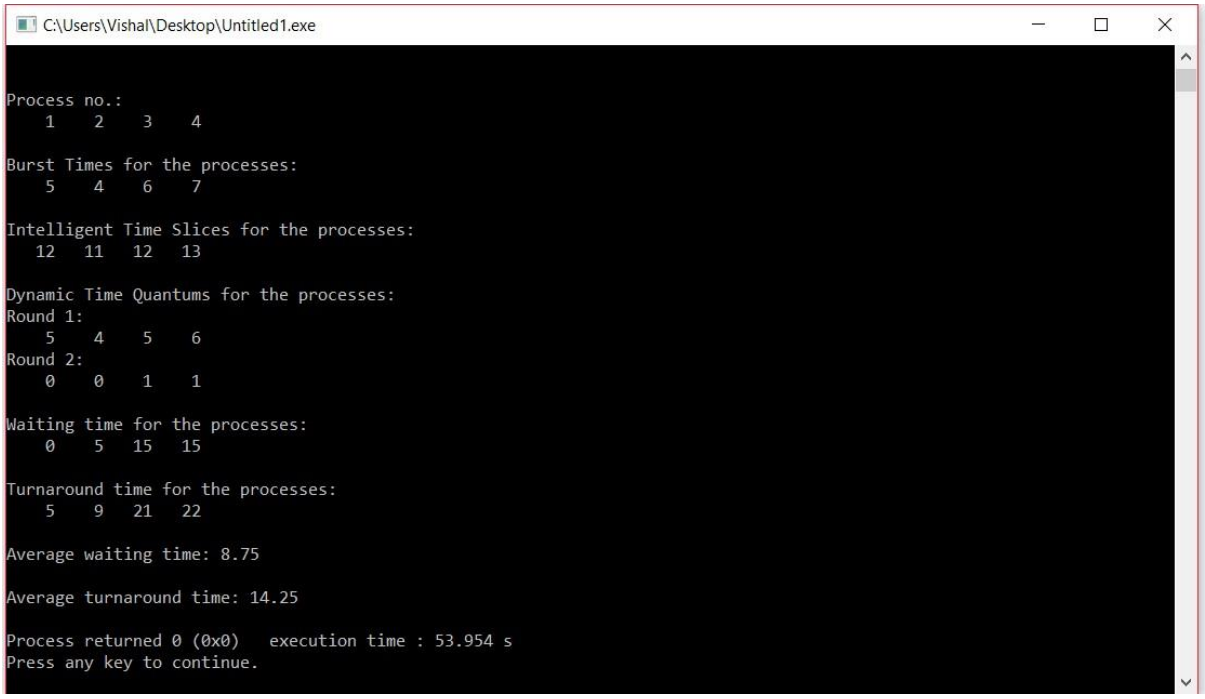
Algorithm	**Parameter**											
	Process Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**AVG**
	Burst Time	**80**	**60**	**65**	**120**	**30**	**90**	**25**	**40**	**90**	**75**	
Round Robin	**Waiting Time**	520	430	460	555	245	550	210	325	555	520	**437**
	Turnaround Time	600	490	525	675	275	640	235	365	645	595	**504.5**
Priority	**Waiting Time**	210	380	515	90	580	0	610	635	290	440	**375**
	Turnaround Time	80	60	65	120	30	90	25	40	90	75	**442**

Proposed Algorithm	**Waiting Time**	0	90	155	429	228	486	503	520	397	600	**340.8**
	Turnaround Time	90	155	180	519	258	546	583	640	437	675	**408.3**

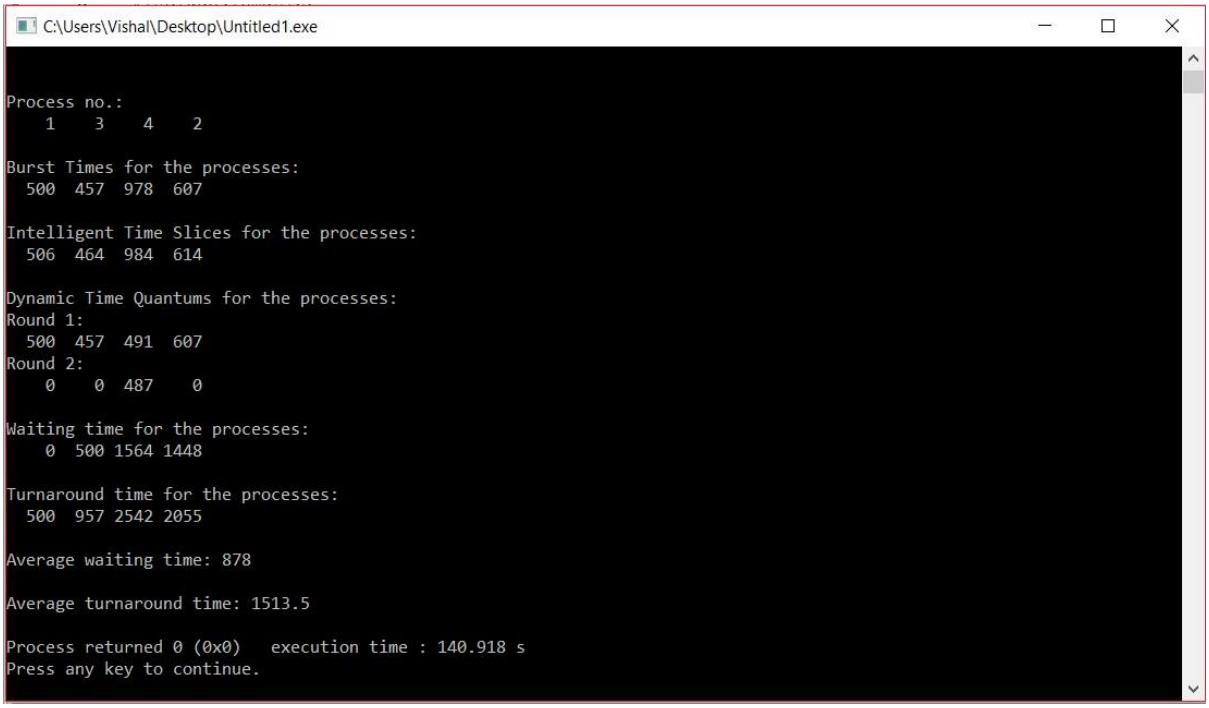


The proposed algorithm has less Avg. waiting time and Avg. turnaround time as compared to RR and Priority Algorithm.

Low burst time



High burst time



Conclusion:

From the above comparisons, we observed that our new proposed algorithm is performing better than the RR, Priority algorithm MRR proposed in paper in terms of average waiting time and average turnaround time thereby reducing the overhead, saving of memory spaces and solving the problem of starvation which was caused by Priority Algorithm.

Therefore, the proposed algorithm will meet the demands of a SOFT REAL TIME SYSTEM.

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