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A New Proposed Two Processor Based CPU Scheduling Algorithm with Varying Time quantum for Real Time Systems

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***Abstract*—** The performance and efficiency of multitasking operating systems mainly depends upon the use of CPU scheduling algorithm. In time shared system, Round Robin (RR) scheduling gives optimal solution but it may not be suitable for real time systems because it gives more number of context switches and larger waiting time and larger turnaround time. In this paper two processor based CPU scheduling (TPBCS) algorithm is proposed, where one processor is exclusively for CPU-intensive processes and the other processor is exclusively for I/O-intensive processes. This approach dispatches the processes to appropriate processor according to their percentage of CPU or I/O requirement. After the processes are dispatched to respective processors, the time quantum is calculated and the processes are executed in increasing order of their burst time. Experimental analysis shows that our proposed algorithm performs better result by reducing the average waiting time, average turnaround time.

Keywords— Scheduling, Round Robin scheduling, Context Switches, Waiting Time, Turnaround time.

INTRODUCTION

CPU scheduling is a very essential task of operating system in multitasking environment. When there is more than one process to be executed, a ready queue is maintained. Here in a two processor system, ready queue is maintained for each processor. The operating system follows a predefined procedure for selecting process from a number of processes waiting in the ready queue and assigns the CPU to the process. Careful attention is required to assure fairness and avoid starvation during allocation of CPU to the processes. Scheduling decision always try to minimize average waiting time, average turnaround time and number of context switches.

It is a good practice to schedule CPU-intensive processes separately from I/O–intensive processes, which means one CPU is exclusively dedicated for CPU-intensive processes and another CPU is exclusively dedicated for I/O-intensive processes. This is because I/O-intensive processes do not need to wait for their turn after several CPU-intensive processes execute. It can reduce response time significantly for interactive I/O processes.

In our proposed algorithm we have used percentage values to classify the processes into two groups of CPU-intensive and I/O-intensive processes.

A. Scheduling Algorithms:

Many CPU scheduling algorithms are used such as First Come First served scheduling (FCFS), shortest job First scheduling (SJF), Priority Scheduling etc. All the above algorithms are non-preemptive in nature and also not suitable for time sharing systems. In the First-Come-First-Served (FCFS), the process that arrives first in the ready queue is allocated the CPU first. In SJF, when the CPU is available, it is assigned to the process that has the smallest next CPU burst. If two processes have same next CPU burst time, FCFS scheduling is used to break the tie. In priority scheduling algorithm a priority is given to each process and the process having highest priority is executed first and so on. Round Robin scheduling is similar to FCFS scheduling, but preemption is added to switch between processes. A small unit of time, called a time quantum or time slice is defined and the CPU scheduler goes around the ready queue, allocating the CPU to each process for a time interval of up to 1 time quantum. The Round Robin (RR) Scheduling is one of the most popular scheduling algorithms found in computer systems today. In addition it is designed especially for time sharing systems and found in multiple processor systems.

B. Related Work:

In the recent past, a number of CPU scheduling mechanisms have been developed for predictable allocation of processor. Self-Adjustment Time Quantum in Round Robin Algorithm [2] is based on a new approach called dynamic time quantum in which, time quantum is repeatedly adjusted according to the burst time of the running processes. Dynamic Quantum with Readjusted Round Robin Scheduling Algorithm [1] uses the job mix order for the algorithm in [2]. According to [1], from a list of N processes, the process which needs minimum CPU time is assigned the time quantum first and then highest from the list and so on till the Nth process. Again in the 2nd round, the time quantum is calculated from the remaining CPU burst time of the processes and is assigned to the processes and so on. Both [2] and [1] are better than RR scheduling and overcomes the limitations of RR scheduling regarding the average waiting time, average turnaround time and context switch. Algorithm in [3] uses an approximation of K-means clustering algorithm to group processes of same kind together and dispatches them to appropriate processor. A new fair-share scheduling with weighted time slice [4] assigns a weight to each process and the process having the least burst time is assigned the largest weight. The time quantum is calculated dynamically, using weighted time slice method and then the processes are executed. [5] calculates the original time slice suited to the burst time of each processes and then dynamic ITS (Intelligent Time Slice) is found out in conjunction with the SRTN algorithm[7]. Algorithm in [6] is improved by using dynamic time quantum and multi cyclic time quantum

C. *Our Contribution:*

We have proposed a new scheduling algorithm for two processor systems, that first separates the CPU-intensive and I/O-intensive processes into two groups and dispatch them to two different processors. Then the processes are executed in each processor. Our execution approach gives better result than Round-Robin (RR) and Dynamic Quantum with Readjusted Round Robin Scheduling Algorithm (DQRRR) in [1]. Instead of taking job mix order we have taken the processes in ascending order in the two ready queues of two processors and the time quantum is calculated using our proposed method which changes with the every round of execution.

D. *Organization of the Paper:*

Section II shows the background work. Section III presents the pseudo code and illustration of our proposed algorithm. In section IV, experimental analysis is discussed. And finally the conclusion and future work is presented in section V.

BACKGROUND PRELIMINARIES

A. *Terminologies:*

A *process* is a program in execution. *Ready queue* holds the processes waiting to be executed or to be assigned to the processer. *Burst time (b_t)* is the time, for which a process requires the CPU for execution. The time at which the process arrives is called the *arrival time (a_t).Time quantum (t_q) or time slice* is the period of time given to each process to have CPU. *Average waiting time (a_{wt})* is the time gap between the arrival of a process and its response by the CPU. *Average Turnaround time (a_{tat})* is the time gap between the instant of process arrival and the instant of its completion. Average Response time (a_{rt}) is the time taken to start responding a process. The number of times the CPU switches from one process to another is called the *context switches (cs). PC_{CPU}* and *$PC_{I/O}$* are the percentage requirement of a process for CPU and I/O respectively.

B. *Dynamic Quantum with Re-adjusted Round Robin [1] Scheduling Algorithm*

The DQRRR scheduling [1] has improved the RR scheduling by improving the turnaround time, waiting time and number of context switches. Processes are arranged in job mix order in the ready queue and time quantum is found using median method. The CPU scheduler goes around the ready queue, allocating the CPU to each process for a time interval of up to 1 time quantum. Again the time quantum is calculated from the remaining burst time of the processes and so on. New processes are added to the tail of the ready queue. The CPU scheduler picks the first process from the ready queue and allocates the CPU to the process for 1 time quantum.

PROPOSED APPROACH

The proposed algorithm TPBCS finds the time quantum in an intelligent way which gives better result in a two-processor environment than Dynamic Quantum with Readjusted Round Robin Scheduling Algorithm [1](DQRRR) and RR scheduling. Out of two processors one is solely dedicated to execute CPU-intensive processes (CPU_1) and the other CPU is solely dedicated to execute I/O-intensive processes (CPU_2). The algorithm is divided into part I and part II. Part I algorithm classifies a process and dispatches it into an appropriate ready queue. Part II algorithm calculates the time quantum for both CPUs in a dynamic manner in each cycle of execution. The time quantum is repeatedly adjusted in every round, according to the remaining burst time of the currently running processes. We have taken an approach to get the optimal time quantum, where a percentage value $<PC_{CPU,} PC_{I/O}>$ is assigned to each processes. For instance, <75, 25> represents a process whose time comprises 75% of CPU activities and 25% of I/O activities. For instance in database systems, a process can easily spend 70% of its time accessing the hard disk and 30% on computation. Here the shorter processes are executed first, to give better turnaround time and waiting time.

The Time Quantum (t_q) is calculated as below.
t_{q1} (for CPU_1) =

$$\frac{\sum_{i=1}^{i=n1}(PC_{CPU}[i]\ .\ b_t[i])}{\sum_{i=1}^{i=n1} PC_{CPU}[i]}$$

t_{q2} (for CPU_2) =

$$\frac{\sum_{i=1}^{i=n2}(PC_{I/O}[i]\ .\ b_t[i])}{\sum_{i=1}^{i=n2} PC_{I/O}[i]}$$

Where, n1= number of processes in the ready queue for CPU1

n2= number of processes in the ready queue for CPU2

$PC_{CPU}[i]$ = Percentage requirement of process i for CPU

$PC_{I/O}[i]$ = Percentage requirement of process i for I/O

A. *Proposed Algorithm*:

Algorithm Part I

```
While there is an entering process P do {
     if ( $PC_{CPU}$[p] >=70)
         Enqueue ($CPU_1$ Ready queue, P)
      else if ($PC_{I/O}$[p] >=70)
         Enqueue ($CPU_2$ Ready queue,P)
}
```

```
Algorithm Part II for both $CPU_1$ and $CPU_2$
 Initialize: $a_{wt}$=0,$a_{tat}$=0.
 while ($CPU_1$ ready queue queue!=  NULL)
     find the time quantum  $t_q$
    //Sort the processes in ready queue
          for i=1 to $n_1$
               Put the processes with ascending order of burst time
                in ready queue
          end for
    //Assign $t_q$ to each process
          for i=1 to $n_1$
            if(b[i] < $t_q$)
              p[i]=b[i]=$t_q$ and rb[i]=0
            else if (b[i] = t)
              p[i]=$t_q$ and rb[i]=0
            else
              p[i]=$t_q$ and rb[i]=b[i]-$t_q$
          end of for
     if rb[i]=0,remove the process from the ready queue
     if rb[i] > 0, insert the process in the ready queue with rb[i]
  end of while
 $a_{wt}$ , $a_{tat}$  are calculated.
 stop & exit.
```

Algorithm Part II for CPU_2 is same as for CPU_1

Here p[i] is process i, b[i] is the burst time of process i, rb[i] is the remaining burst time of process i.

B. *Time Complexity:*

Any freshly arriving task would be inserted at the end of the ready queue. Each task insertion will be achieved in O(1) or constant time in Algorithm part I. In algorithm part II, the order of sorting the processes in the ready queue is $O(n_1 \log n_1)$ for CPU_1 and $O(n_2 \log n_2)$ for CPU_2. Then the assignment of t_q to each processes will be achieved in $O(n_1)$ and $O(n_2)$ for CPU_1 and CPU_2 respectively.

C. *Illustration:*

We have considered an example to demonstrate the above algorithm .The burst time sequence are:22, 31, 53, 69, 79 assigned to processes P1,P2,P3,P4,P5 along with Membership values <80, 20>, <79, 21>, <25, 75>, <11, 89>, <9, 91> respectively. The processes (P1,P2) having PC_{CPU} more than 70 are fed into CPU_1 ready queue and the processes (P3 P4, P5) having $PC_{I/O}$ more than 70 are fed into CPU_2 ready queue. Inside the ready queues processes are arranged in ascending order of burst time(b_t). Then the time quantum is calculated in each CPU using the proposed formula.Using the above algorithm the t_q calculated for CPU_1 are 26 and 5 and t_q for CPU_2 are 68, 6 and 5 respectively.

EXPERIMENTAL ANALYSIS

A. *Assumptions*

The environment where all the experiments are performed is a two processor environment and all the processes are independent. Time quantum is assumed to be not more than the maximum burst time. All the attributes like burst time, number of processes, Percentage values of the processes for each processor are known before submitting the processes.

B. *Experimental Frame Work*

Our experiments consists of several input and output parameters. The input parameters consist of burst time, percentage values, time quantum and the number of processes. The output parameters consist of average waiting time, average turnaround time.

C. *Experiments Performed*

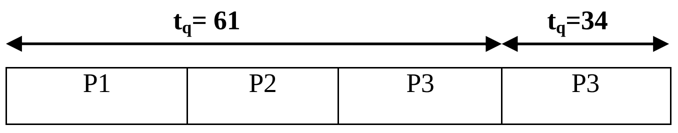
To evaluate the performance of our proposed algorithm, we have taken a set of processes in three different cases. This algorithm can work effectively with large number of data. In each case we have compared the experimental results of algorithm with the scheduling algorithm DQRRR [1] and with Round-Robin (RR) algorithm.

Increasing Order:

We consider six processes p1, p2, p3, p4, p5 and p6 arriving at time 0 with burst time 28, 52, 95, 110, 141, 153 respectively shown in Table I. Table II and Table III shows the comparing result of DQRRR algorithm, RR algorithm and our proposed TPCS algorithm for CPU_1 and CPU_2 respectively.

Table I: Data in Increasing Order

No. of process	**b_t**	**PC_{CPU}**	**$PC_{I/O}$**
P1	28	80	20
P2	52	70	30
P3	95	95	50
P4	110	25	75
P5	141	15	85
P6	153	10	90



0 28 80 141
175

Fig I: Gantt chart of TPCS for **CPU$_1$** in Table I

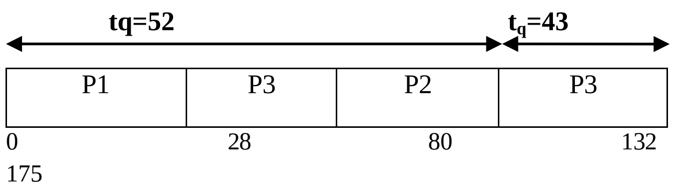


Fig II: Gantt chart for DQRRR for CPU$_1$ in Table I

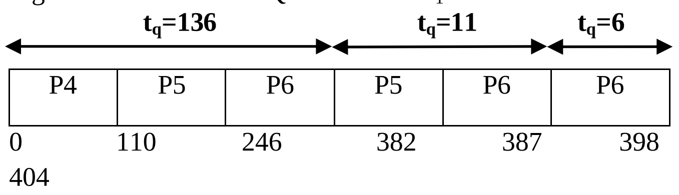


Fig III: Gantt chart of TPCS for CPU$_2$ in Table I

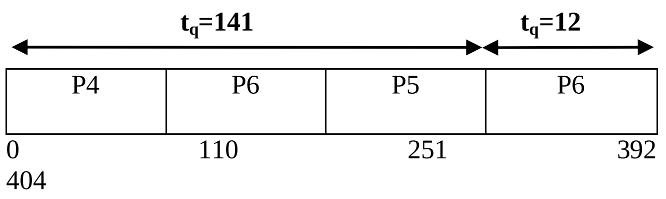


Fig IV: Gantt chart for DQRRR for CPU$_2$ in Table I

Table II: Comparison between DQRRR, RR and our TPCS algorithm for CPU$_1$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	61,34	52,43	35
a_{wt}	36	53.3	47.6
a_{tat}	94.3	111.6	106

Table III: Comparison between DQRRR, RR and DSMT for CPU$_2$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	136,11,6	141,12	35
a_{wt}	165.7	167.3	248
a_{tat}	300.3	302	371.67

Decreasing Order:

We consider six processes p1, p2, p3, p4, p5, p6 and p7 arriving at time 0 with burst time 254, 209, 182, 99, 42, 58 and 37 respectively shown in Table IV. Table V and Table VI shows the comparing result of DQRRR, RR and our proposed TPCS algorithm for CPU$_1$ and CPU$_2$ respectively.

Table IV. Data in decreasing Order

No. of process	**b_t**	**PC_{CPU}**	**$PC_{I/O}$**
P1	254	30	70
P2	209	82	18
P3	182	79	21
P4	99	12	88
P5	72	50	95
P6	58	91	90
P7	37	85	15

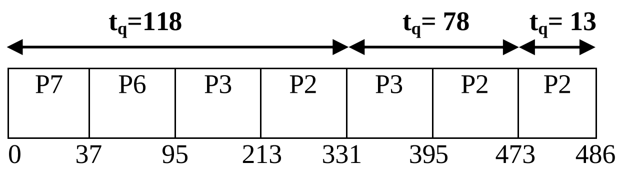


Fig. V: Gantt chart for TPCS for CPU$_1$ in Table IV

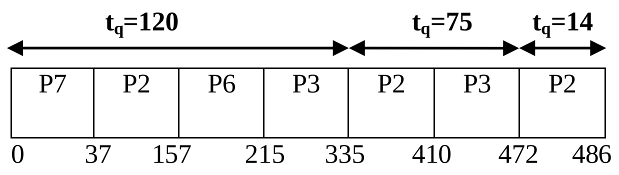


Fig. VI: Gantt chart for DQRRR for CPU$_1$ in Table IV

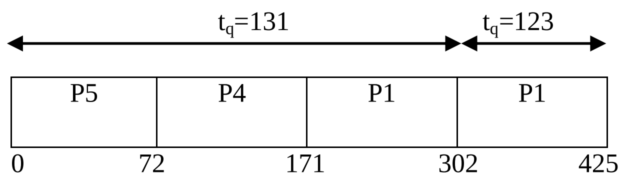


Fig.VII: Gantt chart for TPCS for CPU$_2$ in Table IV

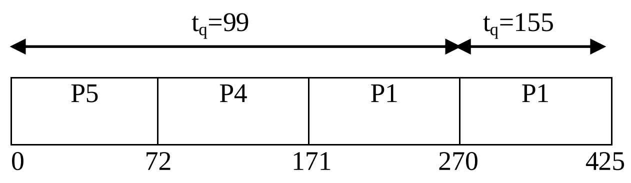


Fig. VIII: Gantt chart for DQRRR for CPU$_2$ in Table IV

Table V: Comparison between DQRRR, RR and TPCS for CPU$_1$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	118,78,13	120,75,14	35

a_{wt}	131.75	181	237
a_{tat}	253.25	302.5	358.5

Table VI: Comparison between DQRRR, RR and TPCS for CPU$_2$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	131,123	99,155	35
a_{wt}	81	114	183
a_{tat}	222.67	255.67	325

Random Order:

We consider six processes p1, p2, p3, p4, p5, p6 and p7 arriving at time 0 with burst time 94, 52, 39, 155, 113, 238 and 167respectively shown in Table VI. Table VII and Table IX shows the comparing result of DQRRR algorithm, RR algorithm and our proposed algorithm TPCS for CPU$_1$ and CPU$_2$ respectively.

Table VII. Data in Random Order

No. of process	**b_t**	**PC_{CPU}**	**$PC_{I/O}$**
P1	94	12	88
P2	52	90	10
P3	39	85	15
P4	155	17	83
P5	113	77	23
P6	238	21	79
P7	167	90	91

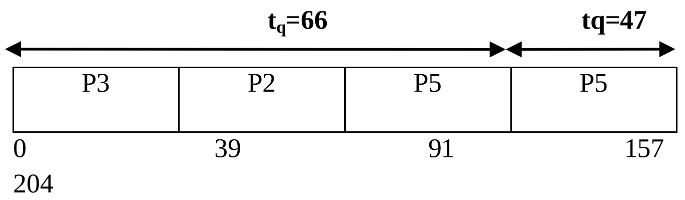


Fig IX: Gantt chart for TPCS for CPU$_1$ in Table VII

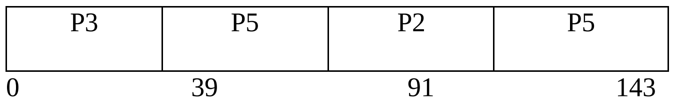


Fig.X: Gantt chart for DQRRR for CPU$_1$ in Table VII

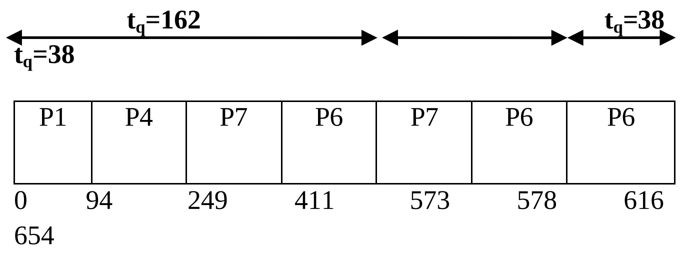


Fig XI: Gantt chart for TPCS for CPU$_2$ in Table VII

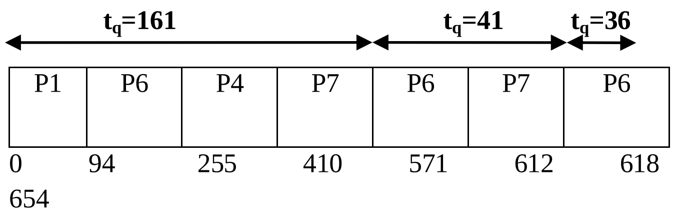


Fig.XII: Gantt chart for DQRRR for CPU$_2$ in Table VII

Table VIII. Comparison between DQRRR, RR and TPCS for CPU$_1$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	66,47	52,61	35
a_{wt}	43.3	60.7	82.67
a_{tat}	111.3	128.7	452

Table IX. Comparison between DQRRR, RR and TPCS for CPU$_2$

Algorithms	**TPCS**	**DQRRR**	**RR**
t_q	162,38,38	161,41,36	35
a_{wt}	230.25	280	356
a_{tat}	393.75	444	519.5

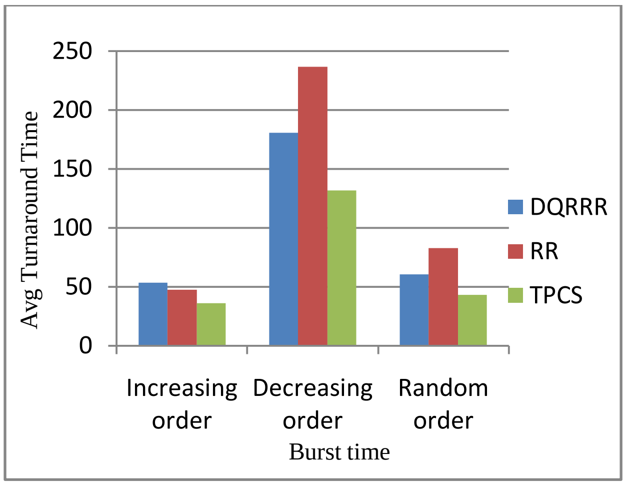


Fig. XIII: Comparison of average turnaround time between DQRRR, RR and TPCS for CPU_1

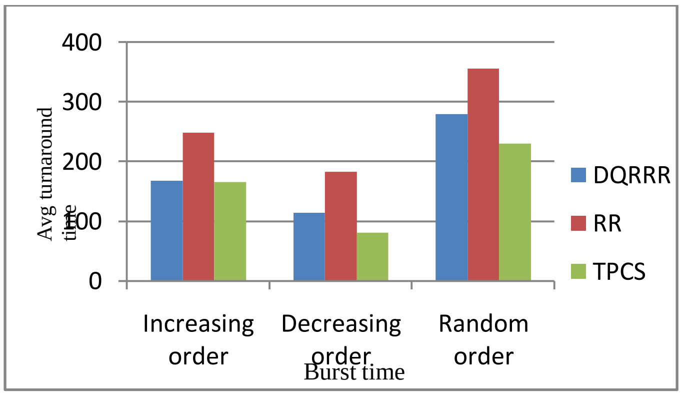


Fig XIV: Comparison of average turnaround time between DQRRR, RR and TPCS for CPU_2

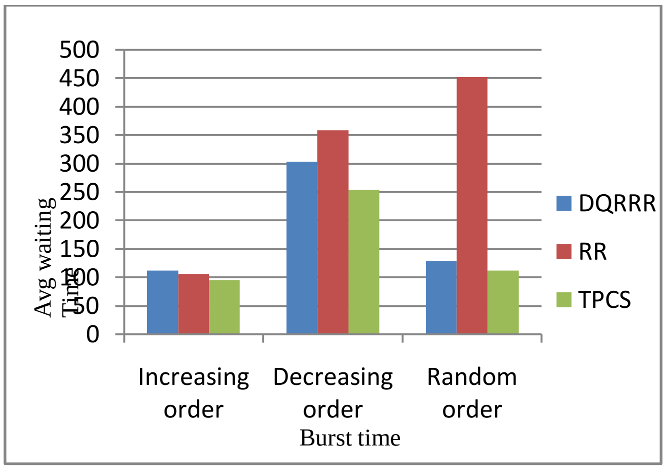


Fig XV: Comparison of average waiting time between DQRRR, RR and TPCS for CPU_1

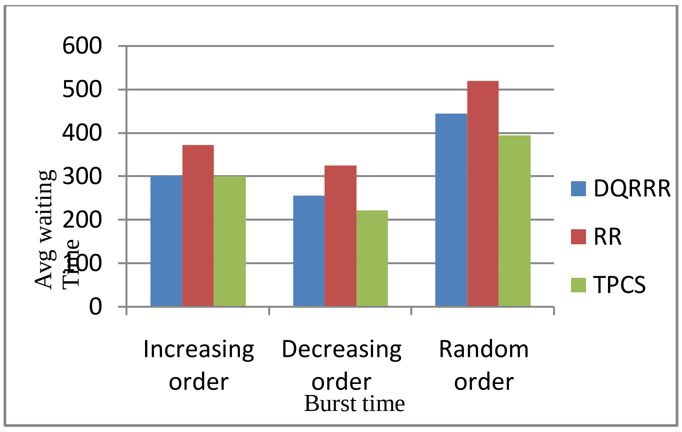


Fig XV: Comparison of average waiting time between DQRRR, RR and TPCS for CPU_2

CPU Utilization:

Percentage of time that CPU is busy (not idle), over some period of time, is called CPU utilization. The CPU utilization should be 100% in real time systems. In our proposed algorithm CPU-utilization is 100% since there is no context switch time between any two processes. The CPU remains busy all the time in executing the processes.

CONCLUSION

In this paper a new scheduling algorithm TPBCS, which is a modified Round Robin algorithm, used on a two processor system. One processor is designated exclusively for CPU-intensive processes and the other CPU is designated exclusively for I/O-intensive processes. The above comparisons show that the proposed TPBCS algorithm provides much better results than the algorithm proposed in [1] and Round-Robin algorithm[7] in terms of average waiting time, average turnaround time. This algorithm can be further investigated to be useful in providing more and more task oriented results in future.

REFERENCES

[1] H.S. Behera, R. Mohanty, Debashree Nayak "A New Proposed Dynamic Quantum with Readjusted Round Robin Scheduling Algorithm and its Performance Analysis", International Journal of Computer Applications(0975-8887) Volume 5- No.5, 10-15, August 2010.

[2] Rami J. Matarneh. "Self-Adjustment Time Quantum in Round Robin Algorithm Depending on Burst Time of Now Running Processes", American J. of Applied Sciences 6(10):1831-1837,2009.

[3] Sanpawat Kantabutra, Parinya Kornpitak, Chengchai Naramittakapong "Dynamic Clustering-Based Round-Robin Scheduling Algorithm". Proceedings of the 3rd international symposium on communication and information technology (ISCIT2003) September 03-05,2003, Hatyai, Songkhla, Thailand.

[4] H.S. Behera, Rakesh Mohanty, Jajnaseni Panda, Dipanwita Thakur, Subasini Sahoo "Experimental analysis of a new fair-share scheduling algorithm with waited time slice for real time systems". Journal of Global Research in Computer Science (ISSN-2229-371X), Volume 2, No. 2, 54-60, February 2011.

[5] H.S. Behera, Simpi Patel, Bijaylaxmi Panda. "A new dynamic Round-robin and SRTN algorithm using variable original time slice and dynamic intelligent time slice for soft real time system". International Journal of Computer Applications (0975-8887), Volume 16, No.1, 54-60, February 2011.

[6] H.S. Behera, Rakesh Mohanty, Sabyasachi Sahu, Sourav Kumar Bhoi, "Design and performance evaluation of multi cyclic round robin(MCRR) algorithm using dynamic time quantum" Journal of global research in computer science(ISSN-2229-371X), volume 2, No.2, February 2011.

[7] Silberschatz,A.,P.B.GalvinandG.Gange,2004."Operating systems concepts". 7th Edn.,John wiley and Sons, USA. ,ISBN:13:978-0471694663,pp:944.