Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 9, Number 1, January 2025
DOI : https://doi.org/10.33395/sinkron.v9i1.13920
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Median-Average Round Robin (MARR) Algorithm for Optimal CPU Task Scheduling

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Submitted : Jul 20, 2024 | **Accepted** : Nov 3, 2025 | **Published** : Jan 9, 2025

Abstract: In operating systems, multitasking or multiprocessing terms are used. If more than one task operating consecutively, but the users feel that they are running simultaneously, than it is called multitasking. Round robin algorithm is a noted algorithm in multitasking. Several modifications of classical round robin algorithm have been proposed by experts. The idea behind these modifications are to get lower turnaround time and lower waiting time. The main topic's discussion is about median-average round robin (MARR) algorithm. In this algorithm, the processes are arranged in ascending order. Then we get the median of the burst time. Afterwards, the calculation of the average burst time is done. The summation of average and median, divide by two is the time quantum. So, the time quantum will be dynamic, based on each iteration of round robin. First iteration can have a different time quantum compared to the second and so on. Each iteration will have one time quantum. Three analyses are given. Each with five processes. In the first analysis, time quantum for 1st iteration is 11 and the 2nd iteration is 4. The average turnaround time is 29. The average waiting time is 19. For the second analysis, time quantum for 1st iteration is 10 and the 2nd iteration is 8. The average turnaround time is 24.2. The average waiting time is 13.6. For the third analysis, time quantum for 1st iteration is 10 and the 2nd iteration is 9. The average turnaround time is 23.2. The average waiting time is 12.8.

Keywords: MARR, median-average round robin, quantum, turnaround time, waiting time

INTRODUCTION

In operating systems, multitasking or multiprocessing terms are used. Multitasking and multiprocessing can be used in substitutions. In multiprocessing, if more than one CPU is used. But if more than one task operates consecutively, but the users feel that they are running simultaneously, then it is called multitasking (Abdelkader et al., 2022)(Khokhar & Kaushik, 2017)(Putra & Purnomo, 2022).

In the systems, real time scheduling is a critical part. High efficiency is needed in operating systems. Numerous of researchers have proposed many algorithms to make this efficiency happen. Round robin algorithm is one known algorithm. Many enhancements have been researched and found by experts. Numerous modifications to round robin algorithm have been made (Omar et al., 2021)(Manish Kumar Mishra, 2014)(Ali et al., 2021).

Round robin algorithm is an algorithm that used time slice, which is also called time quantum (Ghazy et al., 2022)(Putra & Purnomo, 2022)(Putra & Purnomo, 2021). A small period of time, which is called time quantum is used to execute the process. The size of time quantum is the most important characteristic of this algorithm (Zouaoui et al., 2019). If the time quantum is too large, then starvation will occur. This starvation is a problem that should be avoided (Fiad et al., 2020). However, the shorter time quantum will make the context switching too large, which is making another problem(Olofintuyi Sunday Samuel, Omotehinwa Temidayo Oluwatosin, 2020)(Ghazy et al., 2022). CPU scheduling algorithm is efficient if it has low waiting time, low turnaround time, low response time (Purnomo & Putra, 2022)(Putra & Purnomo, 2023)(Purnomo & Putra, 2022)(Putra, 2022).

There are several parameters in CPU scheduling algorithms. Namely, context switch, throughput, CPU utilization, turnaround time, waiting time, and response time. Context switch helps CPU to start its processing from the same state where it paused earlier. The operating system gives time to process the tasks, and several processes completed in the allotted time are called throughput. The time for which one can hold the CPU for its usage is known as CPU utilization. If the utilization is high, then the performance of the system also high. The total time taken by any process to complete the process is turnaround time. Each process needs time to be executed. In an instance, only one unit can be executed. The total waiting time taken by any process in the available queue is considered as the process's waiting time (Mostafa & Amano, 2020)(Vinay Kumar Reddy & Aakash, 2021)(Alhaidari & Balharith, 2021).

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In enhancing the performance of round robin algorithm, many researchers have proposed many modified algorithms, from the classical round robin algorithm. In this research, a median-average round-robin is proposed and analyzed. The median-average round-robin algorithm is an algorithm that uses the median and average as the calculated components to get the dynamic time quantum. Before each iteration of round robin, the calculation is done, so that in each iteration, the time quantum will be different. It depends on the average and the mean of the burst time data set. Three analysis's are given. Each with calculation of time quantum, turnaround time, waiting time, and the total burst time.

This article is arranged in five sections. First section is introduction. In this section discussion about the idea of round robin algorithm in general are presented. The second section is about the method. Here the main content of this algorithm is discussed, namely the median-average round robin, which also called MARR. The third section is result. In this chapter, three analysis's are given and explained thoroughly. The fourth section is discussion. Table is presented to understand the comparison of this analysis thoroughly. The fifth section is conclusion and future works.

METHODS

Sakshi and friends proposed a new median-average round robin algorithm to find the optimal way of process scheduling. In their proposal, the method is that in each iteration, the time quantum is dynamic. It depends from the median and average of burst times. Based on their research, the proposed algorithm outperforms the existing algorithms. It is called Median Average Round Robin Algorithm (MARR) (Sakshi et al., 2022).

The formulas and definitions are:

$$Median = The\ Vlaue\ in\ The\ Middle\ of\ data\ Set\ of\ Burst\ Times\ in\ ascending\ Order \quad (1)$$

$$Average = \frac{Summation\ of\ burst\ Time\ of\ All\ processes}{Number\ of\ Processes} \quad (2)$$

$$Time\ Quantum = \frac{(Median+Average)}{2} \quad (3)$$

This calculation is done in every iteration of round robin. So, it is possible that in each iteration, the time quantum is different and dynamic. For the algorithm, first we must arrange the process with the same arrival time, and is arranged in ascending order. Then we get the median, and after that we get the average by calculating of all the burst times. The time quantum is equal to the summation of median and average, divide by two, as per the formula above.

Usually task scheduling runs behind the application. It runs in the background. But it depends on the operating system used. To see it we can open the task bar of the operating systems. And to make sure whether operating system uses what kind of task scheduling algorithm, we have to look at the programs written by the developer.

RESULTS

As mentioned in the method, Median Average Round Robin Algorithm (MARR) is applied in this analysis. First the table of process arrival time and burst time are given. Each with algorithm of MARR. To see the result of process scheduling analysis, here we discuss three analysis cases, namely, first analysis, second analysis and third analysis.

All the arrival times is zero, since the assumption is that all process arrives simultaneously. As mentioned in the method above, we must arrange the burst time in ascending order. However, in this analysis it is already in ascending order. So we do not need to do it anymore. In all analysis, each is given with five processes. The total burst time for all analysis is 50, 53, 52, consecutively.

a) First analysis

Table 1. Process with Arrival Time and Burst Time

Process	Arrival Time	Burst Time
G1	0	2
G2	0	5
G3	0	12
G4	0	15
G5	0	16

First iteration, median equals to 12. Average is (2+5+12+15+16)=10. Time Quantum equals to (12+10)/2=11. In the second iteration, G3 is 1, G4 is 4, G5 is 5. The median equals to 4. Then we get the average, which is (1+4+5)/3=3.3. Time Quantum equals to (4+3.3)/2=3.65, round it up to be 4. The gantt chart analysis can be seen in Figure 1.

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
G1	G1	G2	G2	G2	G2	G2	G3	G3	G3	G3	G3	G3	G3	G3	G3	G3	G3	G4	G4

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G4	G4	G4	G4	G4	G4	G4	G4	G4	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5

41	42	43	44	45	46	47	48	49	50
G3	G4	G4	G4	G4	G5	G5	G5	G5	G5

Fig. 1. Gantt Chart First Analysis

Here is the calculation of waiting time:
Waiting time G1 = 0
waiting time G2 = 2
waiting time G3 = 7 + (40 - 18) = 29
Waiting time G4 = 18 + (41 - 29) = 30
waiting time G5 = 29 + (45 - 40) = 34

So the average waiting time is 19.

Table 2. Calculation of Waiting Time and Turnaround Time

Process	Arrival Time	Burst Time	Start Time	Finish Time	Turnaround Time	Waiting Time
G1	0	2	0	2	2	0
G2	0	5	2	7	7	2
G3	0	12	7	41	41	29
G4	0	15	18	45	45	30
G5	0	16	29	50	50	34
			Average		29	19

b) Second Analysis

Table 3. Process with Arrival Time and Burst Time

Process	Arrival Time	Burst Time
G1	0	1
G2	0	6
G3	0	10
G4	0	16
G5	0	20

In the first iteration, median equals to 10. Average is (1+6+10+16+20)/5=53/5=10.6. Then time quantum equals to (10+10.6)/2=10.3, rounded down to be 10. For second iteration, G4 is 6, G5 is 10, and the median equals to 8. Then we get the average which is (6+10)/2=8. Time Quantum equals to 8. The gantt chart analysis can be seen in Figure 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
G1	G2	G2	G2	G2	G2	G2	G3	G3	G3	G3	G3	G3	G3	G3	G3	G3	G4	G4	G4

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G4	G4	G4	G4	G4	G4	G4	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5	G4	G4	G4

41 42 43 44 45 46 47 48 49 50 51 52 53

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G4	G4	G4	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5

Figure 2. Gantt Chart Second Analysis

Here is the calculation for waiting time:
Waiting time G1=0,
waiting time G2=1,
waiting time G3=7,
waiting time G4=17+(37-27) = 27
Waiting time G5=27+(43-37)= 33

Table 4. Calculation of Waiting Time and Turnaround Time

Process	Arrival Time	Burst Time	Start Time	Finish Time	Turnaround Time	Waiting Time
G1	0	1	0	1	1	0
G2	0	6	1	7	7	1
G3	0	10	7	17	17	7
G4	0	16	17	43	43	27
G5	0	20	27	53	53	33
			Average		24.2	13.6

c) Third Analysis

Table 5. Process with Arrival Time and Burst Time

Process	Arrival Time	Burst Time
G1	0	2
G2	0	3
G3	0	10
G4	0	17
G5	0	20

For the first iteration, median equals to 10. The average is (2+3+10+17+20)/5=10.4. The time quantum equals to (10+10.4)/2=10.3, rounded down to be 10. For the second iteration, G4 is 7, G5 is 10. Then we get the median, which is equals to (7+10)/2=8.5. The average is (7+10)/2=8,5. Then the time quantum equals to 9. The gantt chart analysis can be seen in Figure 3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
G1	G1	G2	G2	G2	G3	G3	G3	G3	G3	G3	G3	G3	G3	G3	G4	G4	G4	G4	G4

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
G4	G4	G4	G4	G4	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5	G4	G4	G4	G4	G4

41	42	43	44	45	46	47	48	49	50	51	52
G4	G4	G5	G5	G5	G5	G5	G5	G5	G5	G5	G5

Fig. 3 Gantt Chart Third Analysis

Here is the calculation of waiting time:
Waiting time G1=0,
Waiting time G2=2,
waiting time G3=5,
waiting time G4=15+(35-25)=25,
waiting time G5=25+(42-35)=32

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Table 6. Calculation of Waiting Time and Turnaround Time

Process	Arrival Time	Burst Time	Start Time	Finish Time	Average Turnaround Time	Average Waiting Time
G1	0	1	0	2	2	0
G2	0	6	2	5	5	2
G3	0	10	5	15	15	5
G4	0	16	15	42	42	25
G5	0	20	25	52	52	32
			Average		23.2	12.8

DISCUSSION

Below is the proposed median-average round-robin. Below also, is the discussion of the three analysis's given. Tables are used to explain this algorithm more clearly. The summary of process analysis, with columns of case, iteration, time quantum, total burst time, average turn around time, and average waiting time. The comparisons are given between these three cases.

Please take a look at table 7. below. In the first analysis, second analysis and third analysis, there are two iterations for these processes each. The time quantum for the first analysis is 11 and 4. For the second analysis is 10 and 8, and for the third analysis is 10 and 9. From the point of view of turnaround time and waiting time, for these three analysis's, the lowest average waiting time is 12.8. It is in the third analysis. The lowest average turnaround time is 23.2, it is also in the third analysis. From the time quantum point of view, the lowest time quantum is 4 in the first analysis and the highest time quantum is also in the first analysis which is 11. All the burst times is 50, 53 and 52 each in these three analysis's.

Table 7. Summary of Process Analysis

Case	Iteration	Time Quantum	Total Burst Time	Average Turn Around Time	Average Waiting Time
First Analysis	1st iteration	11	50	29	19
	2nd iteration	4			
Second Analysis	1st iteration	10	53	24.2	13.6
	2nd iteration	8			
Third Analysis	1st iteration	10	52	23.2	12.8
	2nd iteration	9			

CONCLUSION

It is concluded that for MARR, in these three analysis's, the iterations are two times for these five processes each. It is first iteration and second iteration. These are the prove of dynamic time quantum. In comparison, if we compare these algorithms with classical round robin algorithm in terms of time quantum, then the classical is monotone since the time quantum is predetermine, and the same all the time, where in MARR, the time quantum in each iteration can be different, depending on the calculation of the algorithm. Thus, this dynamic time quantum makes the system more effective than the classical round robin. For future works, may be comparison with other variants of round robin algorithm can be presented and a new novelty can be given for round robin algorithm.

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Volume 9, Number 1, January 2025 e-ISSN : 2541-2019
DOI : https://doi.org/10.33395/sinkron.v9i1.13920 p-ISSN : 2541-044X

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