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Performance evaluation task scheduling rule based algorithms in datacenter using CloudSim

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Abstract: Cloud computing is a relatively new way of utilizing online resources, and it's growing increasingly popular. The cloud could have very strong traffic at times and very low traffic at other times. Scheduling algorithms are essential to the process. The cloud computing issue is affected by causative factors, such as execution time, end time, waiting, and average waiting. However, the number of jobs in cloud environments is effectively impacted by the algorithms' higher latency and rapid response times. The research aims to improve the accuracy of task finishing time and waiting time by minimizing waiting time and execution times. The algorithms were elaborated, compared, and evaluated in terms of execution time, end time, waiting time, and average waiting time. The dataset was coded using the Java programming language and inserted into the simulation tools. The result was achieved in terms of execution time, completion time, and waiting time using the simulation tool Cloudsim in the comparison program, the Eclipse program. Compare the average waiting time between the SJF, FCFS, and RR algorithms. The SJF algorithm has the lowest rate, rather than Findings also proved that the SJF algorithm was the most effective over other alternative algorithms.

Keywords: cloud computing; task scheduling; CloudSim; SJF algorithm; FCFS algorithm; RR algorithm

1. Introduction

Cloud computing represents a relatively new paradigm of using remote computer resources and is becoming increasingly important to popular technology. Clouds provide a substantial number of resources, including calculators, Datacenters, storage, networks, firewalls, and software, in the form of services. At the same time, it also provides ways to manage these resources, such as allowing cloud users access to them without having to deal with any performance-related issues [1]. Cloud Computing Services are divided into three classes, depending on the output level and the service provider model: 1) Service as a service; 2) Platform as a service; and 3) software as a service. Distribution, virtualization, and expansion are the basic features of cloud computing [2]. Virtualization is one of the key features of the cloud. Most software and hardware provide practical support. We can do virtualization on many things, like hardware, software, storage, and operating systems, and manage them on a cloud platform. Cloud computing is a customer-based requirement for a wide range of services that you intend to share as an online service. Cloud computing services, including storage, applications, and other services, require management and scheduling in order to be better utilized [3].

Scheduling is a collection of policies for controlling the order in which a computer system must complete tasks. There are several types of scheduling algorithms, and job scheduling is one of them. Job scheduling is a mapping mechanism from users' tasks to the appropriate selection of resources and their execution [4]. Job scheduling is flexible and convenient; the main advantage of job scheduling algorithms is that they achieve high performance computing and the best system throughput. Scheduling manages the availability of CPU and memory, and a good scheduling policy makes the most of the resources [5]. Job algorithms are a mechanism for selecting tasks to perform in order to obtain less waiting time and improve performance. Job planning is a particularly critical issue that is used to arrange tasks to make better use of resources throughout time by assigning a specific task to specific resources. The main purpose of the job planning algorithm is to increase performance and service while also maintaining task efficiency and reducing costs. The main goal is to schedule for growing resource usage without interfering with cloud-based services [6].

Cloud computing provides an execution environment that is cost-effective and provides its services under a pay-per-use model. There may be very high traffic, and sometimes there may be very little traffic. The scheduling algorithm plays a key role in the serving process. Algorithms have higher latency and a high response time, which is an effective factor, that is, the number of jobs in cloud environments [7].

This paper focuses on the problem of task scheduling in datacenters using CloudSim simulation. The main goal is to analyze and evaluate the performance of three task scheduling algorithms: First-Come-First-Serve (FCFS), Shortest Job First (SJF), and Round Robin (RR). The evaluation is conducted based on various performance metrics, including execution time, finishing time, wait time, and average wait time. By studying these metrics, the paper aims to understand how each algorithm performs in a datacenter environment with tasks of different characteristics and resource requirements.

This paper try to answer several key questions, such as; the differences in execution times, finishing times, and wait times among the three algorithms, providing insights into their impact on the overall system efficiency. Then, investigates which algorithm is more effective in reducing average waiting time and optimizing resource utilization for different types of tasks in cloud environment.

The contribution of this paper lies in the comprehensive analysis and evaluation of three task scheduling algorithms, namely First-Come-First-Serve (FCFS), Shortest Job First (SJF), and Round Robin (RR), in the context of datacenters using CloudSim simulation. The study investigates their performance based on crucial metrics such as execution time, finishing time, wait time, and average wait time. That providing a foundation for efficient resource management and improved system performance in cloud computing environments.

2. Related work

Cloud computing, to put it simply, is the process of storing and accessing data and programs over the Internet rather than on our computer's hard drive. The cloud is a metaphor for the Internet. As shown in Figure 1, the internet is commonly represented as a cloud on a computer network [8]. The Job of computing in cloud computing is attractive and requires great attention. Most research in project planning uses a paradigm in which work in a cloud computing program is characterized by its workload, deadline, and related resources obtained by its predeadline completion, which are factors in designing an effective planning algorithm [9].

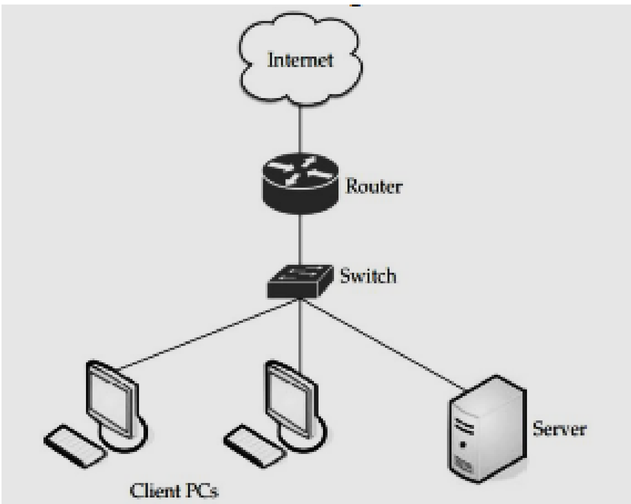

Figure 1. Internet is depicted by a cloud in a network.

Many researchers have come up with various theories and simulations that work in your area. Table 1 discusses a comparison of related works for task scheduling in cloud computing regarding the main features of cloud computing in terms of algorithm tools.

Examples of the task planning algorithms used in [10] highlighted Cloud applications, including Round Robin (RR), MaxMin, MinMin, FCFS, MCT, PSO, and GA, are provided. The interpersonal behavior of organizing circular robin activities within the environment has also been examined by CloudSim and compared between RR and MRR in terms of waiting time. Results show that when you use MRR to set the number of cloudlets over the number of VMs, the average waiting time is less than when you use RR, using the same number of cloudlets and CC location.

Table 1. Comparison of related works for the task scheduling in the cloud computing.

Algorithm	Tools	Limitation	Authors
MaxMin, MinMin, FCFS, MCT, PSO, GA Round Robin (RR), MRR	CloudSim	Waiting Time and Average Waiting Time	[11]
FCFS, SJF, MSJF	CloudSim	Setup Time and Response Time	[12]
FCFS, SJF, RR	CloudSim	Terms of Throughput	[13]
FIFO, SJF	Cloud Computing Environment	Service Quality, Load balance, average waiting time, and total processing time	[14]
FCFS, STF, LTF, and RR	CloudSim	Total completion time and Finishing Time	[15]

Planning for Work in Cloud Computing [14] discussed the flexibility of credit-based evaluation activities that are flexible and emphasizes the problem of planning using FIFO algorithms, such as SJF, which is a credit-based system. An algorithm based on length and importance and taking into account the service quality of the user's needs. In addition, this paper focused on balancing the load on virtual machines and increasing resource utilization. The test parameters considered in the work include total processing costs, average waiting time, and total processing time.

Using task scheduling in a cloud environment, [13] implemented and evaluated its impact. Cloud computing has found wide use due to the numerous provisions that have made the very same thing easier in the technology sector. The research paper is based on analyzing and implementing the three salient elements. Task scheduling algorithms (FCFS, SJF, and RR) play an important role in cloud computing; the more efficiently processes are organized to run on remote servers, the better the cloud Accommodation. The paper detailed the performance of three task scheduling algorithms under different scenarios, and an effective result has been reached. On the basis of the three cases that have been studied and implemented in this paper, it is concluded that SJF It is the best among the three algorithms under study in terms of throughput.

Both scheduling algorithms (SJF) and FCFS were used in [16]. It aims to improve the scheduling algorithm for the shortest task first in cloud computing. In task scheduling, the most important parameters are setup time and response time. Therefore, we proposed a modified algorithm for shortest task first (MSJF) to reduce last task completion time (Makespan) and reduce average response time while maximizing resource usage. MSJF has two functions: one is to calculate the average age length of tasks, and the other is to balance the load between virtual machines. An important advantage of MSJF is that the longest tasks are sent to the fastest machine. The results of the proposed algorithms were compared, and MSJF obtained better results compared to SJF and FCFS.

The tasks scheduling and the most used in cloud computing, FCFS, STF, LTF, and RR, were taken into consideration in a comparative simulation research [15]. CloudSim conducted the evaluation, which included all unique scheduling regulations shared across time and common space. The simulation revealed that the STF method outperformed the other algorithms in terms of total completion time while using the policy of assigning the common area. In comparison to the policy of allocating common space, the policy of allocating common time has a higher performance in terms of reducing job completion time.

The methodology flow in this paper includes choosing the best data collection tools, like Cloudsim and Eclipse, and three algorithms: FCFS, SJF, and round robin. The method of searching and gathering data also includes identifying issues and goals.

The algorithm is evaluated using the CloudSim simulator. After the test is finished, the algorithms are evaluated and simulated, presenting the verified results in the cloud computing system based on a variety of variables, including implementation time, completion time, waiting time, and finally the average waiting time. If the result is what was expected, the simulation is finished, or it is repeated to find the optimum algorithm.

3. Experiment setup

Cloudlets from the GitHub dataset and used the Java programming language. The factors of dataset execution time, finish time, waiting time, and average waiting time. Therefore, the purpose of this research is to evaluate and compare scheduling algorithms in cloud computing. Eclipse IDE Java tool because it is the best software used in cloud computing, because it deals with CloudSim simulation tools also used for scheduling algorithms, and because most of the researchers have worked with it and because it is easy to use. Scheduling algorithms FCFS, SJF, and Round Robin were used to determine the factors of execution time, finish time, waiting time, and average waiting time.

4. Experimental and discussion

This section contains the analysis of the experimental Eclipse IDE software. The code data set was processed and input into the CloudSim simulation program, with basic Java programming and some basic cloud computing. All the experiments aim at analyzing, evaluating, and comparing several performances for execution time, finish time (Makespan), wait time, and average wait time. The FCFS, SJF, and RR scheduling algorithms were discovered and compared. The SJF algorithm was found to be the most effective among these algorithms. In order to verify our algorithm, we conducted experiments on an Intel (R) Core (TM) i5 4GB Processor at 2.6 GHz, Windows 10, 32 bits, and the CloudSim 3.0.3 simulator. Figure 2 shows the experimental design steps.

Table 2 shows the executive description of the three algorithms, and each algorithm has a different number of cloudlets, Datacenter IDs, and VM IDs. It was discovered for Claudelts29 that SJF has a higher value of 20313.38 compared to FCFS of 16976.83 and RR of execution time of 16935.91 using the execution times of three algorithms as indicated in Table 2 and Figure 3.

The descriptions in Table 3 are the FCFS algorithm, the SJF algorithm, and the RR algorithm, in terms of the finish time of all operations, and each algorithm has a number of Cloudlets, DataCenter IDs, and VM IDs.

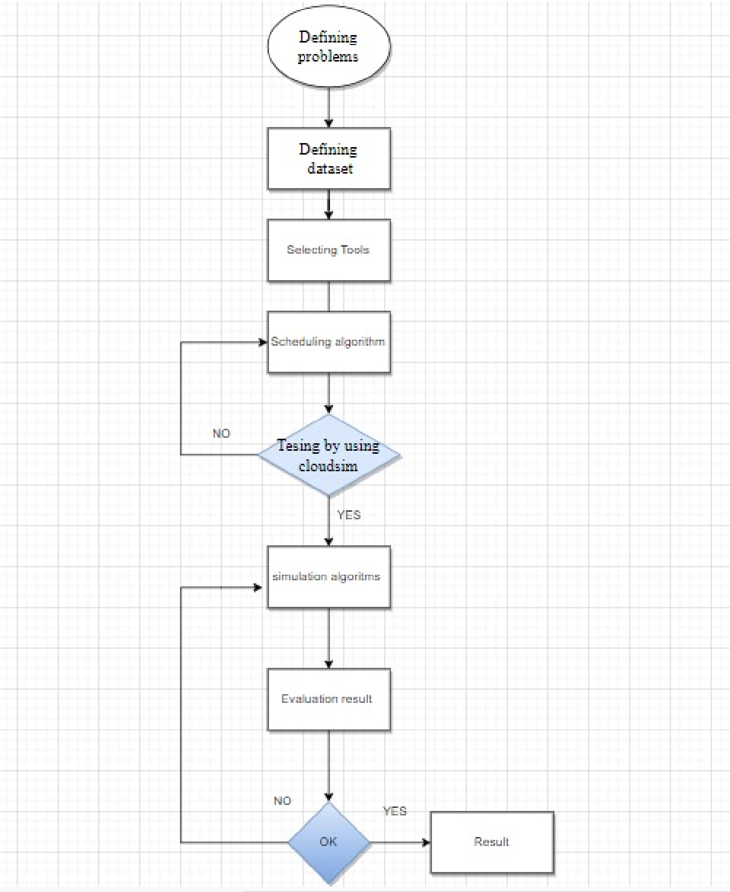

Figure 2. Experimental design steps.

Table 2. Total execution time with different number of tasks.

SJF Algorithm				FCFS Algorithm				Round Robin Algorithm			
Cloudlet	Data center ID	VM ID	Execution Time	Cloudlet	Data center ID	VM ID	Execution Time	Cloudlet ID	Data center ID	VM ID	Execution Time
2	6	6	0.1	0	2	5	0.2	0	5	5	0.1
0	4	4	0.1	1	2	2	0.2	4	6	6	0.1
7	5	5	0.1	2	3	6	0.2	6	2	2	0.1
11	2	2	0.1	3	2	4	0.2	13	6	6	1845.19
19	5	5	2735.85	4	2	2	2841.02	3	4	4	0.1
13	2	2	2973.08	5	2	2	5281.97	2	5	5	1562.24
4	6	6	1632.28	6	2	5	362.57	9	2	2	2180.02
1	3	3	0.1	7	2	3	0.2	1	3	3	0.1
10	4	4	2436.62	8	2	5	2443.92	16	5	5	3697.76
3	3	3	4027.16	9	2	2	8706.3	15	6	6	3674.33
21	6	6	3769.58	10	2	3	3180.68	5	4	4	3680.39
24	2	2	3710.07	11	2	4	3558.47	7	3	3	4010.84
14	4	4	4834.58	12	2	5	4839.22	10	2	2	3883.24
25	2	2	5686.64	13	2	2	11834.71	25	5	5	4767.15
26	6	6	5235.79	14	3	6	1208.16	8	4	4	6679.83
5	3	3	5224.65	15	2	4	4376.55	19	6	6	4779.36
6	3	3	8014.68	16	2	2	12565.67	23	2	2	7480.14
15	4	4	7213.86	17	2	2	16316.81	27	5	5	7773.34
27	2	2	7393.9	18	2	3	5963.51	11	3	3	7188.9
8	3	3	8966.91	19	2	4	6160.86	12	4	4	8224.28
9	3	3	11649.9	20	2	2	17784.23	24	2	2	9335.72
28	2	2	11071.66	21	2	5	8296.57	14	4	4	11427.39
16	4	4	9586.89	22	2	2	20530.38	17	3	3	11002.11
17	4	4	13161.66	23	2	3	9793.99	28	2	2	12813.12
12	3	3	12859.16	24	2	3	11815.69	18	4	4	13409.27
18	4	4	14564.28	25	2	4	10375.19	22	3	3	14058.44
20	3	3	15473.02	26	2	3	14257.64	29	3	3	16935.91
22	4	4	16656.02	27	2	4	14002	20	4	4	15761
23	3	3	17694.64	28	2	4	15976.82	21	4	4	19422
29	3	3	20313.38	29	2	3	16976.83	26	4	4	22530.5

Table 3. Total finish time with different number of tasks.

SJF Algorithm				FCFS Algorithm				Round Robin Algorithm			
Cloudlet	Data center ID	VM ID	Finish Time	Cloudlet	Data center ID	VM ID	Finish Time	Cloudlet ID	Data center ID	VM ID	Finish Time
2	6	6	1632.28	0	2	5	362.57	0	5	5	1562.24
0	4	4	2436.62	1	2	2	2841.02	4	6	6	1845.19
7	5	5	2735.85	2	3	6	1208.16	6	2	2	2180.02
11	2	2	2973.08	3	2	4	3558.47	13	6	6	3674.33
19	5	5	3496.72	4	2	2	5281.97	3	4	4	3680.39
13	2	2	3710.07	5	2	2	8706.3	2	5	5	3697.76
4	6	6	3769.58	6	2	5	2443.92	9	2	2	3883.24
1	3	3	4027.16	7	2	3	3180.68	1	3	3	4010.84
10	4	4	4834.58	8	2	5	4839.22	16	5	5	4767.15
3	3	3	5224.65	9	2	2	11834.71	15	6	6	4779.36
21	6	6	5235.79	10	2	3	5963.51	5	4	4	6679.83
24	2	2	5686.64	11	2	4	4376.55	7	3	3	7188.9
14	4	4	7213.86	12	2	5	8296.57	10	2	2	7480.14
25	2	2	7393.9	13	2	2	12565.67	25	5	5	7773.34
26	6	6	7852.16	14	3	6	3202.92	8	4	4	8224.28
5	3	3	8014.68	15	2	4	6160.86	19	6	6	8440.43
6	3	3	8966.91	16	2	2	16316.81	23	2	2	9335.72
15	4	4	9586.89	17	2	2	17784.23	27	5	5	10420.51
27	2	2	11071.66	18	2	3	9793.99	11	3	3	11002.11
8	3	3	11649.9	19	2	4	10375.19	12	4	4	11427.39
9	3	3	12859.16	20	2	2	20530.38	24	2	2	12813.12
28	2	2	12949.14	21	2	5	9983.96	14	4	4	13409.27
16	4	4	13161.66	22	2	2	23723.18	17	3	3	14058.44
17	4	4	14564.28	23	2	3	11815.69	28	2	2	15608.38
12	3	3	15473.02	24	2	3	14257.64	18	4	4	15761
18	4	4	16656.02	25	2	4	14002	22	3	3	16935.91
20	3	3	17694.64	26	2	3	16976.83	29	3	3	18347.19
22	4	4	20018.22	27	2	4	15976.82	20	4	4	19422
23	3	3	20313.38	28	2	4	19660.96	21	4	4	22530.5
29	3	3	22804.63	29	2	3	20003.25	26	4	4	24762.86
Makespan=26.056				Makespan=81.039				Makespan=32.172			

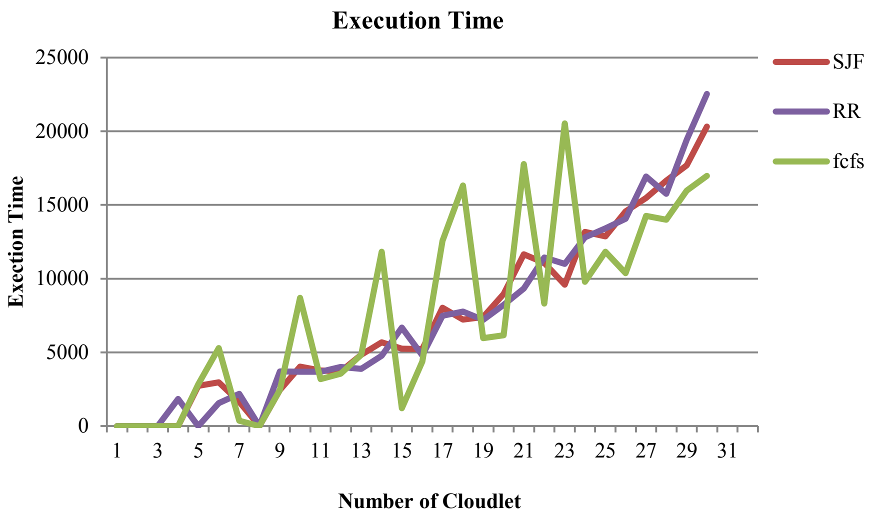

Figure 3. Total execution for RR, FCFS, SJF.

In Figure 4, the final times of various algorithms are displayed. The three scheduling algorithms' finishing times were computed and shown in Table 2. According to the results, SJF completion takes longer than Round Robin, which takes the longest amount of time, but less time than FCFS, which requires a value greater than 4000. The FCFS algorithm, the SJF algorithm, and the RR algorithm are individually described in this Table 4, along with their waiting times for all operations and associated Cloudlet, Datacenter, and VM ID numbers.

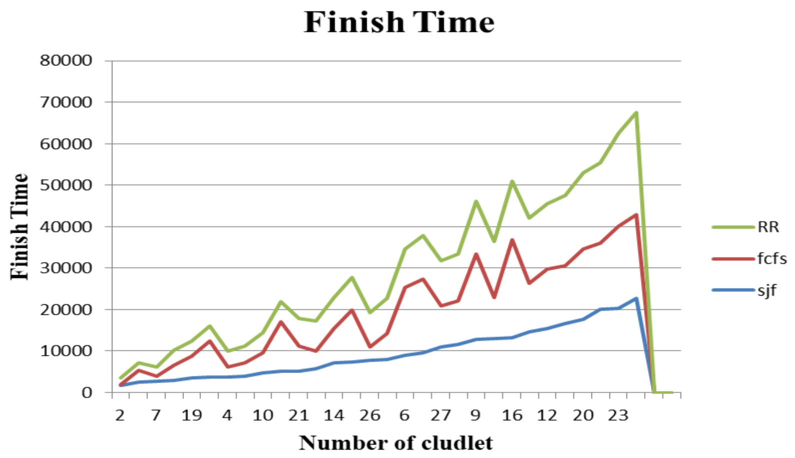

Figure 4. Finish time for RR, FCFS, SJF.

Table 4. Total waiting time with different number of tasks.

SJF Algorithm				FCFS Algorithm				Round Robin Algorithm			
Cloudlet ID	Data center ID	VM ID	Waiting time	Cloudlet	Data center ID	VM ID	Waiting Time	Cloudlet ID	Data center ID	VM ID	Waiting Time
2	6	6	0	0	2	5	0	0	5	5	0
0	4	4	0	1	2	2	0	4	6	6	0
7	5	5	0	2	3	6	0	6	2	2	0
11	2	2	0	3	2	4	0	13	6	6	1845.09
19	5	5	2735.75	4	2	2	2840.82	3	4	4	0
13	2	2	2972.98	5	2	2	5281.77	2	5	5	1562.14
4	6	6	1632.18	6	2	5	362.37	9	2	2	2179.92
1	3	3	0	7	2	3	0	1	3	3	0
10	4	4	2436.52	8	2	5	2443.72	16	5	5	3697.66
3	3	3	4027.06	9	2	2	8706.1	15	6	6	3674.23
21	6	6	3769.48	10	2	3	3180.48	5	4	4	3680.29
24	2	2	3709.97	11	2	4	3558.27	7	3	3	4010.74
14	4	4	4834.48	12	2	5	4839.02	10	2	2	3883.14
25	2	2	5686.54	13	2	2	11834.51	25	5	5	4767.05
26	6	6	5235.69	14	3	6	1207.96	8	4	4	6679.73
5	3	3	5224.55	15	2	4	4376.35	19	6	6	4779.26
6	3	3	8014.58	16	2	2	12565.47	23	2	2	7480.04
15	4	4	7213.76	17	2	2	16316.61	27	5	5	7773.24
27	2	2	7393.8	18	2	3	5963.31	11	3	3	7188.8
8	3	3	8966.81	19	2	4	6160.66	12	4	4	8224.18
9	3	3	11649.8	20	2	2	17784.03	24	2	2	9335.62
28	2	2	11071.56	21	2	5	8296.37	14	4	4	11427.29
16	4	4	9586.79	22	2	2	20530.18	17	3	3	11002.01
17	4	4	13161.56	23	2	3	9793.79	28	2	2	12813.02
12	3	3	12859.06	24	2	3	11815.49	18	4	4	13409.17
18	4	4	14564.18	25	2	4	10374.99	22	3	3	14058.34
20	3	3	15472.92	26	2	3	14257.44	29	3	3	16935.81
22	4	4	16655.92	27	2	4	14001.8	20	4	4	15760.9
23	3	3	17694.54	28	2	4	15976.62	21	4	4	19421.9
29	3	3	20313.28	29	2	3	16976.63	26	4	4	22530.4

In Figure 5, three algorithms are contrasted and presented in terms of waiting times in Table 3. It was observed that the SJF algorithm had the lowest waiting rate among the other algorithms, while the Round Robin algorithm had the greatest waiting time rate and was quite close to the First Call, First Service approach by calculating the average wait rate.

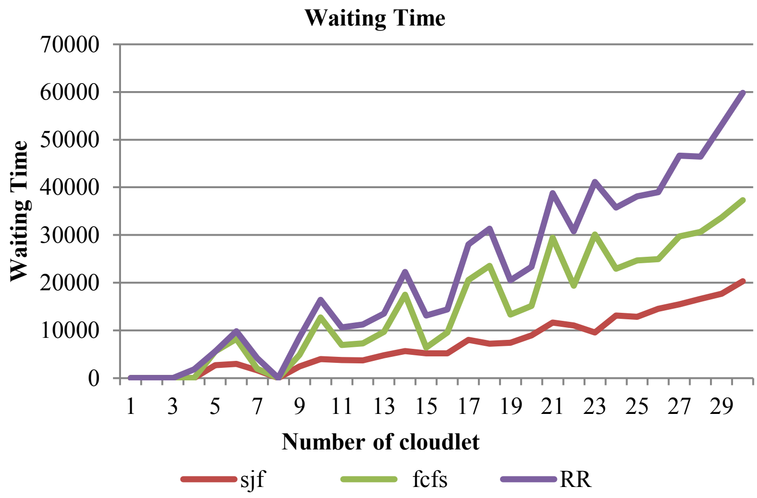

Figure 5. Waiting time for RR, FCFS, SJF.

5. The result

In terms of execution time, finishing time, wait time, and average wait time, the three algorithms FCFS, SJF, and RR were analyzed and evaluated in this section. Figure 5 illustrates the Average Waiting Time that was obtained for the three algorithms: Round Robin (7276.666), SJF (7229.459), and FCFS (7648.159). Short job first performs effectively compared to the round robin and the first come first serve, based on the results of the performance analysis. Since their implementation requires a lot of time, it is apparent from the comparison that each of these algorithms, FCFS and RR, is better than the SJF algorithm.

We used the First-Come-First-Served (FCFS), Shortest Job First (SJF), and Round Robin (RR) scheduling algorithms to compare the volatility of the execution time, finish time, and waiting time within a datacenter. The quantity of jobs and cloudlets are two variables that can have an impact on how volatile these performance measures are. Volatility is also influenced by the volume of tasks that are sent to the datacenter. The chance of task collisions and resource contention rises as the number of tasks increases. Due to the potential need to wait for resources to become available, tasks may take longer to execute and complete. The queuing of tasks might further lengthen the waiting period.

The number of cloudlets available in the datacenter plays a crucial role in determining resource availability for tasks. When there are fewer cloudlets than the number of tasks, resource contention can occur, leading to longer waiting times and higher execution times. On the other hand, an adequate number of cloudlets can efficiently distribute the workload, reducing waiting times and improving overall performance. The characteristics of the tasks themselves, such as their size, resource requirements, and priority, also impact the observed volatility. Certain tasks with higher resource demands may experience longer execution and waiting times if resources are limited. Moreover, tasks with higher priority may be given preference in scheduling, influencing their execution and finish times.

The choice of the scheduling algorithm (FCFS, SJF, RR) also contributes to volatility. Each algorithm handles task prioritization and resource allocation differently, leading to variations in execution, finish, and waiting times. SJF, for example, may prioritize shorter tasks, resulting in reduced execution and waiting times compared to FCFS or RR. However, the volatility in execution time, finish time, and waiting time within the datacenter is influenced by the number of cloudlets, the number of tasks, task characteristics, and the choice of scheduling algorithm. To optimize resource utilization and mitigate the effects of volatility, datacenter administrators should carefully consider these factors while designing and implementing task scheduling strategies.

6. Results and discussion

In this section, the performance of three task scheduling algorithms, namely First-Come-First-Serve (FCFS), Shortest Job First (SJF), and Round Robin (RR), was thoroughly analyzed and evaluated based on various metrics, including execution time, finishing time, wait time, and average wait time.

The results presented in Figure 6 showcase the Average Waiting Time obtained for each algorithm: Round Robin (7276.666), SJF (7229.459), and FCFS (7648.159). From the analysis, it is evident that the Shortest Job First (SJF) algorithm performs effectively in comparison to the Round Robin and First-Come-First-Serve algorithms, as indicated by its significantly lower average waiting time. The superiority of the SJF algorithm can be attributed to its ability to prioritize shorter jobs, resulting in reduced wait times and quicker task completion. By focusing on smaller tasks first, SJF optimizes resource utilization and minimizes the average waiting time for all jobs in the system.

On the other hand, both the FCFS and RR algorithms also demonstrate respectable performance. The FCFS algorithm, being simple and easy to implement, serves tasks in the order of their arrival, but this can lead to longer average waiting times, especially when faced with varying job sizes. The RR algorithm, with its time-slicing approach, ensures fair execution of tasks by providing each job a fixed time quantum. While this can prevent starvation and maintain fairness, it may introduce additional overhead due to frequent context switching.

Considering the trade-offs, it is evident that each algorithm has its strengths and limitations. While SJF exhibits the best average waiting time, its implementation complexity might be higher compared to FCFS and RR (Table 5).

The results affirm the effectiveness of the Shortest Job First (SJF) algorithm for task scheduling in datacenters. However, the choice of the most suitable algorithm depends on the specific requirements of the cloud environment and the characteristics of the workload. Future research could explore hybrid approaches that combine the strengths of multiple algorithms to further optimize task scheduling in cloud datacenters. Additionally, considering larger datasets and exploring real-world scenarios would enhance the generalizability of the findings.

Table 5. Total average waiting time for the algorithm.

Algorithms	Average Waiting Time
FCFS	7648.159
SJF	7229.459
Round Robin	7270.666

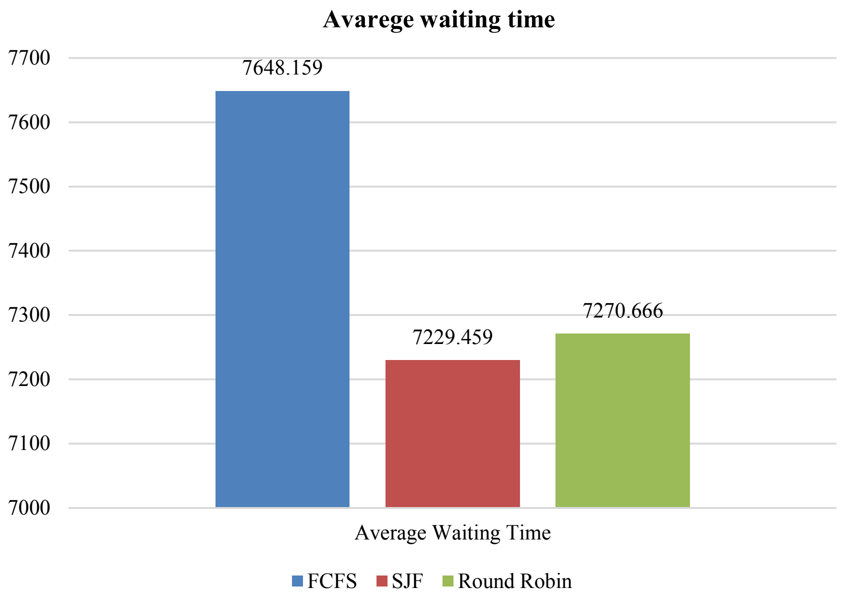

Figure 6. Average waiting time for RR, FCFS, SJF.

7. Conclusion and future works

The key contribution of this research, related to discussing cloud computing, is that it is a platform that tries to provide shared data to its customers at the same time, and one of its most important challenges is job scheduling. The task is set to complete a process with fewer available resources. The primary objective of this study is to evaluate the performance of the algorithms used to configure them in the CloudSim environment. After doing this research, we tried to find the algorithm that gave the best performance.

In the cloud computing system, through the factors studied, we built this system and that to compare the performance of the three proposed algorithms, and these algorithms are the next algorithm. First come, first served, short job first, and Round Robin algorithms depend on several factors including execution time, finish time, waiting time, and average waiting time. The results of the paper showed that there is no algorithm that can be considered the absolute best algorithm, so the short job first algorithm was the best in most cases. Further research can be conducted on the proposed new algorithm in the cloud computing environment according to the nature, priority, and size of the incoming work to enhance the scheduling process. In addition, we can expand the performance the topic to cover cloud monitoring and consider intrusive and non-intrusive monitoring approaches [17].

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