Comparative analysis of Job Scheduling algorithms, A Review

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Abstract—Algorithms comparison has performed to evaluate the performance of individual in terms of different scheduling parameters such as Execution Time, Response Time, and Cost, Scalability, Trust, Reliability, Resource utilization, Energy consumption and load balancing.

Keywords—Job scheduling, FCFS, SJF, RR, optimization algorithm

1. INTRODUCTION

Scheduling may be defined as a technique that is used to allocate the specific work to the specific resource. The specific task or work can be expressed as virtual calculating elements like threads or data flows and these works are allocated to the hardware equipments like processors or expansion cards in order to complete the task.

Usually the main focus of job scheduling technique is to trade off between different processors; on the other hand reduction of total processing time is also the field to be concerned. [1].In grid type scheduling two things need to be considered and that are job scheduling and resource scheduling. Firstly in job scheduling it is required to determine the suitable resource that can be allocated to the specific job [2]. Therefore the optimum processor needed to be determined so that the specific job can be allocated to it. In grid type scheduling two types of schedulers are required: local and grid. Firstly consider the local schedulers, these are the type of schedulers that perform in local region therefore they are highly efficient, quicker, and operates in identical environment and that's why completely take over the identical processors [3]. Grid type Schedulers are also referred as Meta type schedulers [4]. Further the scheduling technique can also be divided into two types: first is static scheduling and second is dynamic scheduling. In static type of scheduling, firstly the processes are allocated to appropriate processor and this particular processor will start execution of processes without any pause. In dynamic type of scheduling, the rescheduling of processes is permitted. It is possible to change the process execution on the basis of dynamic data gathered related to workload on processing units [5]. In the grid, various processing units are present to execute the process. Major objective is that it is required to identify the suitable processor to execute the particular job. Various techniques that can be used for job scheduling:

- **Centralized scheduling:** The type of scheduler used here is centralized scheduler. When all the processor is busy then it makes the performance of system efficient.
- **Hierarchical scheduling:** it also contains central type of scheduler and it will direct the process to the global type of scheduler.
- **Decentralized scheduling:** It does not contain any central type scheduler. It consists of distributed type of schedulers that cooperates each other in order to schedule the process [6].

2. EXISTING JOB SCHEDULING ALGORITHM

In recent years, there are number of job scheduling algorithms are existed which has been used by several researchers in their work. Some of the algorithms have mentioned below.

2.1 First Come First Serve Scheduling Algorithm(FCFS)

This algorithm works as first in first out order where in the waiting queue number of jobs is available and FCFS executes the job which arrives at first in the queue. This algorithm provides several merits such as simple and easy executing whereas there is no requirement of any priority to the job [7]. On the flip side it has several demerits as it is non-preemptive, increases waiting and turnaround time and time consuming.

The diagrammatically representation of FCFS algorithm has explained below where there are two queues such as ready and waiting. The tasks which are in waiting queue are waiting for their processing. The process which comes first will be processed first or wait until its turn.

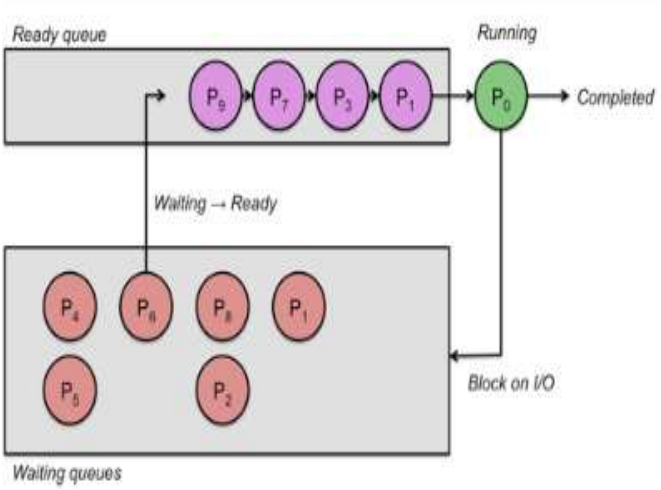

Fig 1. FCFS algorithm [24]

2.2 Shortest Job First Algorithm(SJF)

In such type of algorithm, a job having less or minimum time has executed at first and then highest execution time jobs executes which waits in the queue until short execution time job has not completed. In contrast with FCFS algorithm, it gives average waiting and minimum average turnaround time [8]. As it is based upon the priority mechanism so the jobs having same priority runs by the shortest job first manner.

2.3 Round Robin Algorithm(RR)

The Round Robin algorithm designed on the basis of time distribution where a time quantum or slice has given to individual job. Thus, based upon this concept each job has assigned with the slice and executes according to that time interval and works as a circular queue model [9].

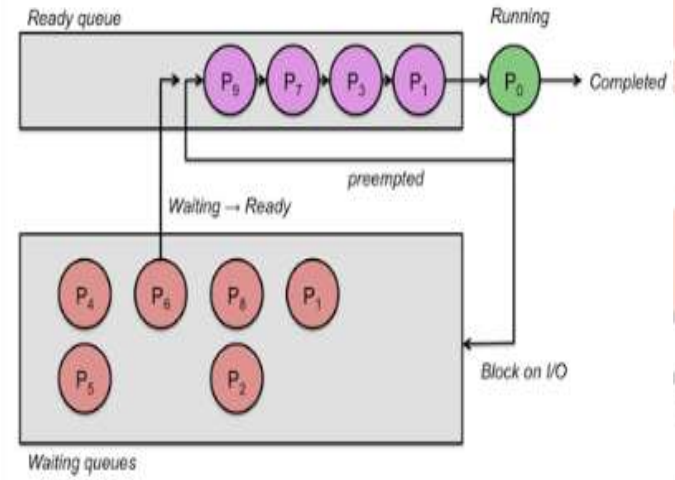

Fig 2. Round Robin Algorithm [24]

The new arrived job added to the tail of the queue and in case if the executing job is not completed within given time quantum then scheduler moves to the next job for the execution of process. And the remaining task of a job forms a circular queue and runs again when it turns come. Moreover, if any job completed, processor releases the finished job and move to the next which is waiting in the queue. The main advantage of this algorithm is that all the jobs available in the queue run at least once while cycle described in the Fig 2. Whereas the major drawback of this algorithm is that the largest jobs takes long time in a periodic queue to finish their task.

2.4 Heuristic Scheduling Algorithm

Yichao Yang et al. [10] proposed an algorithm which particularly focused on the allocation of virtualized network. The proposed algorithm considered computing resources for the process of scheduling. Thus, for the completing process of all the jobs service oriented resource broker was used. The deployment of data transmission and computing time in the virtual environment has done using the Abilene network which has proposed by many authors. Lastly, the proposed algorithm achieved high performance with respect to proper utilization of resources. Furthermore, it provided high throughput, load balancing and minimum processing time.

2.5 Resource Aware Scheduling Algorithm(RASA)

Jing Mei et al. [11] provided a mechanism where the duplication of task on heterogeneous computing systems can be reduced. This duplication based scheduling algorithm performed fairly better than other existing algorithms. Duplication in the system may leads to the high delay in the subsequent tasks and increases the overall Makespan. Alternatively, the proposed method increased the

efficiency of the system with less duplication. Thus, the reason behind proposing a new technique was search and remove redundancy. Consequently, the experimental results save the overall consumption of resources which is 15.59% in comparison with other existing algorithms. Furthermore, the makespan has also increased with the implementation of the proposed technique.

2.6 Particle Swarm Optimization-based Heuristic for Scheduling

Suraj Pandey et al. in [12] proposed an algorithm that provides less computation and data transmission cost. In the workflow scenario, PSO algorithm plays a significant role in minimizing the total cost of execution process. The proposed algorithm in this paper was compared with the Best Resources Selection algorithm. And the experimental results acquired from the algorithms concluded that the proposed algorithm performed three times better than the existing algorithm. Moreover, the proposed technique produced good distribution of workload among available resources.

2.7 An ANT Colony Algorithm for Balanced Job Scheduling in Grid

Ruay-Shiung Chang et al. in [13] presented a grid computing based algorithm. In the grid computing environment, the primart parts are computing grid as well as data grid. Thus, proper utilization of resources in a grid is quite difficult. In order to balance the resource scheduling, this paper introduced a new ANT colony algorithm for the optimum selection of favorable path. This proposed balanced ant colony optimization algorithm i.e. BACO has compared with improved ant colony optimization, Sufferage, Fastest processor to largest task first i.e. FPLTF, dynamic FPLTF and random selection method. From the analysis, it has concluded that proposed BACO algorithm outperformed other algorithms with reduced Makespan.

3. METHODS FOR JOB SCHEDULING

The major focus of job scheduling is to choose the optimum processors in a grid to allocate different jobs. In case of each processor, the creation of job schedulers is totally dependent on management system. In grid scheduling the optimum calculation and process scheduling is major challenge.

3.1 Efficient Utilization of Computing Resources using Highest Response Next Scheduling in Grid (HRN)

In this scheduling scheme, on the basis of priority allotted to the job and the efficiency of processing unit, different tasks are assigned to the processors [14]. Highest Response Next scheduling technique was projected to resolve the issues that are concerned with both algorithms Shortest Job First and First Come First Serve. Various benefits in this scheme are efficiently utilization of processor and highest response next model is more beneficial for Grid processors. Problems associated with it are as follow: It consists of high rotational time, memory wastage.

3.2 Node Allocation in Grid Computing using Optimal Resource Constraint (ORC) Scheduling

Optimal Resource Constraint, this is type of scheduling which is mixture of two types of scheduling first is Best fit allocation and second is Round Robin scheduling [15]. Load sharing and dynamic ability of grid processors can be efficiently achieved by implementing this type of algorithm. Various benefits of this type of algorithm are waiting time and turnaround time has been minimized whereas processing time has been maximized. Major disadvantage of this type of scheduling algorithm is high communication load.

3.3 Hierarchical Job Scheduling For Clusters of Work Station (HJS)

In this type of scheduling technique two levels are implemented first is global scheduling and second is local scheduling [16]. In the global scheduler in order to schedule the job different queues are used and then first come first serve algorithm is implemented. The local scheduler utilizes the same queue to implement the Shortest Job First and FF algorithm to be implemented in various processes. Various benefits of this scheduling algorithm are making the use of multi queue to efficiently allocate the processors to different tasks and it also minimize the turnaround time. Problems associated with this type of algorithm are that the varying nature of grid processors is not considered and the processors are not completely utilized.

3.4 Scheduling Framework for Bandwidth Aware Job Grouping Based Scheduling in Grid Computing (SFBAJG)

In order to improve the efficiency of scheduling, the concept of bandwidth is introduced [17]. The scheduler acquires the data from grid information service. After acquiring the information regarding the resources, the group of jobs has been created and properly allocated to the particular resource. The collection and selection application is present in the framework and this application is used for collection of information regarding the bandwidth of each processor. Benefits of this algorithm are enhanced distribution of jobs.

3.5 Grouping Based Fire Grained Job Scheduling in Grid Computing (GB FJS)

This type of scheduling algorithm is derived from the fire grained algorithm [18] and it initiate with acquiring the data related to processors. GBFJS algorithm helps in effective utilization of processors by integrating the first come first serve algorithm with greedy algorithm. Benefits associated with it are minimized total execution time, and enhance utilization of processors. Problems associated with this are limited memory size and before execution some time is required for preprocessing.

3.6 A Bandwidth- Aware Job Grouping – Based Scheduling On Grid Environment (BAJGS)

In this type of scheduling technique, the idea of grouping has been utilized with the BAJG dependant scheduling technique has been utilized with the bandwidth aware scheduling algorithm [19]. Mostly focus of this technique on the group independent processes which needs small amount of processing or large amount processing and schedule accordingly. At SCTP layer of protocol the idea of bandwidth has been utilized to make the tradeoff between loads. Major focus of this algorithm is to provide timely delivery on different routes. By implementing this algorithm the time required for job processing has been minimized whereas it is more in case of job scheduling without grouping algorithm. Benefits of this technique are: reduction in total processing time. Problems associated with it are: load tradeoff techniques cannot be deployed and this job scheduling algorithm does not consist of Quality of service necessities.

3.7 An Agent Based Dynamic Resource Scheduling Model with FCFS Job Grouping Strategy in Grid Computing (ABDRS)

This type of scheduling technique can increase the execution time of job [20]. The technique implemented to choose a particular process is heap tree based algorithm. This type of algorithm is implemented on the model that has two layers and that are as follow:

Top layer known as grid level and the second one is cluster level. Various benefits of this technique are as follow: improved scalability, toughness and load tradeoff accessibility of Grid, improved processor utilization and reduced time required for execution of jobs. Problems associated with this algorithm are as follow: it does not deploy job and resource scheduling along with the genetic paradigm to enhance the system efficiency.

3.8 A Dynamic Job Grouping Based Scheduling for Deploying Application with Fine Grained Task on Global Grid (DJGBS)

In the DJBS scheduling technique, on the basis of group of process, the jobs are allotted to the MIPS processor [21]. The processors are selected on the basis of FCFS technique. The process are selected and allotted to the processor on the basis of first come first serve technique and compared with the processors, if in case the group job MI is comparatively less than the processor MIPS then this process will continue its execution unless the value of processor MIPS is greater than the group process. Various benefits associated with this technique are to enhance the utilization of processor and also it minimizes the total time required to process the job. Problems associated with it are: the bandwidth and memory size limitations are restricted.

3.9 Virtual Computing Grid Using Resource Pooling (VCGRP)

This is type of scheduling algorithm in which the system itself will select the processor to which the process needs to be allocated [22]. It utilizes the virtual calculation grid monitor and it point where the web can accessed and it is manager of central processor. Benefits associated with it are: the system is cost efficient. Problems associated with it are: not highly reliable and the Quality of service is not so high.

Table 1. Comparison of existing algorithms in terms of scheduling parameters

Algorithms	Execution Time	Response Time	Cost	Scalability	Trust	Reliability	Resource Utilization	Energy Consumption	Load Balancing
First Come First Serve	Yes	Yes	No	No	No	No	No	No	No
Shortest Job First	Yes	No	No	No	No	No	No	No	No
Round Robin	Yes	No	No	Yes	Yes	No	Yes	No	Yes
Heuristic Scheduling	Yes	No	No	No	No	No	Yes	No	Yes
Resource-Aware Scheduling algorithm RASA	No	No	Yes	No	No	No	Yes	No	No
Particle Swarm Optimization	No	No	Yes	No	No	No	No	No	No
ANT colony algorithm	No	No	No	No	No	No	No	No	yes

4. RELATED WORK

Job scheduling algorithms have described by several researchers in their work. Some of the work of researchers have mentioned below.

Dipti Sharma et al, "Job Scheduling Algorithm for Computational Grid in Grid Computing Environment", [4] in the grid computing environment, the sharing of resources in an efficient manner is a big concern for several researchers. Besides this fact, it has several applications in science, medical as well as in research areas. To allocate the job to the number of users in the distributed environment is a primary factor in the grid computing so this paper presented an algorithm which scheduled the resources available in the environment accurately and proficiently.

Harshadkumar B. Prajapati et al, "Scheduling in Grid Computing Environment", [5] offered a precise view in understanding the scheduling in grid computing system. The paper has focused on the grid computing environment and discussed some vital subsystems which enabled the possibility of grid computing. Apart from the environment of the grid, paper also presented the methodology of the scheduling algorithms which can be used to evaluate both real and simulation based approaches. The presented work would be helpful for the researchers in understanding the grid computing as it provided the scheduling methodology as well as scheduling algorithms.

Rizos Sakellariou et al, "Job Scheduling on the Grid: Towards SLA-Based Scheduling", [6] argued the requirement of flexibility in the services which are offered by the Grid. From the paper, it has derived that this problem can be die out while making separate service level agreements in between the owner of the resource and the person or user who wants to submit their job on these resources. Moreover, different vision regarding to materialization had highlighted in this paper.

G. Jaspher W. Kathrine et al, "Job Scheduling Algorithms in Grid Computing – Survey",[7] reviewed several issues related to the grid environment where the number of resources has shared between the computers. The Grids can be used for several purposes. In this grid environment, job scheduling is used to schedule the user jobs and allocate the required resources to the dedicated user. This paper surveyed several job scheduling algorithms. Moreover, it has compared and contrast different job scheduling algorithms in terms of make span, flow time, resource utilization as well as the completion time.

M. Balajee et al, "Premptive Job Scheduling with Priorities and Starvation cum Congestion Avoidance in Clusters",[8] described a new mechanism which can be used to schedule the parallel jobs onto the clusters which are the part of the computational grid. This algorithm further proposed three different job queues. Thus each queue had assigned with some number of resources in each cluster. The low expected execution time and high expected execution time had allotted to the 1st and 2nd queue respectively. And the 3rd queue consisted of jobs which are treated as the part of the Meta-job from computational grid. In the 1st queue of the proposed model, there was no chance of starvation but if considered the 2nd queue then there can be a chance of having a problem of starvation. Thus, this algorithm makes use of the aging technique which had used to preempt the job having low priority. Moreover the 3rd queue was designed to execute the part of meta-jobs only. Consequently, multiple job queues were maintained in this work which are separated based upon the projected executed time for the local jobs and for the part of Meta job. Lastly, the low execution time job had been preempted with the application of aging technique. The performance of the proposed method can be evaluated through the traffic congestion where the expected execution time was compared with the total time taken for submitting the jobs and receiving the desired output from the particular node.

Jorge Manuel Gomes Barbosa et al, "Dynamic Job Scheduling on Heterogeneous Clusters", [9] addressed the job scheduling problem in dynamic environment where there are multiple users and independent jobs on the clusters such as homogenous and heterogeneous. This paper proposed two static DAG i.e. Direct Cyclic Graph schedulers for the heterogeneous machines particularly. The DAG provided the help in scheduling the parallel tasks at the right time. From the result it has acquired that proposed algorithm outperforms when compared with the other common schedulers strategies. Additionally, it assigned per job to one processor respectively.

In grid, the scheduling of jobs is difficult to achieve. The above mentioned algorithms or methodologies have been suffering from several issues which can be resolved in future.

5. CONCLUSION AND FUTURE SCOPE

The performance of several job scheduling algorithms has been compared in this paper which showed the superiority of individual. The parameters which are used for the comparison are those that can conclude the proficiency and efficiency in scheduling. From the comparison table described in this paper concluded that each algorithm has not perform well in terms of all the parameters. Moreover, the existing algorithms were mainly focused on the execution time, cost and computation cost but from the survey it has confirmed that suitable job scheduling algorithm must satisfy all the parameters mentioned in the table. It has also referred that existing optimization algorithms does not perform accordingly in terms of each parameter.

In future, more enhanced optimization algorithm or their hybridization can be applied to schedule the jobs in a system for the proper utilization of available resources.

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