# Grid Computing: Various Job Scheduling Strategies

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## ABSTRACT
Grid computing solves larger scale applications by coordinating and sharing computational power, data storage and network resources across dynamic and geographically dispersed organizations by providing high performance computing platform with the goal of providing users with access to the resources they need, even when they need. Grids provide remote access to IT assets, and aggregate processing power. The goal of scheduling is to achieve highest possible system throughput and to match the application need with the available computing resources. Scheduling onto the Grid is NP complete, so there is no best scheduling algorithm for all grid computing systems. The basic grid model generally composed of a number of hosts, each composed of several computational resources, which may be homogeneous or heterogeneous. In this article we have discussed all possible job scheduling algorithm in brief and lastly provided comparison for all.

## Keywords
Grid computing, job scheduling, scheduling algorithm

## 1. INTRODUCTION
Grid computing provides a high performance computing platform to solve larger scale applications by coordinating and sharing computational power, data storage and network resources across dynamic and geographically dispersed organizations.
The goal of a computing grid, like that of the electrical grid, is to provide users with access to the resources they need, when they need them.
Grids addresses two distinct but related goals: providing remote access to IT assets, and aggregating processing power.

Scheduling onto the Grid is NP complete, so there is no best scheduling algorithm for all grid computing systems. An alternative is to select an appropriate scheduling algorithm to use in a given grid environment because of the characteristics of the tasks, machines and network connectivity.

Job scheduling is one of the key research area in grid computing. The goal of scheduling is to achieve highest possible system throughput and to match the application need with the available computing resources.

## 2. BASIC GRID MODEL
The basic grid model generally composed of a number of hosts, each composed of several computational resources, which may be homogeneous or heterogeneous. The four basic building blocks of grid model are user, resource broker, grid information service (GIS) and lastly resources.

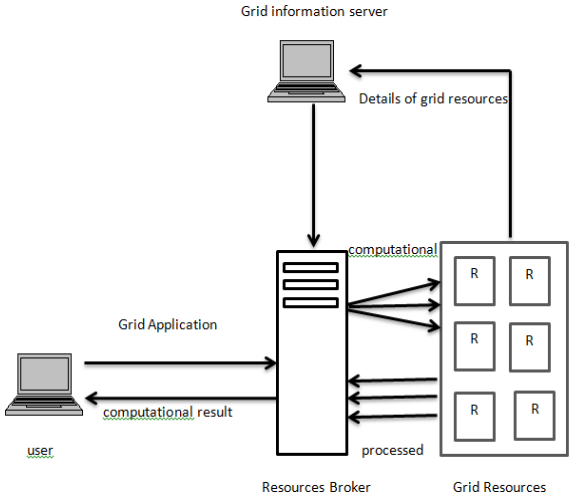


**Fig1: Basic grid model**

When user requires high speed execution, the job is submitted to the broker in grid. Broker splits the job into various tasks and distributes to several resources according to user's requirements and availability of resources. GIS keeps the status information of all resources which helps the broker for scheduling.

Job scheduling: Job scheduling is the process of mapping jobs into specific available physical resources, trying to minimize some cost function specified by the user.

This is a NP-complete problem and different heuristics may be used to reach an optimal or near optimal solution.

## 3. DIFFERENT JOB SCHEDULING ALGORITHMS

### 3.1 Efficient Utilization of Computing Resources Using Highest Response Next Scheduling in Grid (HRN)
Description: Highest Response Next Scheduling provides more responses with time, memory and CPU requirements. Here, jobs are allotted to number of processors based on job's priority and processor's capability. This scheme is adaptive for local jobs and remote jobs without any loss of performance and also highly adaptive for grid environment.
Advantages:
1) HRN with priority will effectively utilize the available resource and complete all the jobs quickly than FCFS.
2) It corrects some of the weakness of both Shortest Job First (SJF) and First Come First Serve (FCFS).
Disadvantages:
1) It is not suitable for more number of jobs allocations because finding priority of job is tedious one.
2) Higher turnaround time.

3) CPU and memory wastage.

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

Description: The Optimal Resource Constraint algorithm allocates the jobs according to processor's capability. It applies best fit algorithm followed by Round Robin (RR) scheduling which distributes the jobs among the available processors. ORC is compared with different algorithms like FCFS, SJF and RR. The comparison shows that ORC gives better performance than other algorithms in terms of turnaround time and average waiting time. It improves the efficiency of load balancing and dynamicity capability of the grid resources.

Advantages:
1) It overcomes the problem of FCFS and HRN scheduling policy as it is suitable for more number of jobs.
2) It helps to minimize the complexity of process allocation reduces the turnaround time and average waiting time of jobs in the queue.
3) It avoids starvation problem.
Disadvantage:
1) High communication overhead.

## 3.3 Hierarchical Job Scheduling for Clusters of Workstations (HJS)

Description: The scheduling model is based on a hierarchical approach using two level scheduling consisting of top level (global scheduling) and local level. The global scheduler uses single or separate queue for different type of the jobs for scheduling with the FCFS, SJF or First Fit (FF) policy. The local scheduler uses only one queue for all types of jobs with any one policy FCFS, SJF or FF. The global scheduler has a number of functions. One of these is matching of the resources requested by a job to those available in the participating clusters. Another is to obtain the best utilization of the available clusters. The local scheduler is responsible for scheduling jobs to a specific resource. At both levels, the schedulers strive to maintain a good load balance.
Advantages:
1) It tries to reduce overall turnaround time and maximize system utilization for high system loads.
2) For high system loads it uses multi queue to maintain the delay of job scheduling at global level.
Disadvantages:
1) SJF can result in extreme delays for long running jobs and also it is strongly biased against large jobs, so there may be starvation problems.
2) There may be a chance of underutilization of grid resources.
3) This algorithm does not consider the dynamic behavior of the grid resources.

## 3.4 Resource Co Allocation for Scheduling Tasks with Dependencies in grid (RCSTD)

Description: The Co Allocation scheduling algorithm provides a strategy for scheduling the tasks with dependencies in grid environment. The algorithm applies on both inside and across the clusters. Every step combines or merge the clusters (tasks inside the cluster or clusters across the cluster) based on the dependencies between the combined clusters. Thus these clusters are combined if any dependencies exist between current and previous cluster. The main goal of the algorithm is to improve efficiency in terms of load balancing and minimum time for the execution of the tasks.
Advantages:
1) Minimize Execution Time of the Task.
2) The algorithm has a dynamic nature because inside a cluster the tasks are allocated to the suitable resource on which it can be scheduled at the earliest time.
3) Due to the decentralized strategy that Co Allocation uses, the method is more reliable than a centralized one for being less subject to single point of failure.
4) This scheduling algorithm obtains good load balancing among all the resources of the system in terms of number of tasks scheduled on each resource.
Disadvantages:
1) More Communication overhead inside and across the clusters.
2) It has not specified the requirements of a task.

## 3.5 A Job Schedule Model Based on grid environment (JSMB)

Description: A Job schedule model based on Maximum Processor Utilization and Throughput (MPUT) scheduling algorithm [5] which maximizes CPU utilization and throughput at the same time and minimizes turnaround time. Grid nodes are divided into Supervisor gird node (S0), Supervisor backup node (B1), and Execute grid nodes (X1).
Advantages:
1) It uses backup node at the condition of failure of the supervisor node so it provides reliability with good load balance.
2) It maximizes CPU utilization and throughput at the same time.
3) Minimizes turnaround time.
Disadvantages:
1) High Communication overhead.
2) It does not consider any constraints of jobs and resources.

## 3.6 A Dynamic Job Grouping-Based Scheduling for Deploying Applications with Fine-Grained Tasks on Global Grids (DJGBS)

Description: A dynamic job grouping-based scheduling algorithm that groups the jobs according to MIPS of the resource. It selects resources in first come first serve order and multiplies the granularity size to increase the resource computation time. It selects jobs and assign to group job in first come first serve order and compare to resource if the group job MI is less that to resource MIPS than assign another job and this process continues until the resource MIPS is less to group job and remove very last job MI and stop the grouping procedure. When the all jobs are groups it sends to their corresponding resource.
Advantages:
1) It reduces the total processing time of jobs.
2) It maximizes the utilization of the resource.
Disadvantages:
1) It doesn't take the dynamic resource characteristics into account.
2) It does not consider the bandwidth and memory size constraints.

### 3.7 Scheduling Framework for Bandwidth-Aware Job Grouping-Based scheduling in grid computing (SFBAJG)

Description: The Bandwidth-aware scheduling schedules jobs in grid systems by taking into consideration of their computational capabilities and the communication capabilities of the resources. It uses network bottleneck bandwidth of resources to determine the priority of each resource. The job grouping approach is also used in the framework where the scheduler retrieves information of the resources processing capability. The scheduler selects the first resource and groups independent fine-grained jobs together based on chosen resources processing capability. These jobs are grouped in such a way to maximize the utilization of the resources. After grouping all the jobs sends to the corresponding resources whose connection can be finished earlier which implies that the smallest request issued through the fastest connection giving best transmission rate or bandwidth.

Advantages:

1) Minimizing the wastage of CPU power.
2) Grouping the jobs fine-grained into grouping fine-grained (coarse-grained) which will reduce the network latencies.
3) It reduces the total processing time.

Disadvantages:

1) It does not consider memory size constraint.
2) It does not take dynamic resource characteristics.
3) Preprocessing time for job grouping and resource selection is high.

### 3.8 A Bandwidth-Aware Job Grouping-Based Scheduling on Grid Environment (BAJGBS)

Description: A Bandwidth-Aware Job Grouping-Based scheduling strategy that schedules the job with MIPS and bandwidth of the resource. The grouping process is repeated until all the jobs are in groups and every group is allocated with a resource. Then, these job groups are sent to the corresponding resources based on Largest Job First (LJF) strategy and the results of the processing are sent back to the user after they have been computed at their respective resources.

The bandwidth-aware scheduling is taken as a part of the primary principle used in the proposed scheduling algorithm. The principle behind the bandwidth-aware scheduling is the scheduling priorities taking into consideration not only their computational capabilities but also the communication capabilities of the resources.

Advantages:

1) It maximizes the utilization of the resource.
2) It reduces the processing time of the jobs.

Disadvantage:

1) Algorithm doesn't take the dynamic resource characteristics into account.
2) The bandwidth strategy is not ensuring that the resource having a sufficient bandwidth to send the group job with required time.

### 3.9 Grouping-based Fine-grained Job Scheduling in grid computing (GFJS)

Description: The grouping strategy in job scheduling model is based on characteristics of resources. The fine-grained jobs grouped into forming coarse-grained are allocated to the available resources according to their processing capabilities in MIPS and bandwidth in Mb/s. The grouping algorithm integrates Greedy algorithm and FCFS algorithm to improve the processing of Fine-grained jobs.

Advantages:

1) The total overhead of fine-grained job scheduling can be reduced by grouping the light weight jobs during the scheduling process for deployment over the resources.
2) Algorithm maximizes the utilization of the resource.
3) The model reduces the execution time of jobs.
4) It reduces the network latency.
5) It reduces the total processing time.

Disadvantage:

1) It does not consider memory size constraint.
2) Preprocessing time of job grouping is high.

### 3.10 An Efficient Approach to Task Scheduling in Computational Grids (TSCG)

Description: A novel job grouping method using Particle Swarm Optimization (PSO) to reduce the communication overhead and hence enhance the speed of completion of the processes and improve resource utilization. It grouping the fine-grained jobs to coarse grained job according to resource capability (in MIPS) and apply PSO method. The aim of the scheduling is to improve the efficiency of resource and to minimize the job completion time. The proposed method improves the computation communication ratio.

Advantages:

1) It provides good load balance.
2) Algorithm maximizes the utilization of the resource.
3) It reduces the total processing time.
4) Algorithm takes the dynamic resource characteristics into account.

Disadvantage:

1) Preprocessing time of job grouping is high.
2) Time complexity is high.

## 4. COMPARISON OF VARIOUS JOB SCHEDULING ALGORITHMS

Following table shows comparison of various scheduling algorithms discussed above. The comparison is done based on mainly response time, resource utilization and load balance done with these scheduling algorithms.

**Table 1. COMPARISON OF VARIOUS JOB SCHEDULING ALGORITHMS**

| Parameter/ Paper | Architecture H/D/C | Environment HE/HO | RT | RU | LB | DY |
|---|---|---|---|---|---|---|
| HRN | D | HO | HI | HI | HI | HI |
| ORC | D | HE | HI | HI | HI | HI |
| HJS | H | HO | AVG | HI | HI | HI |
| RCSD | D | HE | AVG | LO | HI | HI |
| JSMB | D | HE | AVG | HI | HI | HI |
| DJGBS | D | HE | HI | HI | HI | HI |
| SFBAG | H | HE | HI | HI | LO | AVG |
| BAJGBS | D | HE | HI | HI | HI | HI |
| GFJS | D | HE | HI | HI | HI | HI |
| TSCG | D | HE | HI | HI | HI | HI |

Abbreviations: D-Distributed, H-Hierarchical, C-Centralized, HO-Homogenous, HE-Heterogeneous, RT-Response Time, RU- Resource Utilization, LB-Load Balance, DY-Dynamicity HI-High, AVG-Average, LO-Low

## 5. CONCLUSION

In this article we have surveyed grid computing and have discussed all possible types of job scheduling type that can be applied to schedule the various jobs in grid computing environment to improve efficiency. Lastly we have given the comparisons for all the stated type in short

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