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PERFORMANCE AND SCHEDULING OF HPC APPLICATIONS IN CLOUD

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ABSTRACT

Cloud computing is a new concept that started to widely spread with internet connection services to be a strong complemented for many services and a window for several companies and researchers to access to huge platforms with simple cost and without need to use it directly. One of the most important platforms, which most research centers or companies with a high performance computation (HPC), need it. So, this paper concerns about one of the most important problems that faces the application of this service and providing it through cloud. This problem is scheduling jobs that are needed to be executed on HPC. This paper proposed a new scheduling that takes in account the major factors related to any work (cost, time, resources, and quality) to achieve better performance with less cost and complete quality. Through experiments, we proofed that our proposed approach can overcome many previous proposed approached.

Keywords: *Cloud Computing, Scheduling algorithm, High Performance Computer, Classifier .*

1. INTRODUCTION

Cloud computing is using computer resources (hardware, software) which arrive to the user by internet as a service, and is an important idea and a platform provides shared resources for consumers at anytime and anywhere [1] , therefore at the moment most business organizations and educational institutions have become are using cloud environments as a service which focuses on providing high performance with less cost for information services by special payment model (Pay-Per-Use) or upon request. Some people know it as a new type of distributed programming so it depends on distributed computing or Grid Computing or Utility Computing or virtualization [3]. The cloud classified to three basic types public, private, and mixed [4], but wherefrom the structure, it divides to three layers as following figure.

IaaS : the service provider introduces the service to the user, and it is an infrastructure indicates to sharing hardware resources for executing the services by using virtual technology.

PaaS : includes execution software environment such as client server application.

SaaS : the is hosting on internet completely without needing to install it on user device but only need web browser. [2]

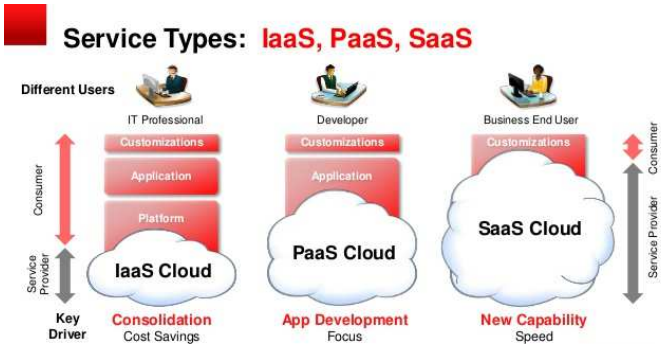

Figure1: Service Types in Cloud

State of problems:

Cloud computing recently emerged as an alternative to the giant computers for high-performance computing applications which don't need fully customized machine [5] so the focusing become on developing applications and not storing or essential structure, therefore promotion the works basis on the work not the resource which means getting creator projects in rapid time and less cost especially with ability of accessing and very large expansion and few risk [6], despite of that the cloud computing is a new important view and can take advantage from its benefits greatly especially through its integration with huge computers for

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high performance computing applications which don't need fully customized machines, but there are some challenges in the virtual environments and many limitations related to the resources and customizing them, communications, cost and time [2] therefore we find a lot of researches oriented to trying to resolve this challenges through many different ideas most of them related to scheduling the works and resources, and many algorithm and standards have proposed in this field and they will be discussed in the section of this research.

In any case, all previous proposed theories were focused on a specific type of business under certain scheduling inspired by nature or other and sent directly to the Data Center to implement it according to its available capabilities and ignoring completely this works classification by groups which facilitate the process of resource scheduling.

On other hand, these theories ignored the scheduling process of these works from the same type to implement them on a certain data center. In other words, they had enough by assigning the works according to the available resources for the data center without taking into account the idea of maximum utilization from these resources.

In this paper we presented data scheduling system management for cloud which that works are classified depending on the most important characteristics of interest to users in real life. In addition to proposing algorithm that aims to the perfect utilizing for presented resources by data centers which dealing with the cloud where these works will implemented in a way that ensure from absence of lazy nodes through meet the demand of user and absence of load balancing on the nodes.

The contributions of this paper may be summarized as following:

- Build categorized book for gathering the arriving works to the cloud in clusters according to their close characteristic and depending on data mining without any effect on rejection rate for the works that don't have the number of requested resources. (note: we can't gathering the works that have the same number of objects or the same time in one group because it does not possible in actual requests because of unlimited number of groups).
- Consideration dividing of groups according to available node locations, thus take benefits from principle of algorithm and allotment models which give better performance with less energy so safeguarding the environment.
- Build smart algorithm aims to the best using of resources (nodes) that presented by data center in short time with reliable insurance to implement all works by owning the work to its allocated resources from beginning to the end without any interruption.
- Improving the accuracy level in the expected value for activity by user through adoption pessimist | optimist principle that anchor in business management science. The average of (optimist value + 4* mean value + pessimist value).
- Implementing the justice in distributing the works better through linking the delay with cost in addition to possibility of depending on the concept of the proposed time margin.
- Evaluate the classifier and the proposed algorithm by practicability simulation and evaluate the results through some comparison to confirm on superiority of the proposed algorithm on the similar algorithm from working.

2. RELATED WORK

algorithms that concern about the size of job and the prediction of work [1].

The work could be predicted based on mathematical analysis patterns.

Experimental patterns on platform off line could be applied on a part of the work, then generalized these results on the rest of the parts [7].

Depending on comparison with historical data [7]. (in realistic life, it could not be predicted or estimated the execution time accurately, but using cloud it could be predicted depending on the paying.

Another algorithms depended on the HPC itself, where it can periodically tell the cloud about the availability degree related to the job itself. This can help for accepting or rejecting the jobs or even accepting or rejecting part of it. For the work related to the developer part, the costs can make sure to define this subject [1].

Dynamic level scheduling (DLC) [11]. It concerned about the credibility to serve the user with trust. In addition, it concerned about the time factor and

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usage of it highly decreased the failure ratio related to its assigned jobs to it. As a result, executing jobs on safe manufacture will be done, but no concern about the resources effectively.

Min-Min algorithm [12]It concerned about speed as could as possible and assigning each mission to VM which can execute the job speedily, where it preforms the short jobs firstly then the long jobs. However, here overhead with unbalancing could be occurred and may be long jobs could not be executed.

Algorithms that widely based on the performance concept through distributing the jobs (allocating) on processors through taking in account the place. For an example, given a job that needs to 10 processors, thus finding them contagiously leads to high enhancement for executing time. In addition, selecting process play a good turn also and thus there are many algorithms in this field (contagious allocation algorithms and discontiguous allocation algorithms) [8].

Stochastic Hill Climbing [15].Its principle depends on the probability in distributing the jobs, but no guarantees related to obtain true results but it minimizes the response time.

this concerns about the energy and decreasing the usage as could as possible.

Green energy efficient scheduling [16]. It relies on distributing jobs in a manner that leads to both less power consumption and generated temperatures.

Location multi objects [16].It depends on locations of processors, according to shady work, to minimize the generated energy.

Cost effective [16]. It starts with the critical jobs that have high costs then turns to the rest.

[17] distributes the resources on form of group and deal with it on this base using techniques related to groups.

there are scheduling ways also specified for cases of dealing with the jobs on various platforms or different platforms with one cloud.

algorithms based on finding the optimal solution and simulations, with other sciences, were done. The principle related to the work of all these algorithms depends on putting initial random solution, then changing the parameters to find better results and so on until to reach an acceptable performance degree or proofing that the performance is steady at certain limitation. But, these algorithms need a long time and could be descripted as complex algorithms.

Ant colony optimization [6].Its aim is to minimize the time of estimated flow of a given assignments and also minimizing the time related to usage of cloud through distributing the jobs on the processors that have less load.

Berger model [10].In this algorithm, the assigning is depending on justice for distributing the scheduled jobs based on expected cases depending on principles and theories of social wealth distribution according to state information, wage, performance, and differences with its impact of each component on the behavior of the rest.

Particle Swarm optimization [13]. It depends on the concept of self-adoption depending on the base of optimization technique and it is considered as like to genetic algorithms. It focused on decreasing the total costs in computational operations that are followed by the application.

Honey bee behavior-Generic Algorithms [16].It follows the same principle of the previous ones. But, the drawback related to all these algorithms is the long time and complexity in the process of finding the optimal solution that can match the constraints and limitations as high as possible, but it must be repeated on the new jobs at each time.

Algorithms concern about certain issues ignoring the impact of other factors.

[18] Algorithms focused on the security.

[19] It depends on costs and evaluations.

[20] It relies on quality of service regardless the other factors.

[21] the static is a steady price for certain services and this ensure the minimizing the time related to scheduling initially.

[25] Decreasing the costs of execution through collecting the deliver time of results.

[26] some researchers depends on clustering the same works that has the same conditions, but these methods are ineffective alone. This is because of the wide diversity of jobs and no complementary algorithms are existed to have benefits of collecting the results.

[27] it divided into four classes (high and low importance and high urgent or high need).

the traditional algorithms that deal with scheduling (their features are simple, understandable, most using, and most realistic).

[22] shorter job (SJS). The shortest jobs will be finished firstly to have no effect on the process of distributing the resources, but it may lead to high load in processing the big jobs.

[23] first in first out. The jobs took the resources according to their arrival. I mean queue concept will be used, but no good exploiting related to the resources.

[24] round robin (FFS) round robin algorithm.It focuses on the balancing the load distribution. It is like to traditional methods, simple, and justice

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where it allocates the load of an activity then it converts, after a period, to another activity and so on. In addition, it provides better load distribution and it is considered as dynamic, but no concern about the kind of tasks, and thus leads to long waiting time for all tasks. It could be developed through weight round robin.

Priority scheduling [14, 22]. The Priority business is very important. This is because in scheduling processing some jobs must be served better than some others, thus it is considered hard to be styed for a long time in the system. The final aim for these algorithms is to impose new priorities to the jobs though hierarchical analysis where it is depending on make decision. Thus, the job that has the highest priority will be executed first, but there is a problem of die from hunger (starvation) for the lowest priority. However, it could be developed through mixing it with a cluster where starvation problem could be solved.

.

3. PROPOSED SOLUTION

3.1 Our Proposed Approach

When we work with cloud computing, we face many difficult and challenges which we have to work with them to implement the biggest benefit of advantages of presented cloud, the most important of these challenges:[1,2,3,5,16,28]

Increase the number of customer and they request the same resources at the same time which may make a blow.

- The deficiency in distributing the load so wasting in using free resources and the load balancing on the other resources.
- Performance problem in the case of huge number of works.
- The communication and the broadband.
- Achieve greater profit implies the need to use resources in the best possible efficiency.
- Economic issues related to cost estimating.
- Quality of provided service.
- Get the best time of implementation.
- Accuracy and credibility in the final exit.
- Justice in distribution and service.
- Heterogeneous resources.
- The nature of the various businesses.
- Difficult to determine the precise time to carry out the required work.
- Increase the demand and the energy consumption that lead to a rise in temperature and a decrease in performance.
- The issue of the allocation of contiguous and non-contiguous processors.
- Link with more than one data center in some cases.
- The dynamic nature of some of the work.

All of the above means that we need to do a process to achieve greater use of available resources without affecting the service provider and that means efficient use of resources for less waste and greater speed and higher profit and better quality, all of this cannot be achieved except through resource scheduling processes for works within the cloud, and this confirms successful scheduling will give better performance, But this is not easy even now there is no unified scheduling algorithm achieve all these things, and solve all the challenges related to the work of the cloud, so we find many different algorithms and different categories have all discussed at the number and type of services that can be achieved and the challenges that worked on resolved.

Scheduling can be defined simply as task scheduling for VM adapted to the time, which involves the right to know the sequence in which tasks can be performed under the logical restrictions to achieve the highest return on less waste. There are two basic types of scheduling (scheduling of resources and use them - and scheduling of work and tasks).

All previous studies have confirmed that applications may vary performance fully when used on different platforms and this opened the door to several opportunities to improve Mapping and scheduling works HPC on the best platforms for business and when it will carry out this work [1,4,6,7,8].

From the literature view in section 2, we can gather all of the factors that depend on it in scheduling algorithms to solve some problems according to natural of the algorithm.

- The effective of using resources
- The justice allocation for resources on works
- The quality of provided service
- Time
- Cost
- Save energy as possible
- Reliability (successful of implementation)

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- Honestly and faith and fairness
- Security
- Adjustment
- Independence
- Scalability
- Load distribution
- Respond to the request time
- Business flow time
- Network performance

In addition to some characteristic related to the application [1]

- The level of activity among elements of application.
- The integration between the remote and the local.
- The homogeneity that means being in one language.
- The dynamic nature of application like deletes entity through working.
- The easy of programming and abstraction.
- Not dependent entities on each other.

((we ensured from exceeded the nature of project in the proposed algorithm by combination and specification process for resources until ending of implementation completely, that means specifying the same resources for work from start to end)).

3.2 Our Proposed Algorithm

The basic goal of proposed algorithm: Using available resources perfectly that means achieve the work in shorter time and prevent waste with ensuring from justice and reliable implementation for all works by linking it with cost directly. That means distributing the activities to the resources with achieving fastest execution and biggest using of available resources through achieving time and that reflects directly on the performance, and at the end will effect on consumption the energy while the proposed algorithm will achieve many advantages to surpass by them on the other similar algorithm wherefrom the work and the ease of implementation and the clarity of the idea by the integration of basic algorithm sections.

The following is the general outline of the proposed theory:

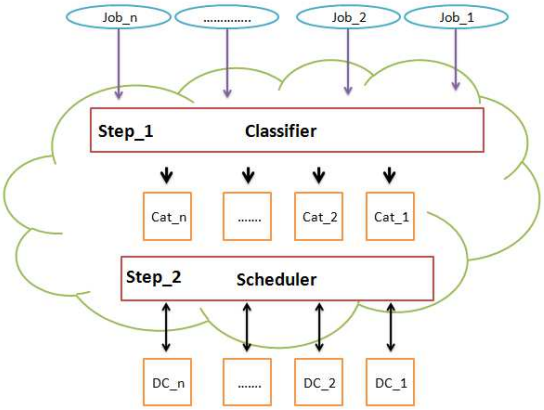

Figure2:. Our Proposed Idea

It is clear that the proposed model consists of two main steps:

The first step is building the classifier.

It is process of classifying works to homogeneous groups by a special classifier depending on data mining and machine learning and it is an adaptable dynamical process which benefits from the previous services. The following table contains measures that are used by classifier in the classification process.

Table1: User's Inputs To A Cloud

JT	Initial cost	allowed Time margin	BT	MT	ET	NR
G, H	It can become less according to the period of delay	1,2,3	X 1	X 1	X 4	X

JT: Job type (GPU or CPU).
BT: Best Time is expected to perform the Job.
MT: Worst Time is expected to perform the Job.
ET: Normal Time is expected to perform the Job.
NOR: Number of Resources.

The most important reality factors have chosen and suite with computing environment that described as the most important factors and indicate to fail or success of any project especially the projects in

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environment of works and it is the most targeting group in computing (time, resources, cost, performance).

Deeply, the target of classifier will be compilation the similar works relying on existing information in the above table where the coming work will be classified and put within the suitable group, the number of groups is determined according to DCs or to location of available nodes and thus observing the principle of customization algorithms according to the location which give big benefits in saving energy and preserving the environment.

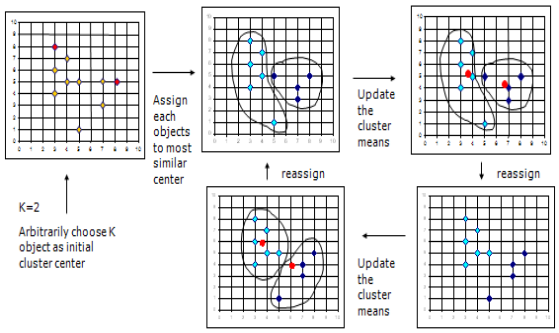

Figure3: Classifier Step

In previous figure we can show K-Mean algorithm principle of the division of the groups according to the conditions and characteristics of the input.

The second step is distributing resources algorithm as its steps show in the figure4.

This step related to provided information from the data centers. Since the maximum provided information are about the number of available resources for leasing, so the second algorithm will works on exploiting these resources perfectly to achieve the maximum benefit from these resources.

Considering the basic restrictions in cloud computing, so our proposed algorithm has to consenting these restrictions which presenting as following:

- Restrictions on time where the group of works will be done in certain time and include all works within them at the end.
- Restrictions on providing resources from data centers where there are not works within the group which need bigger number of resources from the available.
- Margin of permittivity or short delay at starting in a certain activity as result of perfect sorting, but this delay will adapting with cost fairly.

The end goal from proposed scheduling algorithm in this step is sorting works in perfect model which ensure from optimal exploitation for resources (semi symmetric use for resources with time means almost level load evenly throughout the period of ending the group works) in addition to smaller total time average for works group comparison with another algorithm.

```
Job: A (Id, N: Number of Nodes Required,T1: Max Time ,T2: Normal Time, T3: Min Time, Type, Tolerance type, Status)
T=(T1+T2*4+T3)/6
All_JOBS =10
A_N=GET TOTAL AVAILABLE NODES FROM HPC
COUNT_N_WORK=0
NUM_SERVED_JOBS=0
Select First Job from Group
NUM_SERVED_JOBS++
Update Status of Job1 to 1
SAVE JOB1 ID
COUNT_N_WORK = COUNT_N_WORK + Job1.N
While NUM_SERVED_JOBS <> ALL_JOB
    While COUNT_N_WORK <= A_N
        JS = Find Candidate where (COUNT_N_WORK + CANDIDATE.N < A_N, Tolerance, Min Time, Min Node)
        Update Status of JS to 1
        COUNT_N_WORK = COUNT_N_WORK + JS.N
        NUM_SERVED_JOBS++
        SAVE JS_ID
    END
    SORT SAVED JOBS
    FINISH MIN JOB TIME
    RESULT = RESULT + FINISH_JOB
END
PRINT RESULT
```

Figure4: Proposed Scheduling Algorithm

Relying of estimating the time of project on pessimist | optimist principle will raise the level of accuracy and reliability (optimist level+ 4* expected level + pessimist level) dividing on 6 and it gives more accurate results from the normal limiting for presented value from the developer. (in case of not ending of the activity, It can extend the allotted time with the addition of the cost.

Customization the resources on the works from the group done according to the following steps which ensure from the best distribution which giving as a simulation for project management science and distributing workers on the works in certain time. (it is possible to modify the sort of (1, 2) issues according to the priority of time and resources).

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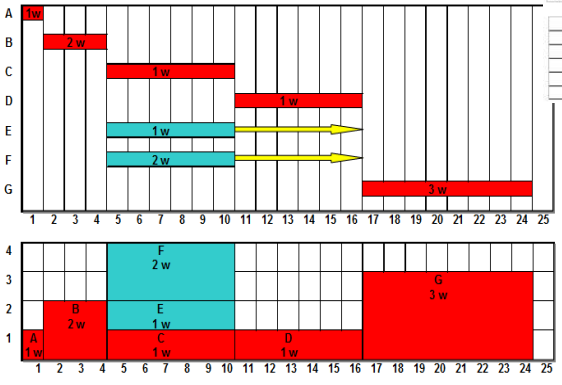
- The first activity takes the resources that allocated for it.
- In case of not using all resources by first activity, these resources will be included in unused resources within the determined number by the next activity takes into account the following issues

1- The project with least flexibility in time as possible in servicing work delayed (which pay more other)
2- In case of equality, the work with minimal period has been taken.
3- In case of equality, the work with minimal resources has been taken.
4- No works will added to the group until ensuring from termination of all works within it, so the case of starvation or lac of justice or great delay or great load wi be passed (the disadvantages whic existing in similar algorithm).
5- during the termination of the first grou the classifier initiates the second group s we ensure from dynamic process.

As result of all previous, we will ensure achievir advantages and principles a group of previou algorithms and avoid many problems ar disadvantages of them.

In the following chart showing the offset proces for some of the activities, which clarify the optima use of resources during the period of terminating a activities:



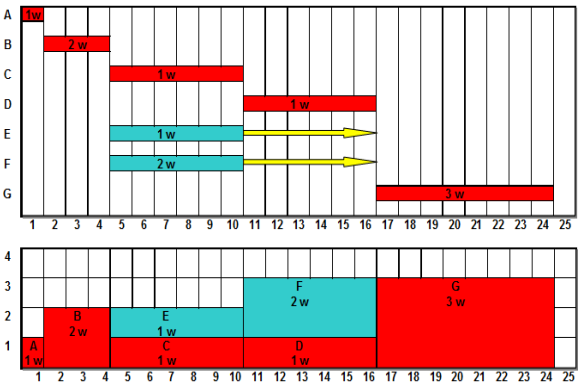


Figure5: Example For Applying Our Algorithm.

Note down the number of allocated resources from 5 to 4 with the sub-optimal use for these allocation resources during the end time of activities

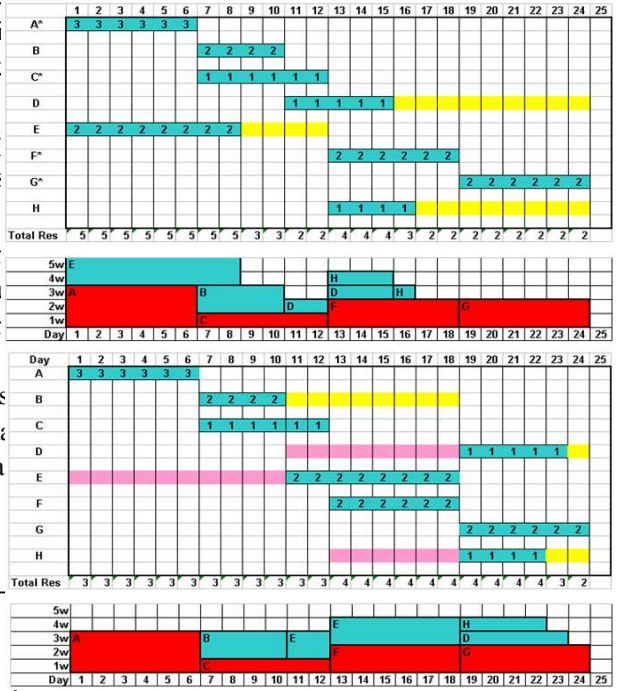


Figure6: Another Example

clarify reducing the number of resources facing a perfect allocation simple shift process for some activities.

4. EXPERIMENTAL RESULTS

The implementation process done as a simulation by using .NET environment and working with data mining algorithm for the first step and building the code for the implementation of algorithm of second step, the testing on a large number of random

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entries and comparing the results with other similar algorithms from the principle of (FCFS – Priority – SFS – RR – MRFS), the proposed algorithm proved its superiority on these algorithms in many characteristics and the most two important standards are:

- The proposed algorithm achieved a total time less than the other algorithms in the completion of all activities within the group.
- The proposed algorithm has made better use of resources is almost symmetric during the period of work and thus reducing the inactive and allocated node rate
- Cost savings for both the customer and the agency responsible for the cloud
- Clustering process gives better results as a result of its similarity to activities within the group, which improves the performance of the second algorithm
- Clustering process of similar characteristics gives the possibility of the implementation of these groups on a contiguous node as much as possible so that we achieve the principles of allocation algorithms and therefore waste less energy and a better environment.
- Clustering process ensured an end to all acts within the group fully during the available time and thus prevents time-delay of the activities and to ensure the reliability and end all activities fully.
- Clustering process ensured a continuous adaption process through preparing a second group by classifier during the period of ending the work on the first group since it has a primal projection about the number of resources that will be available after ending of the first group and it doesn't wait the information from HPC every time.
- Improving forecasting process for the activity time that provided by the user by relying on the principle of pessimist | optimist.

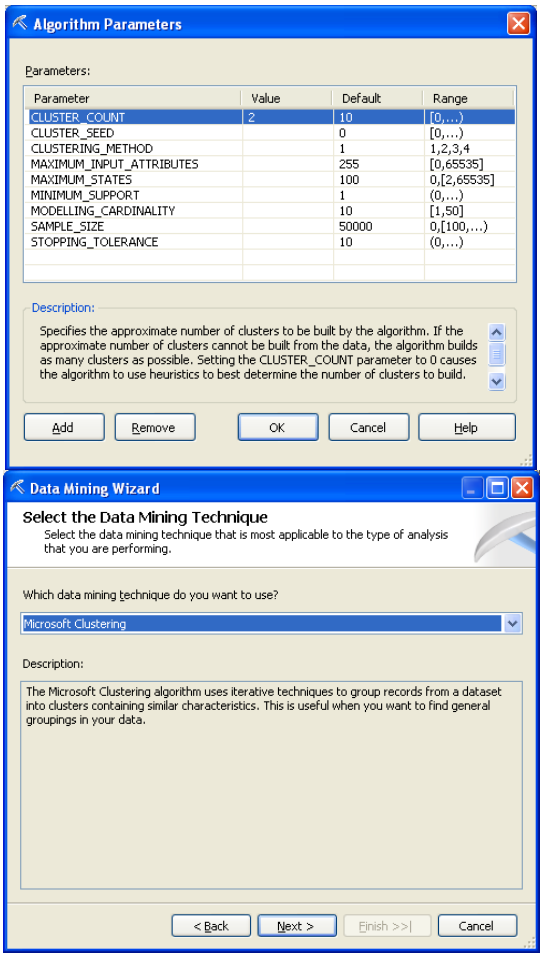

Figure7: Steps Of Classifier Implementation

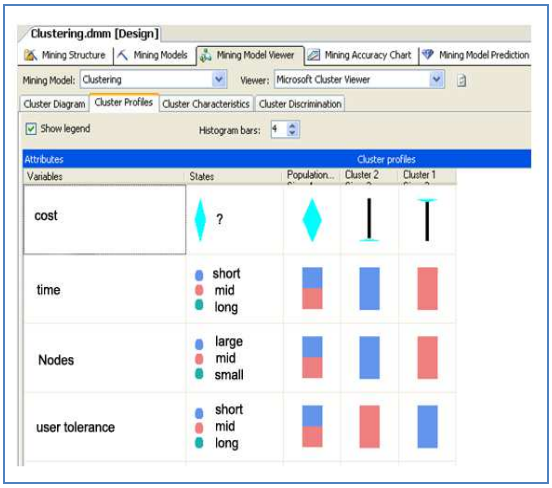

Figure8: Primary Achievement Process Of Classifier

The experimental results of the implementation of distribution algorithm on a set of activities.
For testing (We supposed the available Nodes = 10)

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Table2: Compering For Our Algorithm With Others

JOB_NUMBER	NODE REQUIERED	TIME
1	5	3
2	8	6
3	6	7
4	3	7
5	9	6
6	2	6
results (shortest)	5	3
	8	6
	9	6
	8	6
	9	1
	3	6
1.5	42	28
results (fcfo)	5	3
	8	6
	9	7
	9	6
	2	6
1.178571429	33	28
FCFS results(priority) ,	10	3
our approach	5	3
	9	1
	6	6
	8	6
	9	6
1.88	47	25

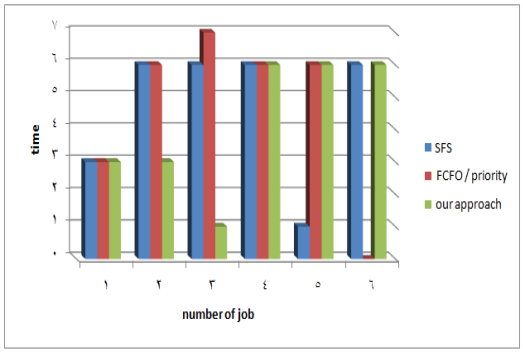

Figure9: Execution Time Cost For Jobs (Ex.1)

Here in previous Figure we can note how the our approach took the minimum average of time for execution all the jobs completely.

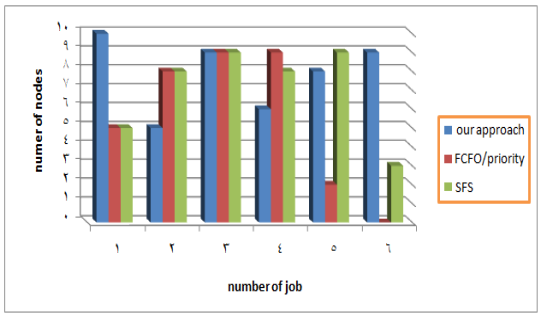

Figure10: Active Nodes During Execution (Ex.1)

Here we can note how the our approach used the maximum number of available nodes to achieve all job completely.

Table3: Other Testing For Our Approach

job number	nodes	time
1	7	1
2	3	5
3	8	2
4	9	5
5	1	7
6	5	1
results(sortest)	7	1
	5	1
	8	2
	3	5
	10	5
	1	2
2.125	34	16
results(FCFO)	10	1
	3	4
	8	2
	10	5
	6	1
	1	1
2.714285714	38	14
our approach	10	1
	9	1
	4	3
	9	2
	10	1
	9	4
4.25	51	12

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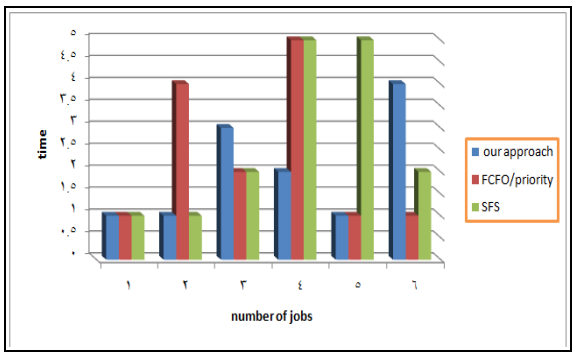

Figure11: Execution Time Cost For Jobs (Ex.2)

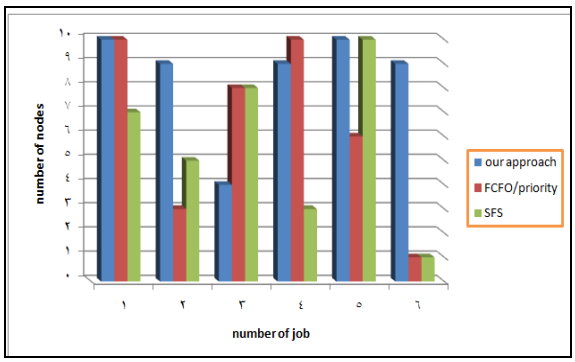

Figure12: Active Nodes During Execution (Ex.2)

5. CONCLUSION

In this paper, we presented a new scheduling algorithm specialized for cloud to scheduling the jobs that are wanted to be executed on HPC. We provided a literature review for many related previous works that concerned about scheduling, since it is considered as the most important issue and has the most impact on the cloud work success. We defined the factors that these previous works concerned about and can affect the process of scheduling. In our proposed idea, we selected the most important features related to any job (cost, time, resources, and quality). We divided our idea into two main parts. First one is to classify the jobs and collect them in homogeneous groups. Second one concerns about arranging the jobs in a manner that can achieve the whole jobs at the heist level of exploiting for available resources, with ensuring the complete execution for the whole jobs successfully, and with the lowest time costs with concerning about cost factor to be lowest as could as possible on the all sides (clients and cloud services).

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