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Enhanced Max-Min Algorithm For Resource Allocation In Cloud Computing

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Abstract

Cloud Computing is one of the leading technique which gathers together different computing techniques into one accomplishing a common objective .Cloud computing is an on-demand service because it offers dynamic flexible resource allocation for reliable and guaranteed services in pay as-you-use manner. The goal of cloud computing is to provide different services to multiple users simultaneously and efficiently. To achieve this goal adroitly, many cloud service providers face challenges to facilitate all the required resources to the users according to their demand. So the fundamental problems with cloud computing are resource allocation and resource scheduling. When scheduling resources in cloud environment, different tasks need to be executed simultaneously by the available resources in order to meet consumers' expectations and to minimize completion time. To achieve this, we proposed a new noble mechanism known as Enhanced Max-Min (EMM) algorithm. The proposed scheduling algorithm increases efficiency in terms of reducing completion time as well as average waiting time by optimizing resource allocations in the cloud. The Max-Min algorithm gives priority to tasks with maximum execution time first before assigning those with the minimum execution time. So the EMM algorithm is used to improve the delay in executing tasks with minimum execution time. CloudSim is used to compare the effectiveness of the EMM algorithm with the traditional Max-Min algorithm. The experimented results show that our Enhanced Max-Min (EMM) algorithm is efficient.

Keywords: *Cloud Computing, Resources, Resource Allocation, Tasks, Dynamic Computing, Virtual Machine , RAS, Max-Min, EMM.*

1. Introduction

Cloud computing is the current emerging technology that aims to provide the hardware and the software residing in the data centers with pay as per need policy to the users in the form of services. Basically, cloud is nothing but large pool of easily accessible and usable virtual resources. It is basically a service provisioning model that provides various kinds of agile and effective services to the consumers where everything is considered as a service [1, 2]. Cloud computing is the new computing paradigm which aims to provide reliable, customized and QoS (Quality of Services) guaranteed computing dynamic environments for end-users. Distributed computing, parallel computing and grid computing together emerged as cloud computing. The basic principle of cloud computing is that user data is not stored locally but is stored in the data center of internet [3, 4, 15].Cloud computing nowadays become quite popular among community of cloud users by offering a variety of resources and services. Cloud computing platforms, such as those provided by Microsoft, Amazon, Google, IBM, and Hewlett-Packard, let developers deploy applications across computers hosted by a central organization. Developers obtain the advantages of a managed computing platform, without having to commit resources to design, build and maintain the network [5, 13, 14].

According to the National Institute of Standards and Technology (NIST), Cloud computing exhibits various characteristics [3, 23]. These are:

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- **On-demand self-services –** A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Broad Network Access –** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous client platforms (e.g. mobile phones, laptops, and workstations).
- **Resource Pooling –** The provider's computing resources are pooled to serve multiple consumers with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- **Rapid Elasticity –** Capabilities can be elastically provisioned and released , in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
- **Measured Service –** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of services (e.g. storage, tasking, bandwidth, and active user accounts). Resources usage can be monitored, controlled, and reported transparency for both the provider and consumer of the utilized service.

Cloud computing is an accelerating technology in the field of distributed computing. It can be used in applications that include storing data, data analytics and IoT applications. It is also a technology that has changed traditional ways in which services are deployed by enterprises or individuals. It provides different types of services to registered users as web services so that the users do not need to invest in computing infrastructure. Cloud computing mainly provides services such as IaaS (Infrastructure as a Service), PaaS (Platform as a Service) & SaaS(Software as a Service). In each type of services, the users are expected to submit the requests to the service provider through the medium of the internet. The service provider is responsible for managing the resources to fulfill the requests generated by users. Service providers employ scheduling algorithms to schedule the incoming request and to manage their computing resources efficiently and effectively [6, 9, 12].

Different physical resources and virtual resources are provided to the users on demand. In cloud computing, access to the resource is based on virtualization [10, 11, 13]. Virtualization is an abstraction of real machines. Virtual Machine has ability to run applications like any real machine. Virtualization provides facilities similar to real machines. Cloud resources can be scaled rapidly using virtualization technique. Cloud resources are dynamically allocated to users on demand [11, 17, 20].

2. Resource Allocation

Resource allocation is one of the challenging tasks in cloud computing. The main goal of the resource management is to allocate resources from resource provider to resource consumers so that the users can use it to the maximum capacity [2, 4, 15, 16, 22]. With the help of virtualization technologies, which help in facilitating the multiplexing of resources makes an efficient utilization of resources. There are 4 types of resources, namely [5, 15, 19]:

1. Compute resources
2. Networking resources
3. Storage resources
4. Power resources

Resource allocation is the subpart of resource management which aims at assigning available resources in an economic way. The concern of resource allocation management is aggravating due to following two main reasons [4, 8]: one is the varying needs of the cloud users dynamically and the second is the need to fulfill the resource requirements in heterogeneous environment. Resource allocation is achieved through various task scheduling algorithm. Scheduling refers to the set of policies to control the order of tasks to be performed by a computer system [6, 15, 22]. There has been various types of scheduling algorithms existing, and task scheduling is one of them. In cloud environment, for scheduling scheme, it is difficult to schedule a set of submitted tasks from different users on a set of computing resources to minimize the completion time of tasks [7, 25, 26]. The main advantage of task scheduling algorithm is to achieve a high performance computing and the best system throughput. Scheduling manages availability of CPU & memory and good scheduling policy gives maximum utilization of resource [2, 6, 27].

Resource Allocation Strategy (RAS) [12, 15] is all about integrating cloud provider activities for utilizing and allocating scarce resources within the limit of cloud environment so as to meet the needs of the cloud applications. It requires the type and amount of resources needed by each application in order to complete a user task. The order and time of allocation of resources are also an input for an optimal RAS. An optimal RAS should avoid the following criteria [2]:

i) **Resource contention** situation arises when two applications try to access the same resource at the same time.
ii) **Scarcity of resources** arises when there are limited resources.
iii) **Resource fragmentation** situation arises when the resources are isolated. [There will be enough resources but not able to allocate to the needed application.]
iv) **Over-provisioning** of resources arises when the application gets surplus resources than the demanded one.
v) **Under-provisioning** of resources occurs when the application is assigned with fewer numbers of resources than the demand.

The major concern in cloud computing is insuring that resources are allocated effectively to cloud applications via the Internet to support cost effective and efficient use of cloud resources [16,21] for the purpose of minimizing cost and maximizing throughput. To be able to allocate resources effectively, efficiently and just-in-time, efficient cloud resource allocator mechanisms or policies is required to ensure cloud users are satisfied with the services provided [18, 24].

3. Existing Max-Min Algorithm

Max-Min algorithm chooses large tasks to be executed first before executing smaller tasks. Here the task with maximum value is selected from the set of tasks to be executed. The ready time of the node is updated by adding the execution time of the task. Finally recently scheduled task is removed from the meta-tasks set, update the completion time, then repeat until meta-tasks set become empty [7, 8].

Pseudo Code for Max-Min Algorithm:

1. For all submitted tasks in meta-task Ti
2. For all resources Rj
3.   Compute Cij=Eij+Rtj
4. While meta-task is not empty
5. Find the task Tm consumes maximum completion time
6. Assign task Tm to the resource Rj with minimum execution time
7. Remove the task Tm from meta-tasks set
8. Update Rtj for selected Rj
9. Update Cij for all Ti

Where Cij is the expected completion time, Eij is the execution time & Rtj is the ready time of the resource.

Let's take an example of Four Tasks (T1, T2, T3 & T4) and Three Resources (R1, R2 & R3) with their execution times and ready times respectively as follows:

- T1: 10
- T2: 14

- T3: 8
- T4: 4

And

- R1: 0
- R2: 1
- R3: 2

The execution of above four tasks with three resources using Max-Min algorithm is shown as follows by Gantt chart:

T2	T1	T3	T4

0 14 25 35 49

The Task completion time and waiting time are calculated as in the below table for the Max-Min algorithm.

Table 1. Completion time and Waiting time of Tasks in Max-Min Algorithm

Task Id	Task Execution Time	Task Completion Time	Task Waiting Time
T1	10	25	25-10=15
T2	14	14	14-14=0
T3	8	35	35-8=27
T4	4	49	49-4=45

From the above table, the average completion time & average waiting time are calculated. The average completion time is 30.75 & average waiting time is 21.75.Max-Min algorithm performs better in situation when the number of short task is more than the longer tasks [7, 25, 26]. In situation when the number of longer tasks to be executed is more than the shorter tasks then it takes maximum time to execute tasks completely present in the meta-task set, i.e, the completion time is maximum in such situation. Hence this algorithm is not efficient.

4. Enhanced Max-Min (EMM) Algorithm

We can reduce the Average completion time, Total completion time and Average waiting time of Max-Min algorithm by using a new approach, known as Enhanced Max-Min (EMM) algorithm. The approach is as follows: initially the task with maximum burst time is executed first then tasks with minimum burst time is selected for execution till the summation of their burst time is less than or equal to the burst time of task that has been executed recently. This procedure continues till every task in the meta- task set is executed completely.

Pseudo Code for Enhanced Max-Min Algorithm:

1. Sort the tasks in the meta-task set T in descending order
2. i= 1, j= T.length ,k=0
3. While i<=j do
4. Select resource R with minimum ready time Rt
5. Ck = Ei+ Rt

```
    k = k+1
    Update Rt for select R
    Sum= Ej
    While sum<=Ei   do
     Select resource R with minimum ready time Rt
     Ck = Ej + Rt
     K = k+1
     Update Rt for select R
     j=j-1
     Sum= Sum+ Ej
     EndWhile
     i  = i+1
EndWhile
```

Let's take the above example of Max-Min algorithm and will execute in EMM algorithm. So the Gantt chart of the execution of same four tasks with three resources is shown as follows:

T2	T4	T3	T1

0 14 19 29 44

The Task completion time and waiting time are calculated as in the below table for the EMM algorithm.

Table 2: Total Completion time and waiting time of Tasks in Enhanced Max-Min Algorithm

Task Id	Task Execution Time	Task Completion Time	Task Waiting Time
T1	10	44	44-10=34
T2	14	14	14-14=0
T3	8	29	29-8=21
T4	4	19	19-4=15

From the above table, the average completion time & average waiting time are calculated. The average completion time is 26.5 & average waiting time is 17.5.Hence it is now clear that the EMM algorithm has less average completion time & average waiting time as compared to Max-Min algorithm while four tasks with three resources are executed.

5. Results

We simulated the existing Max-Min algorithm as well as the EMM algorithm taking four, Six, Eight, Ten and Twelve Tasks with different burst times respectively. For different inputs, average completion time, total completion time & average waiting time are calculated as in below tables:

Table3. Average Completion Time of Tasks in Max-Min Algorithm & Enhanced Max-Min Algorithm

Number of Tasks	Max-Min algorithm	Enhanced Max-Min algorithm
4	30.75	26.5
6	61.66	45.16
8	108.75	88

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10	146.89	104.59
12	158.25	119.08

Table4. Total Completion Time of Tasks in Max-Min Algorithm & Enhanced Max-Min Algorithm

Number of Tasks	Max-Min algorithm	Enhanced Max-Min algorithm
4	49	44
6	112	90
8	222	192
10	310	249
12	345	291

Table5. Average Waiting Time of Tasks in Max-Min Algorithm & Enhanced Max-Min Algorithm

Number of Tasks	Max-Min algorithm	Enhanced Max-Min algorithm
4	21.75	17.5
6	51.33	34.83
8	95.87	75.12
10	135.10	92.80
12	146.58	109.41

The outputs of the calculated values of different Tasks in Max-Min Algorithm & Enhanced Max-Min Algorithm are graphically represented in figure1 to figure6 as below:

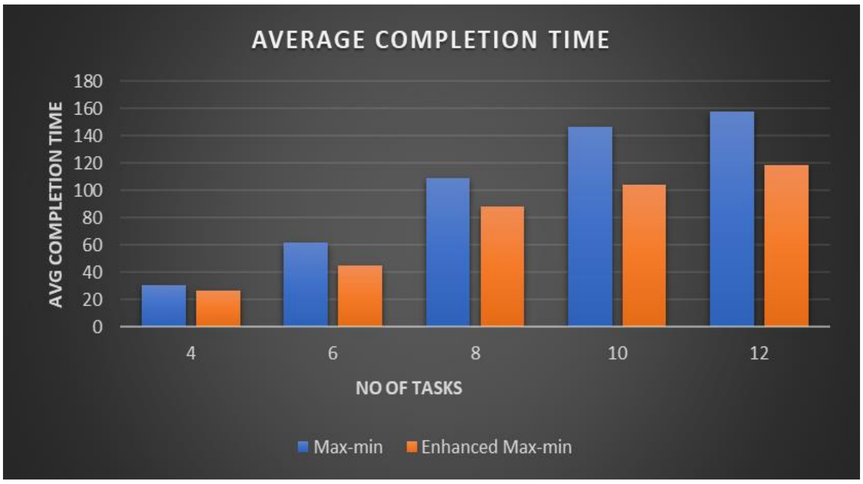

Figure 1. Comparison of Average Completion Time

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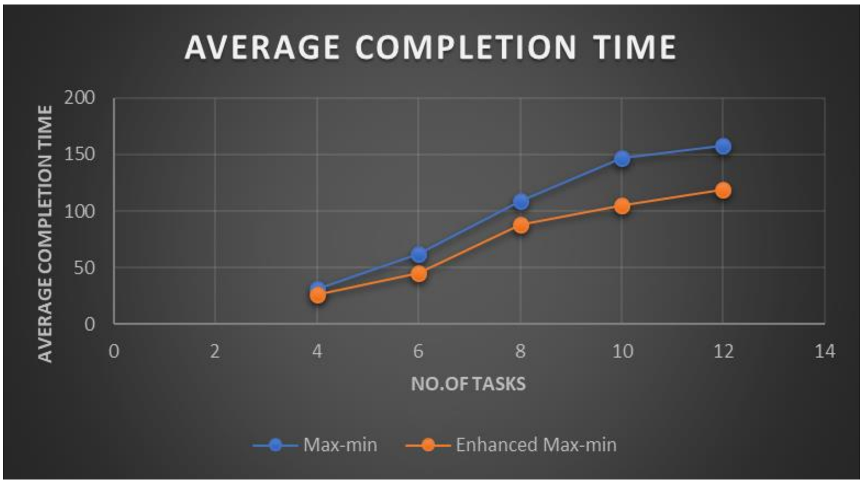

Figure 2. Comparison of Average Completion Time

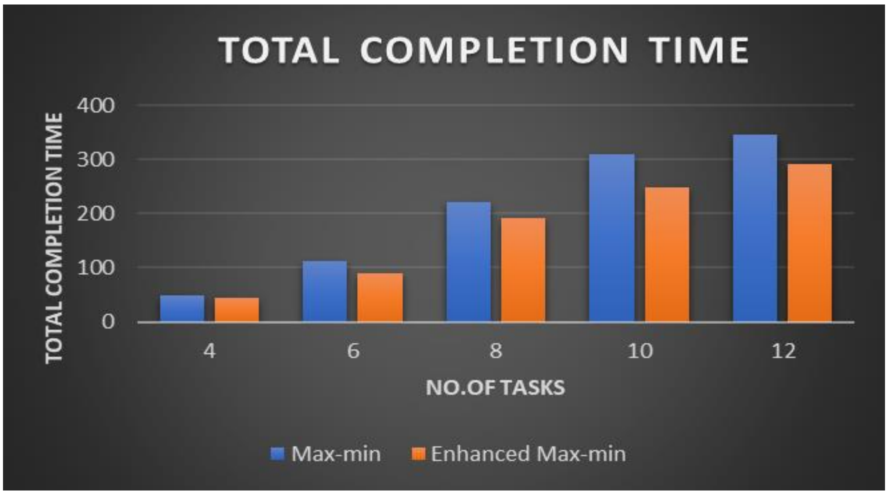

Figure 3. Comparison of Total Completion Time

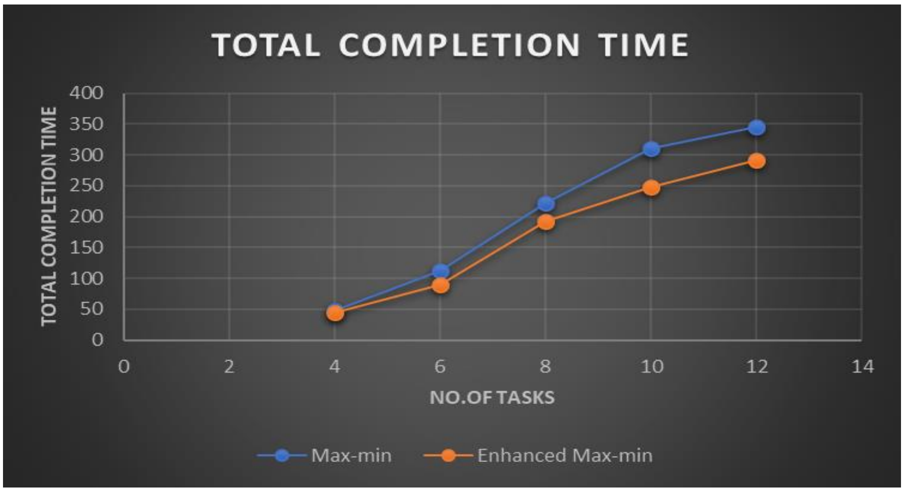

Figure 4. Comparison of Total Completion Time

Figure 5. Comparison of Average Waiting Time

Figure 6. Comparison of Average Completion Time

Therefore it's proved that the proposed Enhanced Max-Min (EMM) algorithm has less (i) average completion time (ii) total completion time & (iii) average waiting time as compared with Max-Min algorithm. Hence EMM algorithm is better and efficient for resource allocation in cloud computing.

6. Conclusion

While executing tasks using Max-Min algorithm, the task with highest burst time is executed first then subsequently the lower ones. As a result the execution of task having the lowest burst time is delayed and the completion time for the lowest task is maximum though it requires less CPU time to get executed. But in this new approach the average waiting time and total completion time are improved by not letting the task with lowest burst time to starve for long. After executing the task with highest burst time subsequently the task with lowest burst time is executed next resulting in reduced waiting time for the lowest burst time task. So EMM algorithm is more efficient and effective as compared with Max-Min algorithm for resource allocation in cloud computing. For future work, it is proposed that the research can be extended to implement the dynamic arrival of tasks. Also the swapping time of tasks should be reduced further.

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