Journal of Theoretical and Applied Information Technology
15th July 2019. Vol.97. No 13
© 2005 – ongoing JATIT & LLS
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# IMPROVING THE TASK SCHEDULING IN CLOUD COMPUTING WITH ANALYTIC HIERARCHY PROCESS

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**ABSTRACT**

Cloud Computing has been recently considered as the most demanded technology. It is a new technology that aims to provide computing resources through a network (mostly internet) with an easy use. However, since it is a new technology, it is struggling with some difficulties, one of which is Task Scheduling. The latter, not only has an important role in the Quality of Service (QoS) but also has a big impact regarding the Service Level Agreement (SLA). In this paper, we strive to use Analytic Hierarchy Process (AHP) in order to improve and give more precision for Task Scheduling in Cloud Computing environment through improving the tasks classification in the tasks priority queues. The results of this paper demonstrate that AHP can be used to give more precision for the tasks priority queues instead of the use of the traditional algorithms.

**Keywords:** *Cloud Computing, Task Scheduling, Analytic Hierarchy Process, Priority Queues.*

## 1. INTRODUCTION

Nowadays, Cloud Computing is one of the most used technology in the majority of the Information Technology (IT) solutions. It is one of the most demanded technologies for its enormous advantages in terms of availability, the number of resources, rapidity and so on. It can be used for many fields like data storage, data analytics and Internet of Things (IoT) applications. Cloud Computing is a type of paralleled and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource. In Cloud Computing, the services are provided through (infrastructure as a service, software as a service, and platform as a service, etc.). In each one of these services, Cloud service consumers submit their request (tasks) through a network (generally internet) [1]. In fact, this new technology is based on other technologies that grant it more performance and rapidity, the most important of which is virtualization. It is the creation of multiple virtual machines that share the same physical resources and act as real machines. These virtual machines are managed by Virtual Machine Manager (VMM) as specific software which can give them the ability to share resources without any conflict [2]. However, every technology in its first stages is challenged by some difficulties that affect its performance such as security, task scheduling, load balancing, migration and so on.

In Cloud Computing, the Cloud Service Provider (CSP) is the only responsible for managing the resources to execute the tasks generated by the Cloud Service Consumers (CSCs). For this reason, the CSPs use the task scheduling, which is the process by which the incoming tasks are mapped to the available resources on the base of different criteria, including the criteria related to the tasks or to the resources [3, 4, 5, 6, 7 and 8]. Therefore, choosing the most suitable criteria with the most efficient task scheduling algorithms could improve the performances, maximizing the revenues, the utilization of resources, and respecting as much as possible the SLA which is a contract signed between the CSCs and the CSPs to guarantee the rules of interaction between the contractors [9]. Thus, in order to overcome such constraints, there is a need for a global strategy in which all the sides of scheduling are clear and optimized. Recently, the use of AHP in some new technologies has given important results regarding the importance of some critical decisions, especially the ones that have an impact on the final targets. AHP is developed by Thomas L. Saaty in the 1970s as a structured technique to organize and analyze complex decisions, based on psychology and mathematics. It starts by creating a hierarchy that contains all information about the problem, then evaluating its elements by comparing them to each other two by two, taking into consideration the elements following in the hierarchy. One of the decision situations to which the AHP can be applied are: choice, ranking, prioritization, resource allocation, benchmarking, quality management and conflict resolution [10, 11, 12]. In this paper, our objective is to improve our work in which we proposed a priority task scheduling strategy for a heterogeneous multi-data-center in Cloud Computing environment [13]. In our previous paper, especially in the part of the task classification, we used multi priority queues and in each one of them we applied First In First Out (FIFO) algorithm as a task classifier, after a main classification which was the main contribution. In this paper, our intention is to improve our strategy through updating this part by the use of AHP instead of FIFO in the main priority queue, which can give more precision in the choice of the tasks to be executed in the last step of the task scheduling process. In the cloud computing, the tasks have different characteristics: such as the task deadline, the task length, the bandwidth requirement, .etc. Moreover, the tasks must be scheduled in the real time and executed on different resources with different capacities. Thus, there are many criteria that could be used to define the tasks priority either for the tasks scheduling or for the tasks classification. Furthermore, there are some criteria that change in the time (waiting time in the queue or the task age). In fact, in the literature, there are many works that propose tasks scheduling algorithms. However, the majority of them didn't propose a real tasks scheduling strategy taking into account the change over time of the tasks characteristics and the importance of increasing the tasks priority for those who have lower priority in order to respect their deadlines. Most of the works are based on one parameter (often the Makespan) [3] and others didn't specify exactly what the priority is and let the choice to the users to define it [5]. Hence, the motivation behind this work is to improve the task classification inside the highest priority queue in order to prevent tasks from exceeding their deadline. The remaining part of this paper is organized as follow: in the following section we shall present some related works that have a relationship with priority and AHP. In section 3 we shall demonstrate our contribution; and finally, the last section is the conclusion and an overview on our future research work.

## 2. RELATED WORK

In the literature, we found out that many researchers tried to use AHP in different subjects to solve their problems either for IT (Information Technology) field or other fields. However, in the task scheduling contributions, we didn't find any work that uses the automatic classification beside the experts' opinion. While our contribution is a new classification model which benefits of the automatic classification and the experts' opinions for task classification. In the following some work that use AHP in their contribution.

In [14] the authors used the AHP for optimal resource allocation in Cloud Computing environment. They used as criteria: network bandwidth, complete time, task cost and reliability of tasks. In [15, 16] the authors used modified AHP for task scheduling in Cloud Computing environment, relying on the criteria: task length and task run time. Besides the modified AHP, they used the longest expected processing time preemption to preempt resources intensive task, bandwidth aware divisible scheduling to manage the bandwidth, divide-and-conquer methods and BAR optimization with the BATS to manage the resource allocation. In [17] the authors used AHP for implementing a new priority based job scheduling algorithm (PJSC) in Cloud Computing environment, using as criteria: the resources performance. In [18] the authors used AHP for proposing a task scheduling algorithm, based on the criteria: VMs performance. In addition to AHP, they proposed the use of the task classification and the VM categorization to reduce the number of comparison in the pair wise comparison matrix for improving the consistency ratio. In [19] the authors used AHP for proposing the dynamic level task scheduling algorithm, following the criteria: priority, Time Scheduling Bottom Line, profit, and resource risk. In [20] the authors used AHP for proposing a scheduling model by prioritizing tasks, relying on the criteria: bandwidth, RAM, MIPS, Computing Power and Storage. In [21] the authors used AHP to propose a scheduling algorithm for improving the resource allocation in Cloud Computing environment, with the criteria: user ranking, computation time, storage and number of cores. In [22] the authors used AHP for improving the backfilling algorithm to choose the suitable lease from the best effort queue which provides free slots to allocate deadline sensitive lease, using as criteria: deadline, duration and start time. In [23] the authors used AHP to propose a task scheduling algorithm for green data-center in

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

order to evaluate the load task, based on the criteria: CPU, Memory, hard disk I/O and network bandwidth. Besides AHP, they used the neural network to predict energy consumption. In [24], the authors used AHP for ranking application in order to serve resources, relying on the criteria: reliability, bandwidth, completion time and cost level analysis during the application prioritization. In [25] the authors used AHP as well as a multi-objective optimization algorithm CNSGA to propose a multiple-criteria decision mechanism for the automatic test task scheduling problem, adopting the criteria: Makespan and mean workload. In this proposition AHP is used most of all for the final decision making process and chooses a best schedule from the solutions obtained by CNGSA. In [26] the authors used AHP besides practical swarm optimization (PSO) algorithm to propose an efficient dynamic priority-queue (DPQ) algorithm for task scheduling in the cloud computing environment. In [27] the authors used AHP to propose a priority-based job scheduling algorithm. The proposition is divided in two steps: in the first step, they assigned priority according to the importance of the task. In the second one, the task is allocated to the optimal resource (VM) by the AHP algorithm calculation, using as criteria: response time, system load and cost. In [28], the authors classified the (QoS) factors into four classes, after that, they used AHP to be the weight deciding method in order to help users to decide the class weight and avoid judgment logical error. After that, they improved PSO scheduling by using of AHP, based on different (QoS) classes to make practical swarm optimization (PSO) so as to have (QoS) preference awareness ability.

## 3. TASK SCHEDULING USING THE ANALYTIC HIERARCHY PROCESS

In Cloud Computing environment, there are many tasks that keep coming to the CSP resources to be executed as soon as possible in the available of them. On the one hand, the tasks have different criteria, and on the other, the resources have different capacity. Hence, task scheduling is known as a complicated process due to the complexity of assigning multiple different tasks criteria to different capacity resources. Thus, in this paper and as an improvement for the task scheduling in Cloud Computing, we use the AHP algorithm for optimizing the final priority queue because it can give us the possibility to make the tasks classifications better with the benefit of the experts' opinions. Moreover, in our previous work [13], FIFO just manage the arrived tasks without any constraints, while AHP take in consideration the tasks constraints and benefit from the experts opinions which can give better queue management. Furthermore, the task scheduling constraints can be change from one client to another according to the type of request. In this paper, we have taken the most used constraints in the literature, which represents for us the opinion of experts. In the following, there is the framework used in the task scheduling process:

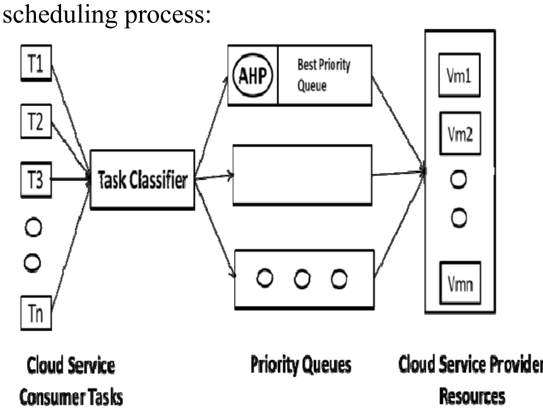


*Figure 1 : Task Scheduling Framework*

In the proposed framework, the tasks are classified into different priority queues. The first is the most important one as a result of its being the only queue by which the tasks are going to the final resources (VMs), which means that it is the last step of the task scheduling process. In this paper, our contribution is manifested in the optimization of this queue through using the AHP to give more precision to the final tasks classification.

In fact, there are different criteria that can be used to choose tasks according to their importance. However, there are some criteria that have a bigger impact than others in terms of specific measurements and requirements, especially for the measurements that have a relationship with the QoS and the response time.

After reviewing all the parameters that are used in AHP in Cloud Computing literature, we have chosen the most important of them. On the one hand, they respond to our requirements (task scheduling purpose), and on the other, they have an impact on the QoS and the response time. Firstly, we have chosen the deadline because it is one of the most important parameters that have to be taken into account in order to respect the SLA. Secondly, we have favored the length by the reason of its big impact on the resource availability, especially for the tasks that have a big length and take a much

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

longer time to be executed than a task that has a small length. Finally, we have chosen the age as an important parameter because it has a big impact on the waiting time in the queues.

According to Saaty, for using AHP, there are a number of steps that have to be followed. The first one is the creation of the hierarchy, which is very important for having a global view of the whole problem and its challenges. In the following, there is the decision hierarchy structure:

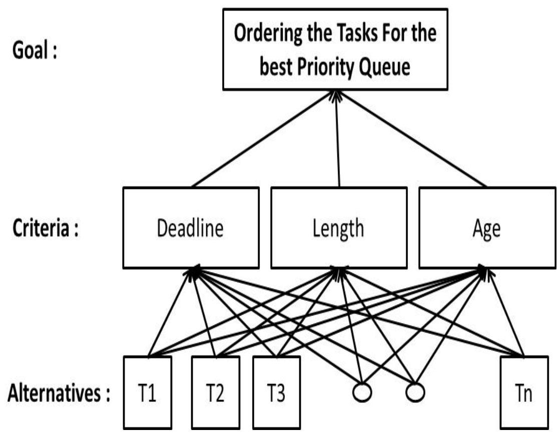


*Figure 2 : Decision Hierarchy Structure*

By the end of making the decision hierarchy structure, we have to pass to the second step, which is the determination of priorities for the tasks (Alternatives) and for the criteria (parameters). Thus, we have to make a Pair wise comparison between alternatives (Tasks) depending on each criterion and comparison between criteria (parameters) depending on the final objective. After the comparison is finished, we have to enter all the results into a matrix, which is processed mathematically to derive the priorities for tasks and criteria. As a final step, we have to check the consistency. This latter is very important in terms of the coherence and the logic in the decisions. It is a measurement that indicates if each comparison matrix has a logically reasonable value which has to be less than 0.1 in order to guarantee a good coherence [10, 11, and 12].

In order to put AHP on the task scheduling process, we applied AHP in an illustrative example where we started by comparing the alternatives (tasks), then we compared the criteria and finally we made the decision matrix.

## 2.1 Alternative Comparison

As an illustrative example for this experiment, we supposed that the first priority queue gets ten classified tasks with different parameters and needs to be reclassified so to have a more precise classification before the final assignment to the resources (VMs).

The tasks' values used in this example are taken through a random system; and the obtained tasks' values are summarized in the table below:

*Table 1 : Tasks Values*

| Tasks | Deadline | Length | Age |
|---|---|---|---|
| 1 | 531 | 873 | 750 |
| 2 | 36 | 988 | 922 |
| 3 | 392 | 657 | 901 |
| 4 | 545 | 686 | 516 |
| 5 | 111 | 518 | 310 |
| 6 | 607 | 967 | 395 |
| 7 | 572 | 131 | 415 |
| 8 | 723 | 883 | 735 |
| 9 | 811 | 440 | 525 |
| 10 | 72 | 655 | 652 |

As a first step in AHP mechanism, we have to compare each task value to the other. Then, we have to judge which task is weaker according to the criterion in consideration. If after the judgment, we find the weakest task, we have to determine the relative importance between the two compared tasks. In this step, there is a need to the AHP fundamental scale to give the suitable relative importance [10, 11, and 12]. The fundamental scale is composed of nine intensity importance elements, and the choice between them has to be framed by a logic judgment. As a result of this, we used a number of constraints to determine the most suitable intensity importance that we can have. In the following, there is the proposed relative importance table:

*Table 2: the relative importance*

| Criteria | Priority | Intensity important |
|---|---|---|
| Tb = Ts | Normal | 1 |
| 1 < Tb/Ts<=2 | Between Equal and normal | 2 |
| 2 <Tb/Ts<=3 | Normal | 3 |
| 3 <Tb/Ts<=4 | Between Normal and Moderate importance | 4 |
| 4 <Tb/Ts<=5 | Moderate importance | 5 |
| 5 <Tb/Ts<=6 | Between Moderate | 6 |

Journal of Theoretical and Applied Information Technology
15th July 2019. Vol.97. No 13
© 2005 – ongoing JATIT & LLS

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

| | | |
|---|---|---|
| | Importance and strong importance | |
| 6 <Tb/Ts<=7 | Strong importance | 7 |
| 7 <Tb/Ts<=8 | Between Strong importance and extreme importance | 8 |
| 8 <Tb/Ts | Extreme importance | 9 |

Tb= The biggest task in term of the comparison parameter.

Ts= The smallest task in term of the comparison parameter.

For the deadline and the length, the smallest parameter is the most important, and for the age the biggest parameter is the most important.

Using the relative importance table and the tasks value table, we completed the AHP tasks criteria weight. In the following the results according to each criterion:

*Table 3: Tasks weights according to the deadline*

| | | | | |
|---|---|---|---|---|
| T1 | 1 | T2 | 9 | T2 is extremely important than T1 |
| T1 | 1 | T3 | 2 | T3 is between equal and moderate important than T1 |
| T1 | 2 | T4 | 1 | T1 is between equal and moderate important than T4 |
| T1 | 1 | T5 | 5 | T5 is strongly important than T1 |
| T1 | 2 | T6 | 1 | T1 is between equal and moderate important than T6 |
| T1 | 2 | T7 | 1 | T1 is between equal and moderate important than T7 |
| T1 | 2 | T8 | 1 | T1 is between equal and moderate important than T8 |
| T1 | 2 | T9 | 1 | T1 is between equal and moderate important than T9 |
| T1 | 1 | T10 | 8 | T10 is between very strong and extremely important than T1 |
| T2 | 9 | T3 | 1 | T2 is extremely important than T3 |
| T2 | 9 | T4 | 1 | T2 is extremely important than T4 |
| T2 | 4 | T5 | 1 | T2 is between moderate and strong important than T5 |
| T2 | 9 | T6 | 1 | T2 is extremely important than T6 |
| T2 | 9 | T7 | 1 | T2 is extremely important than T7 |
| T2 | 9 | T8 | 1 | T2 is extremely important than T8 |
| T2 | 9 | T9 | 1 | T2 is extremely important than T9 |
| T2 | 3 | T10 | 1 | T2 is moderately important than T10 |
| T3 | 2 | T4 | 1 | T3 is between equal and moderate important than T4 |
| T3 | 1 | T5 | 4 | T5 is between moderate and strongly important than T3 |
| T3 | 2 | T6 | 1 | T3 is between equal and moderate important than T6 |
| T3 | 2 | T7 | 1 | T3 is between equal and moderate important than T7 |
| T3 | 2 | T8 | 1 | T3 is between equal and moderate important than T8 |
| T3 | 3 | T9 | 1 | T3 is moderately important than T9 |
| T3 | 1 | T10 | 6 | T10 is between strong and very strong important than T3 |
| T4 | 1 | T5 | 5 | T5 is strongly important than T4 |
| T4 | 2 | T6 | 1 | T4 is between equal and moderate important than T6 |
| T4 | 2 | T7 | 1 | T4 is between equal and moderate important than T7 |
| T4 | 2 | T8 | 1 | T4 is between equal and moderate important than T8 |
| T4 | 2 | T9 | 1 | T4 is between equal and moderate important than T9 |
| T4 | 1 | T10 | 8 | T10 is between very strong and extremely important than T4 |
| T5 | 6 | T6 | 1 | T5 is between strong and very strong important than T6 |
| T5 | 6 | T7 | 1 | T5 is between strong and very strong important than T7 |
| T5 | 7 | T8 | 1 | T5 is very strongly important than T8 |
| T5 | 8 | T9 | 1 | T5 is between very strong and extremely important than T9 |
| T5 | 1 | T10 | 2 | T10 is between equal and moderate important than T5 |
| T6 | 1 | T7 | 2 | T7 is between equal and moderate important than T6 |
| T6 | 2 | T8 | 1 | T6 is between equal and moderate important than T8 |
| T6 | 2 | T9 | 1 | T6 is between equal and moderate important than T9 |
| T6 | 1 | T10 | 9 | T10 is extremely important than T6 |
| T7 | 2 | T8 | 1 | T7 is between equal and moderate important than T8 |
| T7 | 2 | T9 | 1 | T7 is between equal and moderate important than T9 |
| T7 | 1 | T10 | 8 | T10 is between very strong and extremely important than T7 |
| T8 | 2 | T9 | 1 | T8 is between equal and moderate important than T9 |
| T8 | 1 | T10 | 9 | T10 is extremely important than T8 |
| T9 | 1 | T10 | 9 | T10 is extremely important than T9 |

Journal of Theoretical and Applied Information Technology
15th July 2019. Vol.97. No 13
© 2005 – ongoing JATIT & LLS
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

*Table 4: Tasks weights according to the length*

| | | | | |
|---|---|---|---|---|
| T1 | 2 | T2 | 1 | T1 is between equal and moderate important than T2 |
| T1 | 1 | T3 | 2 | T3 is between equal and moderate important than T1 |
| T1 | 1 | T4 | 2 | T4 is between equal and moderate important than T1 |
| T1 | 1 | T5 | 2 | T5 is between equal and moderate important than T1 |
| T1 | 2 | T6 | 1 | T1 is between equal and moderate important than T6 |
| T1 | 1 | T7 | 7 | T7 is very strongly important than T1 |
| T1 | 2 | T8 | 1 | T1 is between equal and moderate important than T8 |
| T1 | 1 | T9 | 2 | T9 is between equal and moderate important than T1 |
| T1 | 1 | T10 | 2 | T10 is between equal and moderate important than T1 |
| T2 | 1 | T3 | 2 | T3 is between equal and moderate important than T2 |
| T2 | 1 | T4 | 2 | T4 is between equal and moderate important than T2 |
| T2 | 1 | T5 | 2 | T5 is between equal and moderate important than T2 |
| T2 | 1 | T6 | 2 | T6 is between equal and moderate important than T2 |
| T2 | 1 | T7 | 8 | T7 is between very strong and extremely important than T2 |
| T2 | 1 | T8 | 2 | T8 is between equal and moderate important than T2 |
| T2 | 1 | T9 | 3 | T9 is moderately important than T2 |
| T2 | 1 | T10 | 2 | T10 is between equal and moderate important than T2 |
| T3 | 2 | T4 | 1 | T3 is between equal and moderate important than T4 |
| T3 | 1 | T5 | 2 | T5 is between equal and moderate important than T5 |
| T3 | 2 | T6 | 1 | T3 is between equal and moderate important than T6 |
| T3 | 1 | T7 | 6 | T7 is between strong and very strong important than T3 |
| T3 | 2 | T8 | 1 | T3 is between equal and moderate important than T3 |
| T3 | 1 | T9 | 2 | T9 is between equal and moderate important than T3 |
| T3 | 1 | T10 | 2 | T10 is between equal and moderate important than T3 |
| T4 | 1 | T5 | 2 | T5 is between equal and moderate important than T3 |
| T4 | 2 | T6 | 1 | T4 is between equal and moderate important than T6 |
| T4 | 1 | T7 | 6 | T7 is between strong and very strong important than T4 |
| T4 | 2 | T8 | 1 | T4 is between equal and moderate important than T8 |
| T4 | 1 | T9 | 2 | T9 is between equal and moderate important than T4 |
| T4 | 1 | T10 | 2 | T10 is between equal and moderate important than T4 |
| T5 | 2 | T6 | 1 | T5 is between equal and moderate important than T6 |
| T5 | 1 | T7 | 4 | T7 is between moderate and strong important than T5 |
| T5 | 2 | T8 | 1 | T5 is between equal and moderate important than T8 |
| T5 | 1 | T9 | 2 | T9 is between equal and moderate important than T5 |
| T5 | 2 | T10 | 1 | T5 is between equal and moderate important than T10 |
| T6 | 1 | T7 | 8 | T7 is between very strong and extremely important than T6 |
| T6 | 1 | T8 | 2 | T8 is between equal and moderate important than T6 |
| T6 | 1 | T9 | 3 | T9 is moderately important than T6 |
| T6 | 1 | T10 | 2 | T10 is between equal and moderate important than T6 |
| T7 | 7 | T8 | 1 | T7 is very strongly important than T8 |
| T7 | 4 | T9 | 1 | T7 is between moderate and strong important than T9 |
| T7 | 5 | T10 | 1 | T7 is strongly important than T10 |
| T8 | 1 | T9 | 3 | T9 is moderately important than T8 |
| T8 | 1 | T10 | 2 | T10 is between equal and moderate important than T8 |
| T9 | 2 | T10 | 1 | T9 is between equal and moderate important than T10 |

*Table 5: Tasks weights according to the age*

| | | | | |
|---|---|---|---|---|
| T1 | 1 | T2 | 2 | T2 is between equal and moderate important than T1 |
| T1 | 1 | T3 | 2 | T3 is between equal and moderate important than T1 |
| T1 | 2 | T4 | 1 | T1 is between equal and moderate important than T4 |
| T1 | 3 | T5 | 1 | T1 is moderately important than T5 |
| T1 | 2 | T6 | 1 | T1 is between equal and moderate important than T6 |
| T1 | 2 | T7 | 1 | T1 is between equal and moderate important than T7 |
| T1 | 2 | T8 | 1 | T1 is between equal and moderate important than T8 |
| T1 | 2 | T9 | 1 | T1 is between equal and moderate important than T9 |
| T1 | 2 | T10 | 1 | T1 is between equal and moderate important than T10 |
| T2 | 2 | T3 | 1 | T2 is between equal and moderate important than T3 |
| T2 | 2 | T4 | 1 | T2 is between equal and moderate important than T4 |
| T2 | 3 | T5 | 1 | T2 is moderately important than T5 |
| T2 | 3 | T6 | 1 | T2 is moderately important than T6 |

Journal of Theoretical and Applied Information Technology
15th July 2019. Vol.97. No 13
© 2005 – ongoing JATIT & LLS
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

| | | | | |
|---|---|---|---|---|
| T2 | 3 | T7 | 1 | T2 is moderately important than T7 |
| T2 | 2 | T8 | 1 | T2 is between equal and moderate important than T8 |
| T2 | 2 | T9 | 1 | T2 is between equal and moderate important than T9 |
| T2 | 2 | T10 | 1 | T2 is between equal and moderate important than T10 |
| T3 | 2 | T4 | 1 | T3 is between equal and moderate important than T4 |
| T3 | 3 | T5 | 1 | T3 is moderately important than T5 |
| T3 | 3 | T6 | 1 | T3 is moderately important than T6 |
| T3 | 3 | T7 | 1 | T3 is moderately important than T7 |
| T3 | 2 | T8 | 1 | T3 is between equal and moderate important than T8 |
| T3 | 2 | T9 | 1 | T3 is between equal and moderate important than T9 |
| T3 | 2 | T10 | 1 | T3 is between equal and moderate important than T10 |
| T4 | 2 | T5 | 1 | T4 is between equal and moderate important than T5 |
| T4 | 2 | T6 | 1 | T4 is between equal and moderate important than T6 |
| T4 | 2 | T7 | 1 | T4 is between equal and moderate important than T7 |
| T4 | 1 | T8 | 2 | T8 is between equal and moderate important than T4 |
| T4 | 1 | T9 | 2 | T9 is between equal and moderate important than T4 |
| T4 | 1 | T10 | 2 | T10 is between equal and moderate important than T4 |

| | | | | |
|---|---|---|---|---|
| T5 | 1 | T6 | 2 | T6 is between equal and moderate important than T5 |
| T5 | 1 | T7 | 2 | T7 is between equal and moderate important than T5 |
| T5 | 1 | T8 | 3 | T8 is moderately important than T5 |
| T5 | 1 | T9 | 2 | T9 is between equal and moderate important than T5 |
| T5 | 1 | T10 | 3 | T10 is moderately important than T5 |
| T6 | 1 | T7 | 2 | T7 is between equal and moderate important than T6 |
| T6 | 1 | T8 | 2 | T8 is between equal and moderate important than T6 |
| T6 | 1 | T9 | 2 | T9 is between equal and moderate important than T6 |
| T6 | 1 | T10 | 2 | T10 is between equal and moderate important than T6 |
| T7 | 1 | T8 | 2 | T8 is between equal and moderate important than T7 |
| T7 | 1 | T9 | 2 | T9 is between equal and moderate important than T7 |
| T7 | 1 | T10 | 2 | T10 is between equal and moderate important than T7 |
| T8 | 2 | T9 | 1 | T8 is between equal and moderate important than T9 |
| T8 | 2 | T10 | 1 | T8 is between equal and moderate important than T10 |
| T9 | 1 | T10 | 2 | T10 is between equal and moderate important than T9 |

Using an online AHP calculator [29], we got the following results. The comparison for the deadline is summarized in the table 6:

*Table6: Deadline Comparison*

| Deadline | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 1.000000 | 0.111111 | 0.500000 | 2.000000 | 0.200000 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 0.125000 |
| T2 | 9.000000 | 1.000000 | 9.000000 | 9.000000 | 4.000000 | 9.000000 | 9.000000 | 9.000000 | 9.000000 | 3.000000 |
| T3 | 2.000000 | 0.111111 | 1.000000 | 2.000000 | 0.250000 | 2.000000 | 2.000000 | 2.000000 | 3.000000 | 0.166667 |
| T4 | 0.500000 | 0.111111 | 0.500000 | 1.000000 | 0.200000 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 0.125000 |
| T5 | 5.000000 | 0.250000 | 4.000000 | 5.000000 | 1.000000 | 6.000000 | 6.000000 | 7.000000 | 8.000000 | 0.500000 |
| T6 | 0.500000 | 0.111111 | 0.500000 | 0.500000 | 0.166667 | 1.000000 | 0.500000 | 2.000000 | 2.000000 | 0.111111 |
| T7 | 0.500000 | 0.111111 | 0.500000 | 0.500000 | 0.166667 | 2.000000 | 1.000000 | 2.000000 | 2.000000 | 0.125000 |
| T8 | 0.500000 | 0.111111 | 0.500000 | 0.500000 | 0.142857 | 0.500000 | 0.500000 | 1.000000 | 2.000000 | 0.111111 |
| T9 | 0.500000 | 0.111111 | 0.333333 | 0.500000 | 0.125000 | 0.500000 | 0.500000 | 0.500000 | 1.000000 | 0.111111 |
| T10 | 8.000000 | 0.333333 | 6.000000 | 8.000000 | 2.000000 | 9.000000 | 8.000000 | 9.000000 | 9.000000 | 1.000000 |
| Priority | 0.042945 | 0.365176 | 0.053106 | 0.037357 | 0.157986 | 0.027581 | 0.032040 | 0.023666 | 0.019575 | 0.240568 |
| Rank | 5 | 1 | 4 | 6 | 3 | 8 | 7 | 9 | 10 | 2 |

Number of comparisons = 45,

Consistency Ratio CR = 4.0%=0.04<0.1,

Principal Eigen value = 10.530,

Eigenvector solution: 5

Iterations, delta = 2.7E-8.

The results of this table tell us that T2 is the best choice according to the criterion deadline followed by T10, T5, T3, T1, T4, T7, T6, T8 and finally T9. In addition, the consistency ratio is less than 0.1 which is very acceptable and respectful to the AHP recommendation. After the evaluation of the deadline, we have to evaluate the length in the same way as the deadline. The comparison for the length is summarized in the following table:

*Table7: Length Comparison*

| Length | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 1.000000 | 2.000000 | 0.500000 | 0.500000 | 0.500000 | 2.000000 | 0.142857 | 2.000000 | 0.500000 | 0.500000 |
| T2 | 0.500000 | 1.000000 | 0.500000 | 0.500000 | 0.500000 | 0.500000 | 0.125000 | 0.500000 | 0.333333 | 0.500000 |
| T3 | 2.000000 | 2.000000 | 1.000000 | 2.000000 | 0.500000 | 2.000000 | 0.166667 | 2.000000 | 0.500000 | 0.500000 |
| T4 | 2.000000 | 2.000000 | 0.500000 | 1.000000 | 0.500000 | 2.000000 | 0.166667 | 2.000000 | 0.500000 | 0.500000 |
| T5 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 1.000000 | 2.000000 | 0.250000 | 2.000000 | 0.500000 | 2.000000 |
| T6 | 0.500000 | 2.000000 | 0.500000 | 0.500000 | 0.500000 | 1.000000 | 0.125000 | 0.500000 | 0.333333 | 0.500000 |
| T7 | 7.000000 | 8.000000 | 6.000000 | 6.000000 | 4.000000 | 8.000000 | 1.000000 | 7.000000 | 4.000000 | 5.000000 |
| T8 | 0.500000 | 2.000000 | 0.500000 | 0.500000 | 0.500000 | 2.000000 | 0.142857 | 1.000000 | 0.333333 | 0.500000 |
| T9 | 2.000000 | 3.000000 | 2.000000 | 2.000000 | 2.000000 | 3.000000 | 0.250000 | 3.000000 | 1.000000 | 2.000000 |
| T10 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 0.500000 | 2.000000 | 0.200000 | 2.000000 | 0.500000 | 1.000000 |
| Priority | 0.055175 | 0.034246 | 0.074128 | 0.064399 | 0.101508 | 0.039424 | 0.369589 | 0.046050 | 0.128915 | 0.086567 |
| Rank | 7 | 10 | 5 | 6 | 3 | 9 | 1 | 8 | 2 | 4 |

Number of comparisons = 45

Consistency Ratio CR = 3.2% = 0.032<0.1,

Principal Eigen value = 10.426,

Eigenvector solution: 4

Iterations, delta = 3.3E-8

The results of this table show that T7 is the best choice according to length followed by T9, T5, T5, T10, T3, T4, T1, T8, T6 and finally T2. In addition, the consistency ration is less than 0.1 which is very acceptable and respectful to the AHP recommendation. Once we finished the length evaluation, we have to evaluate the age. The comparison for the age is summarized in the following table:

*Table8: Age Comparison*

| Age | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 1.000000 | 0.500000 | 0.500000 | 2.000000 | 3.000000 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 2.000000 |
| T2 | 2.000000 | 1.000000 | 2.000000 | 2.000000 | 3.000000 | 3.000000 | 3.000000 | 2.000000 | 2.000000 | 2.000000 |
| T3 | 2.000000 | 0.500000 | 1.000000 | 2.000000 | 3.000000 | 3.000000 | 3.000000 | 2.000000 | 2.000000 | 2.000000 |
| T4 | 0.500000 | 0.500000 | 0.500000 | 1.000000 | 2.000000 | 2.000000 | 2.000000 | 0.500000 | 0.500000 | 0.500000 |
| T5 | 0.333333 | 0.333333 | 0.333333 | 0.500000 | 1.000000 | 0.500000 | 0.500000 | 0.333333 | 0.500000 | 0.333333 |
| T6 | 0.500000 | 0.333333 | 0.333333 | 0.500000 | 2.000000 | 1.000000 | 0.500000 | 0.500000 | 0.500000 | 0.500000 |
| T7 | 0.500000 | 0.333333 | 0.333333 | 0.500000 | 2.000000 | 2.000000 | 1.000000 | 0.500000 | 0.500000 | 0.500000 |
| T8 | 0.500000 | 0.500000 | 0.500000 | 2.000000 | 3.000000 | 2.000000 | 2.000000 | 1.000000 | 2.000000 | 2.000000 |
| T9 | 0.500000 | 0.500000 | 0.500000 | 2.000000 | 2.000000 | 2.000000 | 2.000000 | 0.500000 | 1.000000 | 0.500000 |
| T10 | 0.500000 | 0.500000 | 0.500000 | 2.000000 | 3.000000 | 2.000000 | 2.000000 | 0.500000 | 2.000000 | 1.000000 |
| Priority | 0.132209 | 0.187626 | 0.163028 | 0.072426 | 0.038601 | 0.050241 | 0.057822 | 0.114876 | 0.083355 | 0.099815 |
| Rank | 3 | 1 | 2 | 7 | 10 | 9 | 8 | 4 | 6 | 5 |

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Number of comparisons = 45,

Consistency Ratio CR = 3.3% = 0.033 < 0.1

Principal Eigen value = 10.441,

Eigenvector solution: 5,

Iterations, delta = 3.7E-9,

The results of this comparison tell us that T2 is the best choice according to the Age followed by T3, T1, T8, T10, T9, T4, T7, T6 and finally T5. In addition, the consistency ratio is less than 0.1

which is very acceptable and respectful to the AHP recommendation.

## 3 CRITERIA COMPARISON

Now, after we evaluated the alternatives (tasks) based on their criteria, we need to evaluate the criteria according to their importance to reach the final goal.

The comparison and the priorities for the criteria are shown in the following table:

*Table9: the criteria pair wise comparison and their priorities*

| Criteria | Deadline | Length | Age |
|---|---|---|---|
| Deadline | 1.000000 | 4.000000 | 8.000000 |
| Length | 0.250000 | 1.000000 | 4.000000 |
| Age | 0.125000 | 0.250000 | 1.000000 |
| Priority | 0.707106 | 0.222740 | 0.070154 |

Number of comparisons = 3

Consistency Ratio CR = 5.6% = 0.056 <0.1

Principal Eigen value = 3.054

Eigenvector solution: 4

Iterations, delta = 8.8E-9

The results of this comparison show that the deadline is the most important criterion followed by the length and finally the age. In addition, the consistency ration is less than 0.1 which is very acceptable and respectful to the AHP recommendation.

### 3.1 Alternative Comparison

Once we have all the comparisons, we need to make the final priorities for all the items and finally make a decision on the tasks classification which will be gone to the resources. The final obtained results are shown in the following table which summarizes the priorities for the alternatives from all criteria:

*Table 10: Decision Matrix*

| Tasks | Deadline | Length | Age | Goal |
|---|---|---|---|---|
| T1 | 0,0303 | 0,0122 | 0,0092 | 0,0517 |
| T2 | 0,2582 | 0,0076 | 0,01316 | 0,27896 |
| T3 | 0,0375 | 0,0165 | 0,0114 | 0,0654 |
| T4 | 0,0264 | 0,0143 | 0,005 | 0,0457 |
| T5 | 0,1117 | 0,0226 | 0,0027 | 0,137 |
| T6 | 0,0195 | 0,0087 | 0,00352 | 0,03172 |
| T7 | 0,0226 | 0,0823 | 0,004 | 0,1089 |
| T8 | 0,0167 | 0,01025 | 0,00805 | 0,035 |
| T9 | 0,0138 | 0,02871 | 0,00584 | 0,04835 |
| T10 | 0,1701 | 0,01928 | 0,007 | 0,19638 |

As shown in the table 10, we found out that T2 has the biggest priority. Thus, the final classification according to AHP mechanism is T2, T10, T5, T7, T3, T1, T9, T4, T8, and T6.

## 4. DISCUSSION

In our prior work, we used the priority queues as a solution for managing the tasks classification using three important parameters (task deadline, task length and task age). In which we used eight priority queues and in each priority queue, we used FIFO as an algorithm for managing the arrived tasks inside the queues. Other feature used in that work is that the tasks could ascending in the priority queues, such as a task can ascend to the above queue if the task deadline equal to the min-deadline compared to the existing tasks deadline in the same queue at a specific time. In this work, our efforts focused mainly on improving the tasks classification by improving the task scheduling in the highest priority queue.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Considering that the experts' opinion approves the choice of the three parameters to apply them to the highest priority queue. The obtained results show that the interest of this work lies in the respect of the tasks deadline which can give more reliability to the tasks scheduling.

## 5. CONCLUSION

Nowadays, the Cloud Computing is still one of the most developed fields. However, most of the researchers use some traditional algorithms either for managing their queues or for the task classification. In this paper, we proposed the use of the AHP as a solution for classifying the tasks in the highest priority queue to give more precision in the final tasks classification before their execution in the dedicated resources. As a result of our research, AHP gives good results in terms of classification for our multi-criteria scheduling problem. As a future work, we aim to build a decision support system based on similarity calculations in which the tasks will be automatically classified without repeating the whole AHP process. Also, we intend to extend our scheduling strategy to support multi-criteria (more or less than three parameters) which will be chosen by the experts depending on the priorities expressed by the customers.

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