Machine Learning Based Task Scheduling Algorithm in Cloud Computing

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Abstract : ***Cloud Computing is a new era of remote computing / Internet based computing where one can access their personal resources easily from any computer through Internet. Cloud delivers computing as a utility as it is available to the cloud consumers on demand. Cloud Computing is a simple pay-per-use consumer-provider service model. Task (Job) scheduling is always a major issue in any computing paradigm. Due to the availability of finite resources and time variant nature of incoming tasks it is very challenging to schedule a new job accurately and assign requested resources. From the cloud providers' perspective cloud resources must be allocated in a fair and efficient manner.***

Index Terms - Cloud Computing, Task Scheduling, k-Nearest Neighbors

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I. INTRODUCTION

Because of the advancement in Information and Communication Technology (ICT) over the past few years, Computing has been considered as a utility like water, electricity, gas and telephony. These utilities are available to the consumers based on their requirement at any time. Consumers pay for these services to the service providers based on their usage [1] [3] [7].

Like all the other existing utilities, Computing utility is the basic computing service that meets the day to day needs of the general community. To deliver this vision, a number of computing paradigms have been proposed, of which the latest one is known as Cloud Computing.

Task Scheduling is always a major issue in any computing paradigm. Scheduling of tasks must be done in a fair and efficient manner with accuracy as we have availability of finite resources. In this paper, we tried to use machine learning algorithm for task scheduling. As a part of that we have used k-nearest neighbors algorithm for task scheduling in cloud computing. So, it is a vital issue to meet cloud consumers QoS requirements and satisfaction [10].

Traditional task scheduling techniques are not adequate for cloud computing as cloud computing is based on virtualization technology with distributed nature. Cloud computing introduces new challenges for task scheduling due to heterogeneity in hardware capabilities, on-demand service model, pay per use model and guarantee to meet QoS [2] [5] [15] [17].

Ab-initio resource assignment is a basically an initial resource assignment process, in a manner that resources are requested by application (on behalf of cloud consumers) first time. As a part of Ab-initio resource assignment, this research paper covers task scheduling algorithm in cloud computing using one of the machine learning techniques [11].

The rest of the paper is organized as follows: Section 2 discusses fundamentals of cloud computing. Section 3 introduces fundamentals of machine learning and k-Nearest Neighbor algorithm. Section 4 discusses results based on k-NN algorithm. Section 5 gives comparisons of various ab-initio task scheduling algorithms. Section 6 gives concluding remark and future work.

II. FUNDAMENTALS OF CLOUD COMPUTING

Cloud is like a big black box, nothing inside the cloud is visible to the cloud consumers. Cloud delivers computing as a utility as it is available to the cloud consumers on demand. Cloud Computing is a simple pay-per-use consumer-provider service model [1] [3] [7] [9].

Cloud computing is composed of three kinds of service models. These service models are based on the level and depth of the services provided by cloud computing [4] [7] [8] [14] [19] [20].

1. Cloud Software as a Service (SaaS): In this service model, instead of using locally run applications the cloud consumer uses the cloud providers software services running on a cloud infrastructure. It is the job of cloud provider to maintain and manage the software services that are used by the cloud consumer. The cloud provider may charge according to software quantity and time usage. Salesforge.com and Customer Relationship Management (CRM) are the examples of such service model [8] [10] [13] [18] [20].
2. Cloud Platform as a Service (PaaS): In this service model, the cloud platform offers an environment on which developers create and deploy applications. It provides platform where applications and services can run. The consumers do not need to take care of underlying cloud infrastructure including network, servers, operating system or storage but has a control over deployed application. Google Application Engine, Microsoft Azure and RightScale are the example of such model [8] [10] [13] [19] [20].
3. Cloud Infrastructure as a Service (IaaS): In this service model, cloud providers manage large set of computing resources such as storing and processing capability. Cloud consumer can control operating system; storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls). Sometimes it is also called as a Hardware as a Service (HaaS). The cost of the Hardware can be greatly reduced here. Amazon Web Services, Open Stack, Eucalyptus, GoGrid and Flexiscale offers IaaS [8] [10] [13] [19] [20].

In cloud computing various deployment models have been adopted based on their variation in physical location and distribution. Regardless of the services, clouds can be classified among four models as mentioned below:

1. Private Cloud: It is private to the organization. All the cloud services are managed by the organization people themselves or any third party vendors. In private cloud services are not provided to the general public. Private cloud may exist on premise or off premise [6] [8] [19] [20].

2. Public or Hosted Cloud: All the cloud services managed by the organization are made available as in pay as you go manner to the general public. The business people can adopt such cloud to save their hardware and/or software cost. Public cloud may raise number of issues like data security, data management, performance, level of control etc [6] [8] [19] [20].
3. Community Cloud: Here cloud is available to specific group of people or community. All the cloud services are shared by all these community people. Community cloud may exist on premise or off premise [8] [19] [20].
4. Hybrid Cloud: It is a combination of two or more cloud models mentioned above [8] [19] [20].

III. Fundamentals of Machine Learning and k-Nearest Neighbors Algorithm

Machine learning is basically a subcategory of artificial intelligence. It involves statistical techniques, such as deep learning (aka neural networks), that are inspired by theories about how the human brain processes information.

k-Nearest Neighbors is one of the simple algorithm in machine learning. k-nearest neighbors (k-NN) algorithm is a non-parametric method used for classification and regression. k-NN algorithm is one of the most widely used lazy learning approaches. It is a powerful classification algorithm capable of dealing with complex problems [16].

Table 1, Table 2 and Figure 1 gives an example of kNN scheduling algorithm. Here if we take value of k=3 and if a new process memory requirement is 400 then the algorithm will select nearest neighbors as Nodes 1, 2 and 2. So prediction value is 2 and scheduling can be done on node 2.

Table 1: Configuration Table (Example)

Node	Memory (MB)	Processor Queuing Size (PQS)
1	1024	8
2	2048	8
3	512	3

Table 2: Data Set (Example)

Process Name	Process Memory Requirement	Process Scheduling on Nodes
P1	128	2
P2	256	2
P3	512	1
P4	1024	2
P5	256	3

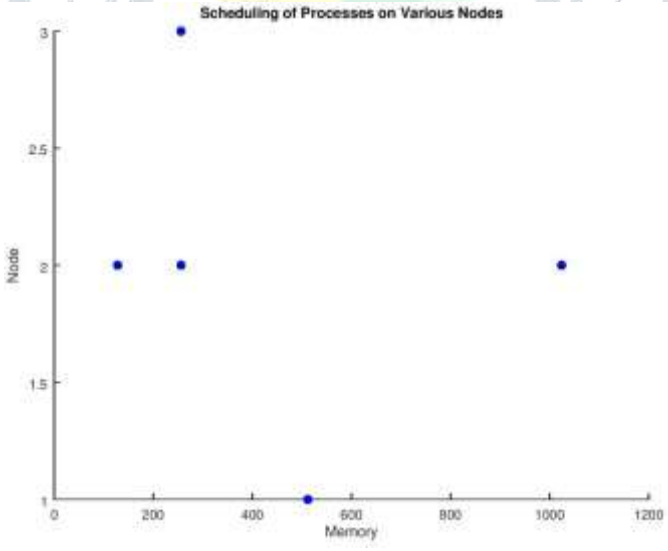

Figure 1: Diagrammatic representation of Data Set table

IV. Machine Learning Based Task Scheduling

Figure 2 shows machine learning based steps or flow for task scheduling.

1. Data Collection: This is the first and foremost step in any machine learning based approach where huge data will be collected from various sources.
2. Building and Analyzing Data Set: This is the step where the whole data set will be build and analyzed.
3. Classification and Training with Machine Learning Algorithm: Here we have used k-NN algorithm for classification and prediction.
4. Cross Validation: This process will evaluate k-NN algorithm by training.
5. Prediction: This process will give the predicted value for scheduling.
6. Scheduling: Task can be schedule on predicted node.

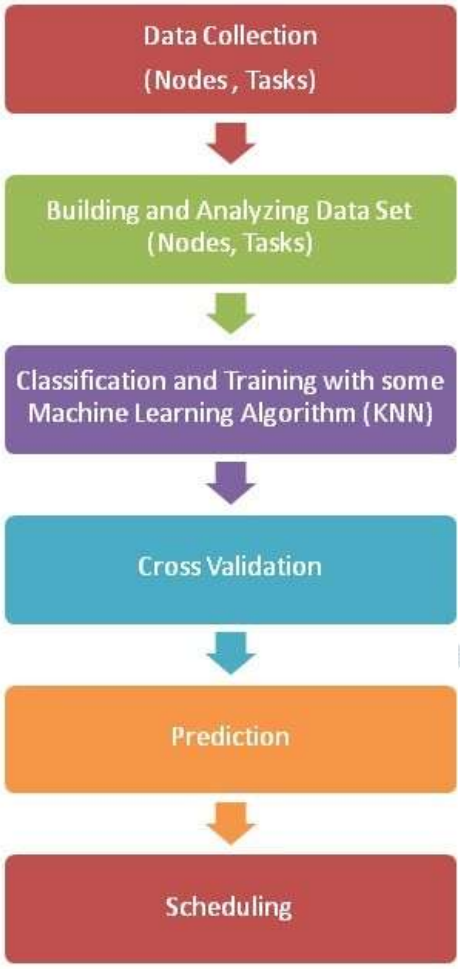

Figure 2: Steps for Machine Learning based Task Scheduling

V. KNN BASED TASK SCHEDULING

Below mentioned steps shows the algorithm of task scheduling using kNN.

1. Load the collected data.
2. Store the training data in to an array.
3. Initialize the test data.
4. Initialize the value of k (from 1 to 5).
5. For predicting scheduling node, iterate from 1 to the number of training data.
6. Calculate the distance between each row of training data and test data.
7. Sort the calculated distance in ascending order and select first k rows.
8. Identify most frequent node.
9. Return the predicted node where scheduling can be done.

Table 3 shows the results based on k-NN algorithm. Here, value of k has been kept from one to five which represents no of neighbors. Last column shows the accuracy value for all various values of k.

Table 3: kNN Result

No of Neighbors	No of Equality	No of Failure	Accuracy (%)
1	13	7	65
2	13	7	65
3	12	8	60
4	9	11	45
5	8	12	40

$$Accuracy = \frac{No\ of\ Equality}{No\ of\ Equality + No\ of\ Failures} \qquad (4.1)$$

Figure 3 shows that with neighbor value (k) 1 accuracy is only 65 %. As we increase no of neighbors (k) accuracy decreases.

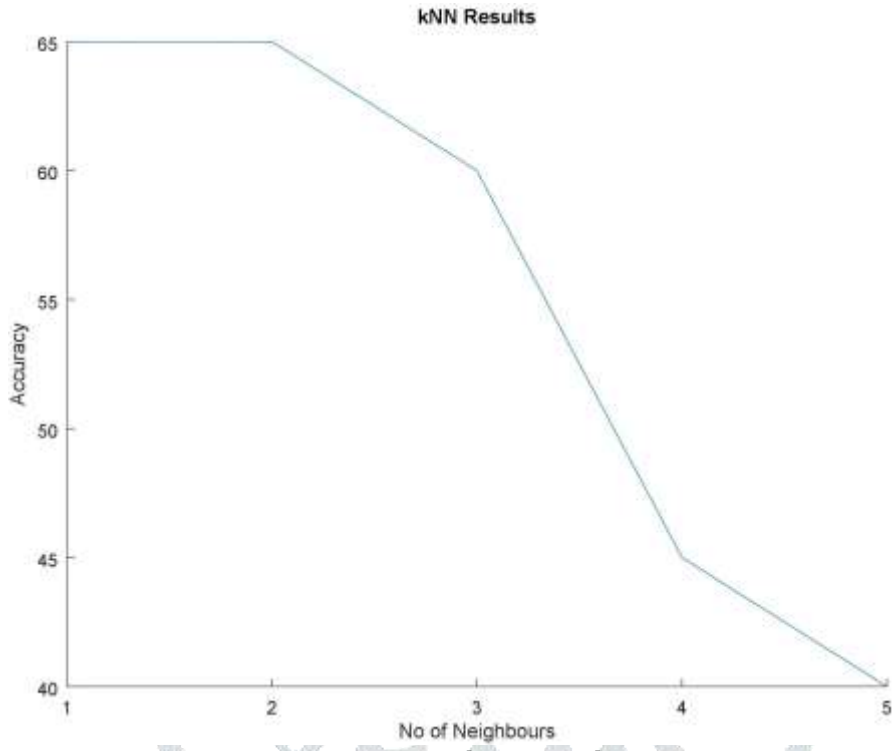

Figure 3: kNN Result

VI. Comparison with Ab-initio Task Scheduling Algorithms

k-NN based task scheduling algorithm is not horizontally scalable as we can not include more no of parameters in k-NN. But this algorithm is vertically scalable where more no of neighbors can be added for prediction purpose. With vertical scalability feature of this algorithm, accuracy decreases. Ab-initio task scheduling algorithms (FCFS, SJF, Priority, RR, Minmin, Maxmin) are not horizontally scalable but are vertically scalable like k-NN [11] [12].

VII. Concluding Remark and Future Work

Task scheduling is always a major issue in various computing fields. k-NN is simplest of all machine learning algorithms. Accuracy of k-NN based task scheduling algorithm is very low. In future work, our main aim to develop an machine learning based task scheduling algorithm in cloud computing with higher accuracy, horizontally scalable and vertically scalable.

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