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Novel Approach for Predicting Performance Degradation in Cloud

Pritam Fulsoundar[1], Rajesh Ingle[2]

[1]Pune University, Pune Institute of Computer Science,
Dhankawadi, Pune, India
Pritam.fulsoundar@gmail.com

[2]Pune University, Pune Institute of Computer Science,
Dhankawadi, Pune, India
author2@email.com

Abstract: ***Cloud computing is became an important paradigm in IT sector. Features like on demand service, cost effectiveness, elasticity made it possible. Because of these features and no upfront investment, many organizations using Cloud for their computational needs. But some organizations still worry about quality of service. To address this issue SLA is generated between Cloud provider and client organization. Avoiding SLA violation becomes necessary for cloud provider which leads in necessity of predicting performance degradation so that necessary action to avoid violation could be carried out. In this work we addressed above issue. Our work focuses on CPU cycles as resource to predict performance degradation of Cloud. Our result shows that performance of Cloud degrades when CPU usage of Virtual Machine (VM) running on cloud increases. We proposed system to predict performance degradation in Cloud.***

Keywords: Cloud Computing, Cloud Monitoring, Performance, QoS, SLA**.**

1. Introduction

Cloud Computing is a model which enables ubiquitous, on-demand network access to a shared pool of resources like networks, bandwidth, servers, storage and services that can be provisioned and released with minimal interaction of service provider [1]. In recent years, Cloud Computing became very useful technology for IT industry. Since it is very economical, many organizations use cloud. Many Cloud Service Providers (CSP) are there in market. For Cloud Service Provider it becomes necessary to provide good Quality service to remain in competition. Many organizations hesitate to go for cloud because of Quality of Service. To settle this issue Service Level Agreement (SLA) is generated between CSP and client organization. Any violation of agreement cause economic loss to CSP. It also affects reputation of Service provider. Because of this reasons, it become very necessary to fulfill SLA. For that CSP can do over provisioning of resources i.e. providing more resources than actual need at that time. But it is not economical, because large no of resources required for the same and also it is not energy efficient.

In this work, we are predicting the performance degradation of Virtual Machines running on cloud infrastructure. Performance of Virtual Machines (VMs) may degrade due to lack of resources in cloud infrastructure. Resources which cause performance degradation are mainly CPU cycles, network bandwidth and memory. If we are able to provide sufficient resources to Virtual Machines, problems related to performance degradation will get solved. In this dissertation, we focused on performance degradation of Virtual Machine because of insufficient CPU cycles. To solve this problem we collect CPU usage from each Virtual Machine and this usage values are used in prediction model which predicts performance degradation of Virtual Machine.

2. Literature Survey

We did the literature survey in previous work [2]. Some important details are discussed below. Ammar Kamel et al. [3] developed system which predicts performance degradation because of insufficient network bandwidth. His work is to monitor bandwidth usage at client side. According to values collected he developed system which predicts performance degradation using Pareto distribution model. In this work system divides all VMs (virtual machines) into three pools. First is provision pool which contains all VMs. Second pool contains active VMs which are called as active pool. Third pool contains VMs which may degrade their performance due to lack of bandwidth. In this work system monitors CPU usage at client side which may be helpful from client side to check SLA gets fulfilled or not but from cloud provider's point of view it is not useful to correctly predict performance degradation. Anton et al. [4] developed system for energy efficient management of virtual machines. In this work his system predicts CPU usage values of VMs using probability. This system considers some particular range of CPU usage in percentage as state and calculates probability of transition from one state to another state. Using this probability values matrix is formed and using that CPU usage of each virtual machine is predicted which helps for energy efficient management of VMs. Dr. Schahram Dustdaret al. [5] designed and developed technique which integrates knowledge management system into cloud management system. This system learns behavior of cloud usage pattern and takes reactive actions to prevent SLA violation. But in this technique large amount of data generated

and it gives prediction of usage pattern of particular machine.

3. Problem Statement

The performance of system running on cloud degrades because lack of resources in cloud. These resources are CPU cycles, Network Bandwidth and Memory. Performance of system is going to degrade due to insufficient memory, bandwidth or CPU cycles. Since, lack of Network Bandwidth causes congestion and If CPU utilization reaches in between 90% to 100% then throughput of system going to decrease which may result in performance degradation. Therefore provision of sufficient resources will solve the problem of performance degradation.

Cloud provider should take necessary steps to avoid SLA violation. For that he has an option of over provisioning, but this method is not economical. Since over provision requires more resources which in turn require more investment in infrastructure. In addition to that because of over provisioning there is also loss of electric energy which adds large amount of electricity bill which leads to economical loss for cloud provider. At the other end if cloud provider opts for under provisioning which may result in chance of SLA violation and ultimately results in economic loss. Therefore to increase profit cloud provider needs to make balance between both options to maximize profit. This need motivated us to develop system which will predict performance degradation to help cloud provider to maintain balance between under provisioning and over provisioning to maximize profit.

For every resource there is upper limit of usage and upper limit of throughput up to that client wants smooth performance. We formulate this problem and named it as dynamic knapsack problem as below

Dynamic Knapsack Problem

V1, V2,…. Vn represents the upper limit of usage of resource which can be CPU cycles, memory or bandwidth of virtual machine instance.

v1, v2,…..vn represents the current usage of resource for VM at time t. these values changes with time for the VM having upper limit V1, V2, V3, V4,…..Vn respectively.

P1, P2, P3,….Pm these values are upper limit of resource usage can be served to VM instances running on physical machines i.e. servers PM1,PM2…PMm (Physical Machine) respectively.

S1, S2, S3….Sk these are sets of VMs running on cloud so that S1, S2 belongs to PM1, PM2 respectively.

W1, W2…Wk represents total usage values of resources for S1, S2…Sk respectively.

To maximize profits

Vi > vi
Wj < Pj for j= 0 to k
Find S1,S2,.. Sk for $k \leq m$
Such that
$(Wj < Pj)$ for j=0 to k

Minimize

$\sum_{i=0}^{k}(Pi - Wi)$ at time t.

In this problem weights are variable which can be taken as any one of resource such as CPU cycles, memory or bandwidth.

To minimize $\sum_{i=0}^{k}(Pi - Wi)$ at time t, we have to keep (Pi-Wi) as low as possible at the same time for every physical machine Wj < Pj for j=0 to k muat get fulfilled otherwise SLA may violate. Violation of SLA leads to loss to CSP. These two conditions need to fulfill for that we should have capability of predicting usage of resource in near future. If we predict resource usage of VMs that will help to generate good result. VM's resource usage varies with time which is represented as v1 for VM1 at time t.

In literature survey, some attempts to solve this problem are discussed in detail. In this work we solve this sub problem of prediction of resource usage. Resource considered is CPU cycles.

4. Proposed System

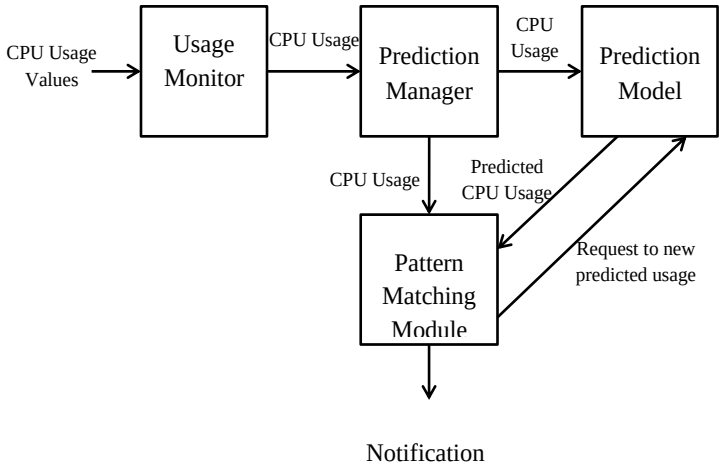

Figure 1: Proposed System

Figure 1 shows system architecture. Input to the system is collected from virtual machines running on compute nodes in cloud. CPU usage collected by usage monitor. Usage monitor does differentiation of CPU usage according to VM id. Usage monitor further pass these input to Prediction manager. Prediction manager passes those input to prediction manager which pass it to prediction model and pattern matching module. Prediction model predicts CPU usage window and pass it to pattern matching module. Pattern matching module uses values collected from prediction manager and prediction model to perform pattern matching process. If pattern is matched then it repeats process till it finds pattern mismatch. After that prediction model recalculates new prediction window and pass it to pattern matching module. Pattern matching module generates notification for that VM if the window crosses predefined CPU usage value otherwise continue pattern matching process.

5. Proposed Algorithm

While designing algorithm, we keep as simple as possible and less calculations are involved in that. Because proposed system is doing continuous monitoring, large calculations involved in

that require more computation power and this leads in loss to CSP.

Performance prediction system for cloud takes input from Virtual machines running on compute node as U. U={u1, u2, u3….un} are usage of virtual machine collected for period t. these values are passed to prediction manager and pattern matcher.

For prediction of performance new model is proposed. Probability matrix is built to predict CPU usage window. Suppose $A[i][j]_{m*n}$ is probability matrix. Where i, j are rows and columns. i^{th} no. of row represents certain interval of % CPU usage i.e. 1 to 3%, 3 to 9%and so on. j^{th} column represents interval of t minutes for which j^{th} column is updated using values collected. Using this matrix maximum probable range of CPU usage is calculated. Pattern matcher uses these vales and according to that notification is generated.

Let S be the system that describes a method to predict performance degradation.

S= {I, O, F, Su, Fa}

Where,

- Let I be the input to the system.
- O is output of the system.
- F is set of functions.
- Su is success of system.
- Fa is failure of system.

- INPUT:
  - I is the input set such that

– I = {U}.

– U = $\{U_1, U_2, U_3, \ldots\}$ A set of usage values collected from VMs.

- OUTPUT:
  - O– Notification to Cloud admin, if there is performance degradation due to lack of CPU cycles.
- FUNCTIONS
  - F is a set of functions where.

– F = {UM, P, PMO, PMA, N}

  - UM collects CPU usage and passing it to corresponding prediction manager for VM_i.
  - P (prediction manager) starts the pattern matching and prediction model process and provides CPU usage to them.
  - PMO (prediction module) predicts CPU usage values using matrix of probability and updates matrix of probability continuously.

– Let A be the Prediction matrix such that

$A[i][j]_{m*n}$

Where i, j are rows and columns. i^{th} no. of row represents certain interval of % CPU usage. j^{th} no. of column is updated for time period t then next $(j++ \% n)^{th}$ column is updated .

W is predicted window of CPU usage which is calculated by prediction model function.

  - PMA (pattern matcher) matches pattern given by prediction model with current usage and if mismatch found update prediction window. If prediction window crosses predefined threshold notification is generated.
  - N generates notification for Cloud Admin, if performance degradation found.

- SUCCESS:
  - Prediction model successfully forecasts CPU usage for short period of time.
- FAILURE
  - If fails to track CPU usage of virtual machine.

Following algorithms performs prediction and pattern matching.

Algorithm 1: To update Prediction Model

Procedure update Prediction Model
$A[i][j]_{m*n}$ is probability matrix
i^{th} no of row represents certain interval of % CPU usage
j^{th} column represents interval of t
U set of CPU usage values collected from VM.

```
1: Start
2: while VM is running:
3:     Collect CPU usage U.
4:     for  time period t
5:         Update probability of j^th column using values of
       U
6:     end for
7:     j = (j % t) + 1
8: End While
```

Algorithm 2: Pattern matching Algorithm

Procedure Pattern Matching.
W_u and Wl are upper and lower limit of prediction window respectively.
N is scoring value.

```
1:  for collected values U
2:      if (U_i > Wu or U_i < Wl)
3:          N++
4:      end if
5:      if(N>threshold)
6:          predictwindow()
7:      end if
8:      if (Wu> 90)
9:          Generatenotification()
10:     end if
11:  end for
```

Algorithm 3: Window prediction algorithm

$Up[k]_m$ is array for storing probability of CPU usage k^{th} row contains probability of % CPU usage interval i.e. 1 to 3%.

```
1:  for(i=0 to m)
2:      for(j=0 to n)
3:          Up[j]=Up[j]+A[i][j]
4:      end for
5:  end for
6:  Find index l of max probability in U.
7:  for(l-3 to l)
8:      for(i=0 to 3)
9:      a[i]=a[i]+U[l]
10: end for
11: Find index for having max value for a[i]
    W_l = l-3 + i
```

6. Result and Analysis

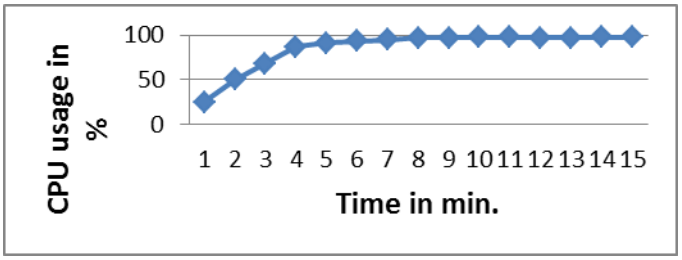

Figure 2: Graph for CPU Usage and Time

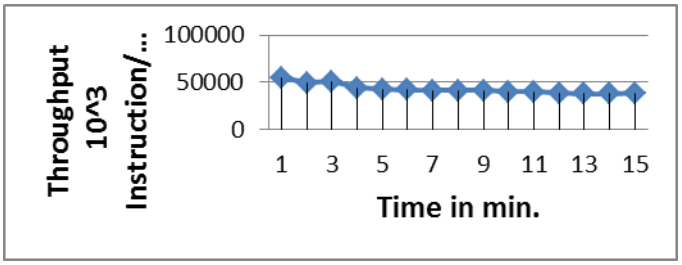

Figure 3: Graph for Throughput and Time

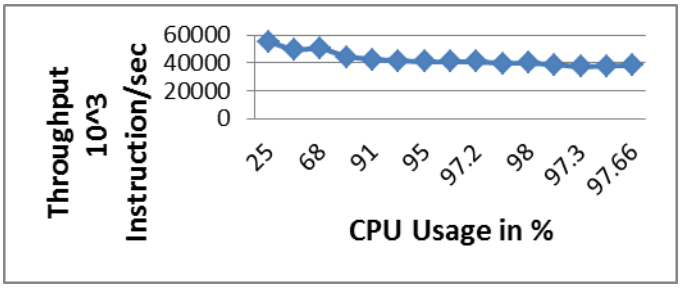

Figure 4: Graph for Throughput and CPU usage

In experiment we first proved our hypothesis that is performance of system decreases if there are not enough resources. In Experiment we increase load on virtual machine using C++ program which increase load on CPU by adding more threads to it i.e. 1 thread for time t, 2 threads for time t2 and so on. Graph in figure 2 shows CPU usage is increasing as program executes more threads. Graph in figure 3 shows decrease throughput at the same time when program gradually increases no of threads. At the same time relation between throughput and CPU usage is shown in graph figure 4.

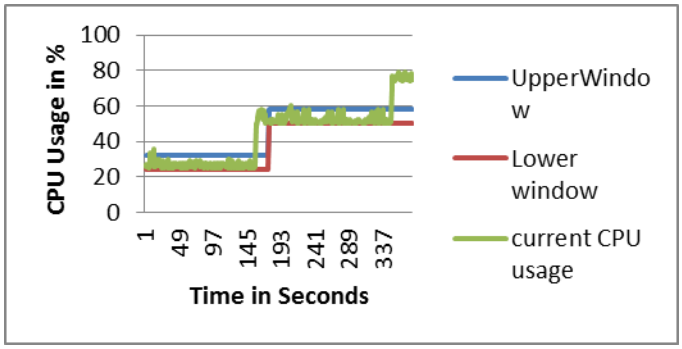

Figure 5: Graph for Predicted CPU and Current CPU (1)

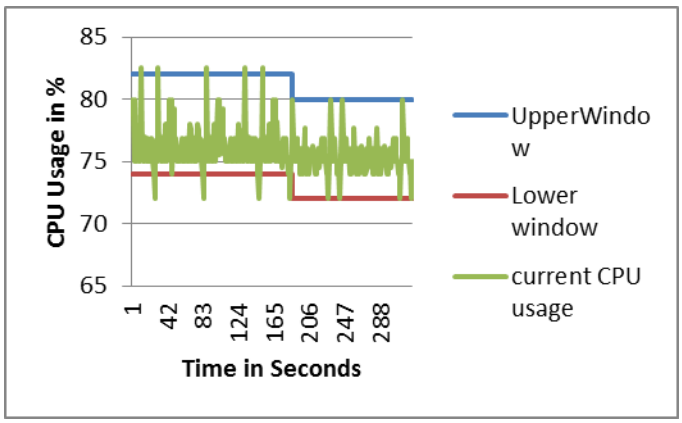

Figure 6: Graph for Predicted CPU and Current CPU (2)

Graph figure 5 and figure 6 shows result of predicted value and current CPU usage for the same experiment carried out above. These graphs show our system successfully predicted CPU usage values and system is capable to avoid SLA violation by generating notification to Cloud Provider.

7. Conclusion

Performance prediction system for Cloud is proposed. This system predicts degradation of performance of Virtual Machine running on compute nodes of Cloud and generates notification for Cloud Administrator. Experimentally, we proved that performance of Virtual Machine degrades if CPU utilization reaches in between 90% to 100%. We implemented proposed system successfully. Our system tracks predicted CPU usage of Virtual Machine successfully. If performance of system degrades we are able to know performance is degraded due to lack of CPU cycles.

8. Future Work

In future one can develop system for all three resources i.e. CPU cycles, Memory and Network Bandwidth. Notification generated by this system will be used in VM placement Algorithms for load balancing.

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Author Profile

Pritam Fulsoundar received B.E. degree in Computer Engineering from Pune University, India in 2011. He is currently pursuing M.E. Computer as PG Scholar in Department of Computer, PICT, Pune, India. His research interest includes Cloud Computing and Grid Computing.

Rejesh Ingle Received Ph.D. CSE from IIT Bombay, B.E. Comp from PICT, Pune University, and M.E. Comp from COEP. M.S. Software Systems from BITS, Pilani. His research interests include distributed system security, grid middleware, cloud computing, multimedia networks and spontaneously networked environments. He has more than 20 research publications in conferences and Journals. He has authored four books.