Fault Prediction and Mitigation in Cloud Computing

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Abstract: Cloud computing provides on-demand service in computing technology. This technology offers integration of software and resources which exhibits dynamic scalability in nature. These systems are beneficial, but there is also disadvantage for the same. If the system has symptoms of failure, then it does not provide its functionality. So the solution is fault prediction and mitigation. It provides the capacity to the system to react smoothly when the system has gone wrong or any unexpected hardware or software failure in the organization. This paper illustrates a better reason of defect prediction and mitigation methods, techniques and tools used for fault prediction and mitigation in cloud computing. In this paper, the techniques of fault Prediction and mitigation has been discussed and implemented.

Keywords: Cloud Computing, Fault Prediction, Fault Mitigation, Proactive, Reactive, Hardware Fault, Software Fault.

I. INTRODUCTION

A. Cloud Computing

Cloud computing is an innovation in range of virtualization, network computing, utility registering. Cloud computing provides IAAS (Infrastructure As A Service), PAAS (Platform As A Service) and SAAS (Software As A Service)[1]. IAAS provides service to network architects. PAAS provides service to application developers. SAAS provides service to end users.

B. Fault Prediction and Mitigation

Fault Tolerance is the procedure of finding faults and failures in a system. If a fault occurs or there is a hardware failure or software failure, then also the system should function properly. Failures should be handled in a dynamic way for reliable Cloud Computing. It will also give availability and robustness against the system hardware and software failure into the organization.

C. Benefits to implemented Fault Prediction and mitigation system

Fault prediction and mitigation has two types of techniques: proactive and reactive. The Proactive fault tolerance policy is to avoid recovery from failure by predicting them and proactively replace the suspected component means detect the problem before it actually come. Reactive fault tolerance reduce the effect of failures on application execution when the failure effectively occurs. The effect of failure is reduced when the failure actually occurs[1].

II. TYPES OF FAULT

A. Fault Prediction and Mitigation Techniques in Cloud Computing

Proactive Fault Tolerance:
This method of is to avoid extra effort for recovering the failed tasks, nodes, by predicting the fault in before and replace them with other working parts. Proactive fault tolerance systems are able to fulfill the time constraints set by the real time systems[5].
Reactive Fault Tolerance:
When an actual fault occurs in the system, then this method helps to reduce the impact of failures on the running system. These techniques provide good fault tolerant solution for general computing application, but a problem with this technique is that it cannot fulfill the time constraints set by real-time computing systems [5].

B. Types of Proactive Fault Tolerance

Software Rejuvenation:
Programming Rejuvenation is the technique in which an application is promptly ended and afterward restarted as a spotless state. There are different restoration interim and the application is restarted at each interim with a clean inward state. In this method, intermittent reboots are planned for the framework [6].

Using Self-Healing:
When multiple components of a single system are running on different multiple VM and when a fault occurs by using self-healing the failure of different application instances can be handled automatically [6].

Using Preemptive Migration:
By using this technique, the parts of a system running on a computing node that is about to fail are migrated to different nodes. By using preemptive migration the application is migrated to a different node before actual fault occurs [6].

C. Types of Reactive Fault Tolerance

Checkpointing/ Restart:
This method used when doing task scheduling, the check-points are inserted to identify fault incidence. These techniques take less computation and less time as a result of the task is restarted at the previously checked point. There is no ought to restart the full task [6].

Replication:
Replication is a very effective technique in fault tolerance. In this, there are various replicas of any application or task on different resources. When any fault occurs in the system then execution continues to succeed until all replicated tasks are destroyed [6].

Job Migration:
When due to resource failure or machine failure any task fails then the task is shifted on another virtual machine. Where it continues its execution of process [6].

Sguard:
It requires less registering investment to ordinary process time and accessible more assets free. It is depended on rollback-recovery. It takes less time to normal process and makes a lot of resources out there [6].

**Retry:**
In this method first of all the unsuccessful task is re-executed on the same resource from starting. If the task continues to fail on different executing points, then to get rid of the additional overhead the average execution time is computed. A threshold value is set to limit the number of retries of the failed job on the same machine [6].

**Task Resubmission:**
Task resubmission means that when any task fails then it is recommitted either to the same machine or a different one [6]. User defines exception handling:
When any task/job fails then the user gives the efficient treatment to that failed jobs for work flow. In exception, handling user can write code into the try, catch and finally block to throws exception and it handles the exception [6].

**Rescue workflow:**
This technique permits the work stream to proceed regardless of the possibility that the undertaking comes up short until it gets to be difficult to push ahead without cooking the fizzled task. [6].

### III. MODELS AND TECHNIQUES OF FAULT PREDICTION AND MITIGATION

#### A. Comparison among various model

Table 1 described comparison among various model. AFTRC (Adaptive Fault Tolerance) a proposed distributed computing. Which is based on constant framework and it gives advantage as the figuring limit, adaptable, and virtualization for a continuous framework. LLFT (Low Latency Fault Tolerance) is a given model which conveys a low dormancy, adaptation to non-critical failure (LLFT) middleware for giving adaptation to internal failure to dispersed applications sent inside the distributed computing environment as an administration offered by the proprietors of the cloud. FTWS is a given model which gives a replication and resubmission and assemble work process planning calculation for giving adaptation to non-critical failure by utilizing the need of the assignments. FTM is a model which is conquer the constraint of existing strategies for the on-request service [7]. The Vega-superintendent is work for virtual group to beat the 2 issues: ease of use and security. Magi-Cube a very tried and true and low excess stockpiling design for distributed computing [8][9].

#### B. Various Fault Prediction and Mitigation Techniques

Fault tolerance challenges and techniques have been implemented using various tools. Table 2 compares these tools based on their programming framework, environment and application type along with Different fault tolerance techniques.

#### TABLE I: Various Fault Tolerance Models [10]

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Protection against type of fault</th>
<th>Applied procedure for the fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFTRC</td>
<td>Reliability</td>
<td>1. Delete node, depending on their reliability 2. Back word recovery with the help of check pointing</td>
</tr>
<tr>
<td>LLFT</td>
<td>Crash-cost, trimming</td>
<td>Fault Replication.</td>
</tr>
<tr>
<td>FTWS</td>
<td>Dead of work flow</td>
<td>Replication and resubmission of jobs</td>
</tr>
<tr>
<td>FTM</td>
<td>Reliability, availability, on demand inspection and repair</td>
<td>Replication on user's application and in the case of replica failure use algorithm like gossip based Protocol</td>
</tr>
<tr>
<td>CANDY</td>
<td>Availability</td>
<td>1. It assembles the model components generated from IBD and STM according to allocated-Then activity SRN is synchronized to system SRN by identifying the relationship between action in activity SRN and state transition in system SRN.</td>
</tr>
<tr>
<td>VEGA-WARDEN</td>
<td>Usability, security, scaling</td>
<td>Two authentication layer and standard technical solution for the application.</td>
</tr>
<tr>
<td>FT-CLOUD</td>
<td>Reliability, crash and value fault</td>
<td>1. Significant component is defined based on the ranking. 2. Optimal ft technique is determined</td>
</tr>
<tr>
<td>MAGI-CUBE</td>
<td>Performance, reliability, low storage cost</td>
<td>1. Source file is encoded in then splits to deliver as a cluster. 2. The file recovery procedure is triggered is the original file is lost.</td>
</tr>
</tbody>
</table>

Disappointments Hadoop is utilized for information escalated applications, yet can in like manner be utilized to actualize adaptation to internal failure systems in a cloud situation. Amazon Elastic Compute Cloud (EC2) gives a virtual register-
ing environment to run Linux-based applications for adaptation to internal failure [5].

IV. RELATED WORK

Deepali Mittal, and Ms. Neha Agarwal designed model on Fault Tolerance in Cloud Computing [12]. In this described Fault Tolerance is the methodology used here is finding faults and failures in a system. In this proposed Dependability Assessment Algorithm and Decision Mechanism Algorithm were discussed [12].

Pankaj Deep Kaur and Kanu Priya defined Fault Tolerance Techniques and Architectures for fault tolerance [3]. It presents, in brief, the need and matrices for performing fault prediction and mitigation in the cloud. It gives an outline of the prevalent architectures and the existing techniques for that have been analyzed and compared[3]. Himanshu Agarwal and Anju Sharma have proposed Fault Tolerance Techniques in Cloud Computing [2].

<table>
<thead>
<tr>
<th>Fault Tolerance Techniques</th>
<th>System</th>
<th>Programming Environment</th>
<th>Fault Detected</th>
<th>Application Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Healing, Job Migration, Replication</td>
<td>HAProx y</td>
<td>Java Virtual Machine</td>
<td>Process/node Load balancing</td>
<td>Fault Tolerance</td>
</tr>
<tr>
<td>Check Pointing, Assure</td>
<td>SHelp SQL, JAVA Virtual Machine</td>
<td>Application Failure Fault tolerance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job Migration, Replication, Sguard, Resubmission</td>
<td>Hadoop Java, HTML, CSS Cloud Environment</td>
<td>Application / node failures Data intensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replication, Sguard, Task Resubmission</td>
<td>Amazon EC2 Amazon Machine Image, Amazon Map Cloud Environment</td>
<td>Application / node failures Load balancing, fault tolerance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE II: Tools Used To Implement Existing Fault Tolerance Techniques

Prasenjit Kumar Patra and Harshpreet Singh introduced fault Tolerance Techniques and Comparative Implementation in Cloud Computing [1]. It has been classifying that to give a superior comprehension of blame recoup methods utilized for as a part of cloud situations with some effectively characterized model and look at them [1].

Harpreet Kaur and Amritpal Kaur described a Survey on fault tolerance techniques in cloud computing [13]. This is described to study different types of failure and different techniques for handling them. By taking a correct action before or after the failure arrived, the system can predicate fault within it and recover the fault [13].

Priority Scheduling Algorithm with Fault Tolerance in Cloud Computing introduced by Seema Bawa and Nimisha Singla[15]. In this, it portrays new need booking calculation with adaptation to non-critical failure.

V. PROPOSED SYSTEM DESIGN

For fault prediction and mitigation we proposed system design. Which is described in figure 2 and figure 3 for fault prediction and mitigation in the system. Which first of all identify the fault and predict the fault using Fault Tree Analysis (FTA). According to that, it will identify by the error code if it is hardware fault or software fault. After identifying the reason behind the system failed it will mitigate the fault to recover the system fault. So that the system take action according to the Event Tree Analysis(ETA). So, by collaborate FTA with ETA it will predict the system fault, identify the reason behind it and recover the system fault.

In given figures, it describes various techniques of fault prediction and mitigation. For fault prediction, it defined various faults among them one of the fault can be predicted by the fault tree analysis. For fault mitigation arrival fault can be mitigate by the particular mitigation technique. By this way, the system can predict the fault using fault tree analysis and mitigate these fault using event tree analysis.
A. Software failures codes

Fig. 2: System Design For Fault Prediction

B. Hardware failures codes

Fig. 4: Software Failure codes

In the given figure 4 and figure 5, it describes hardware and software failure cloud error codes. By which, we can identify the particular one failure and reason behind it. By that code, we can predict the particular failure into the system and take action according to that fault. There is one particular cloud error code
for each and every error if it is hardware error or it is a software error. By this cloud error code, we can identify the root cause of failure. By this, we can identify the error and reason behind it.

C. Proposed Working Model

![Working Model Diagram]

Fig. 6: Working Model

In the given figure 6 it describes proposed working model, described the concept fault prediction and mitigation model will be run on the cloud environment. As given figure shows assuming that, number of virtual machines listed on one host. This is known as one cloud. Resource monitoring and observation module runs on cloud which is provides the resource monitoring and observation of the cloud then any fault occurs in the cloud which is observed by the uncertainty controller. Then after faulty task maintain into failure detection module which is provided the prediction of the fault by the fault error code. Various error codes are describes in the above figure. Various hardware and software error code are specifically defined for the particular error. After fault prediction fault mitigate by the failure mitigation module. In this failure mitigate by the various fault mitigation techniques. Various fault mitigation techniques are defined in two techniques. Such as proactive mitigation techniques and reactive mitigation techniques. For this scenario used reactive techniques such as restart, task submission, job migration, and user defined exception handling, replication, and rescue workflow. For every error code specific mitigation technique are defined. Which is defined into the below table 3. Mitigation techniques for error code.

So, By that way this model describes how to predict error and mitigate the error in when it is occur into cloud.

VI. PROPOSED ALGORITHM

Algorithm 1 Initialization

1: Let the current load is assumed
2: {
3: Initialize the task scheduling for every server s[i]
4: When new task arrives check load server ()

Algorithm 2 Fault prediction and mitigation algorithm

1: if (status= “W”) then
2: {
3: Scheduled the task to that server;
4: Go to next server status ;
5: }
6: else (status= “F”)
7: {
8: Check type of fault
9: if (shf[i]==vmf[i]) then
10: {
11: Check the status code;
12: if (100 || 101 || 102 ) then
13: {
14: Informational error;
15: }
16: else
17: if (200|| 201 upto || 204) then
18: {
19: Success error;
20: }
21: else
22: end if
23: else
24: if (302 ||303 upto || 308 ) then
25: {
26: Redirect error;
27: }
28: else
29: end if
30: else
31: if (400 || 401 upto || 499) then
32: {
33: Client error;
34: }
35: end if
36: end if
37: if (500 ||501 upto || 510) then
38: {
39: Server error;
This algorithm will plan the undertakings introduce on every server at some moment parameter and after that it will additionally continue to next server when an option to the new assignments by its needs and it is done with FCFS (First Come First Serve) algorithm. This calculation principally concentrates on the blame tolerant nature of the calculation to handle the blunder. It takes situation when the bit of assignments running on every server is same.

VII. RESULT

Fault prediction and mitigation implemented on Environment: JAVA, IDE: Eclipse, Simulator: WorkFlowSim-1.0. For fault prediction it is use decision tree method in data mining and for this it is implemented in R statistical tool. By decision tree method, results are as follows which decries in below figure 7.

![Fault Tree](image_url)

As figure 7 shown, by prediction result using decision tree we can do analysis of different error code. Various errors can be assorted based on the performance parameters such as execution time of the task, CPU cost, RAM cost, Depth of the task. By this parameter which error can be arrived that can be augured by the decision tree. It can be predicted which error will be come next by its percentage ratio. By decision tree it classified the task will become success or failed. If the task will be failed then which error will be occurs. Each error can be mitigate by the specific mitigation technique.

By fault prediction and mitigation result using decision tree it can analyze that particular fault can be predicted by its FTA (Fault Tree Analysis). For particular error there is particular mitigation technique defined by ETA (Event Tree Analysis) for one of them. By this we can predicate the fault by FTA and mitigate the fault by mitigation techniques. Various mitigation techniques can be described in the given table.

From table 3, It has been mentioned the mitigation techniques for a particular error code. Such as example of error code 400 it will occur due to missing request parameter and by checkpointing mitigation technique, it will be handled. Which provides efficient resource usage and it is used for long time running applications and it will be detected an application fault. By this means it can be applied for every hardware error code (400, 401, 403, 405, 406, 409, 415) and software error code (500 and 502).

The particular error code can predict the error and by particular mitigation technique, mitigate the fault and recover the system. This provide system robustness and work of the system efficiently even the fault is occur in organization.
### TABLE III: Mitigation techniques for error code

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error Name</th>
<th>Description</th>
<th>Reactive Mitigation technique</th>
<th>Description</th>
<th>Type of fault detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Bad Request</td>
<td>missing request parameter</td>
<td>Check pointing</td>
<td>Effective for long running applications, Provides efficient resource utilization</td>
<td>Application failure</td>
</tr>
<tr>
<td>401</td>
<td>Unauthorized</td>
<td>An invalid element token</td>
<td>Block</td>
<td>Block the request, Notify the user for valid request, More resource utilization</td>
<td>Process failure</td>
</tr>
<tr>
<td>403</td>
<td>Forbidden</td>
<td>Access to the resource is forbidden</td>
<td>Retry</td>
<td>Job is retried, Time inefficient</td>
<td>Host, Network failure</td>
</tr>
<tr>
<td>405</td>
<td>Method Not Allowed</td>
<td>Incorrect HTTP verb used</td>
<td>Rescue Workflow</td>
<td>Workflow is continued until task is failed.</td>
<td>Node, Application failure</td>
</tr>
<tr>
<td>406</td>
<td>Not Acceptable</td>
<td>The response content type does not match</td>
<td>Check pointing</td>
<td>Effective for long running applications, Provides efficient resource utilization</td>
<td>Application failure</td>
</tr>
<tr>
<td>409</td>
<td>Conflict</td>
<td>A resource is already exists</td>
<td>SGuard</td>
<td>It is less stream processing, rollback recovery</td>
<td>Application, Node failure</td>
</tr>
<tr>
<td>415</td>
<td>Unsupported Media Type</td>
<td>The server cannot handle Content-Type</td>
<td>Job Migration or Load balancing</td>
<td>Job can be migrated to different machine.</td>
<td>Application, Node failure</td>
</tr>
<tr>
<td>500</td>
<td>Server Error</td>
<td>Something went wrong on the Cloud Elements server</td>
<td>Job Migration</td>
<td>More resource utilization, Time efficient</td>
<td>Application, Node failure</td>
</tr>
<tr>
<td>502</td>
<td>Failed Request</td>
<td>Endpoint provider was not able to perform a request</td>
<td>Task Resubmission</td>
<td>Job is retried on same or different resubmission resource</td>
<td>Application, Node failure</td>
</tr>
</tbody>
</table>

From the graph we can conclude the results. That shown the comparison of various error parameters. By figure 7, graph showing the error rate which depends on several parameters such as cloudy, VM id, STATUS, error code, execution time, Depth. In figure 8, graph described density VS execution time. Which is concluded that the maximum error rate in particular execution time. In figure 9, graph described density VS RAM cost. Which is concluded that the maximum error rate in particular RAM cost. So, by this results we can concluded that maximum time, maximum usage of RAM and its cost and when
the error occurs into the system. We can also predicted which error will be occur next and mitigate that fault using mitigation techniques.

VIII. CONCLUSION

Fault prediction and mitigation used to provide system availability and robustness when system have hardware or software fault. This literature review focused on the various fault prediction and mitigation techniques and tools used for implementing it and compare this technique and provide the best solution for fault prediction and mitigation.

IX. FUTURE WORK

Identifying the other failures apart from hardware and software as omission, network, response, crash, and mitigating their effects. Find techniques for recover that fault and make the system robust.

X. REFERENCES