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Analyzing Characteristics of Performance Testing in Cloud Computing using Mathematical Models

Kanta Malik
Research Scholar, Mewar University, Rajasthan, India

Abstract: ***This study aims at analyzing the performance testing in cloud computing using mathematical models. Performance testing in cloud computing is a typical job since traditional benchmarks are not enough for analyzing the performance testing in cloud computing.In this paper, performance testing in cloud computing is analyzed on the basis of their characteristics such as pay per use, elasticity, fault tolerance and scalability. Further this paper emphasizes the importance of mathematical models in analyzing performance testing of cloud computing.***

Keywords: ***Cloud computing, performance metrics, Mathematical Models***

I. INTRODUCTION

Computing and computer systemsare becoming morecomplex but easy to use due to advent in network technology such as cloud computing. Performancetesting is a type of testing intended to determine the responsiveness, throughput, reliability, and/or scalability of a system under a given workload [1]. Performance testing in cloud computing is different from that of traditional applications. Thetraditional performance testing focused on theperformance metrics for applications that are under aparticular workload for a fixed configuration. Cloud testneed to measure the performance metrics related to theworkloads that run in a distributed fashion on multiplevirtual and real machines. The enormous growth of cloudcomputing created a demand for mathematical models that canmeasure the performance characteristics of cloudapplications.

This paper is organized as follows. Cloud computing and its characteristics are described in Section II. Section III describes problems related to performance testing in Cloud Computing. Section IVdiscusses and explains the importance of mathematical models in testing performance of cloud computing followed by conclusion (Section V).

II. CLOUD COMPUTING

The Greek Myths tell of creatures plucked from the surface of the Earth and enshrined as constellations in the night sky. Something similar is happening today in the world of computing. Data and programs are being swept up from desktop PCs and corporate server rooms and installed in "the compute cloud." Whether it's called cloud computing or on-demand computing, software as a service, or the Internet as platform, the common element is a shift in the geography of computation.[2] Cloud computing is a model for pooling IT resources to provide real-timeon-demandself-provisioned services to business users on an as-needed basis (Fig 1).[3]

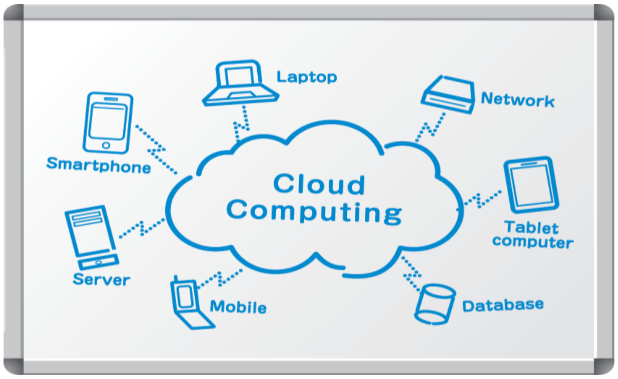

Fig. 1 Idea behind Cloud Computing

1. Cloud computing characteristics

Essential Characteristics: The cloud model is composed of five essential characteristics, three service models, and four deployment models.

The National Institute of Standards and Technology's (NIST) definition lists five essential characteristics of cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service. It also lists three "service models" (software, platform and infrastructure), and four "deployment models" (private, community, public and hybrid) that together categorize ways to deliver cloud services. The definition is intended to serve as a means for broad comparisons of cloud services and deployment strategies, and to provide a baseline for discussion from what is cloud computing to how to best use cloud computing. [4]

On-demand self-service: 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 thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling: The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth.

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 capability1 at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

2. Service Models:

Software as a Service (SaaS): The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited userspecific application configuration settings.

Platform as a Service (PaaS): The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

Infrastructure as a Service (IaaS): The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

3. Deployment Models:

Private cloud: The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

Community cloud: The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

Public cloud: The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

Hybrid cloud: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds) [5]

III. PERFORMANCE TESTING IN CLOUD COMPUTING

A metric is used to measure and understand thebehavior of software. Cloud metrics can be used tomeasure the behavior of cloud which utilizes theresources from the computers as a collective virtualcomputer, where the applications can run independentlyfrom particular computer or server configurations [6].

Cloud delivers its services through internet and providesthe full user functionality of a software application by theweb sites which provide Software as a Service. Dynamicweb sites provide regularly changing information tousers and utilize dynamically generated pages andmaintain data for display in a database [7]. Cloud usesthe dynamic web sites to deliver the web applications ondemand. Cloud metrics should follow somecharacteristics which help to evaluate cloud on eachand every parameter which is necessary for a goodquality cloud, so that a client can rely on it to choose thebest cloud.

The main advantages of cloud computing areelasticity, scalability, reliability, availability, pay-per-use and fault-tolerance [8].

a. Elasticity: is one of the major factors forthe success of the cloud as an IT infrastructure [9]. For aDBMS deployed on a pay-per-use cloud infrastructurean added goal is to optimize the system's operatingcost. Elasticity, i.e. the ability to deal with load variationsby adding more resources during high load orconsolidating the tenants to fewer nodes when the loaddecreases, all in a live system without service disruption,is therefore critical for these systems. Even though

Elasticity is often associated with the scale of thesystem; a subtle difference exists between elasticity andscalability when used to express a system's behavior.

b. Scalability: is a desirable property of asystem, which indicates its ability to either handlegrowing amounts of work in a graceful manner or itsability to improve throughput when additional resources(typically hardware) are added. A system, whoseperformance improves after adding hardware,proportionally to the capacity added, is said to be ascalable system.

c. Reliability: is the probability that a product orpart will operate properly for a specified period of time(design life) under the design operating conditions(such as temperature, volt, etc.) without failure [10]. Theoutcome of the measurement process is reproduciblethat is similar to results over time for some differentinputs and across many different situations. Cloud getsmany requests simultaneously and will also give thesimilar results for some requests in a period of time soclouds have to be reliable.

d. Availability: Cloud Services should beavailable maximum time [11]. The on demand, elastic,scalable, and customizable nature of the cloud must beconsidered when deploying cloud architectures. Manydifferent clients might be accessing the same back-endapplications, and many providers are providing the cloudservices has the expectation that only their applicationwill be properly delivered to users. In cloud computing itis essentially required to gather the information instantlywithout making a user to wait and the gatheredinformation should be related to each other.

e. Cost: Cloud Computing allows anorganization to pay by the hour of computing resources,potentially leading to cost savings even if the hourly rateto rent a machine from a cloud provider is higher thanthe rate to own one. This is essentially preferable whendemand for a service that arise over time.

f. Fault Tolerance: is one of the key issues ofcloud computing. There are many fault tolerancetechniques in parallel computing [12]. Fault tolerance isconcerned with all the techniques necessary to enable asystem to tolerate software faults.

Resource allocations, workloads and system behaviors can fluctuate widely, and performance can further vary based onsystem configurations. Despite the assorted issues with performance analysis of virtualized environments, researchershave made much headway in recent years developing tools and techniques for measuring, modeling and simulatingvirtualized environments.

Various research groups have developed performance metrics and benchmarks specifically to measure the performanceof virtualized systems such as cloud computing. In some cases, research groups have been able to use custom implementations of existingbenchmarks when analyzing virtualized systems. For example, a particular implementation of SPECweb2005 benchmark,which is the standard benchmark used to determine the performance of Web servers, can be successfully used inperformance testing of virtualized applications [13]. However, most benchmarks that were originally developedfor physical machines cannot be used for reliable performance testing of virtualized environments due to the diverse andcomplex nature of these virtualized systems.

IV. Mathematical Models for Performance Testing in Cloud Computing

Performance is generally tied to an application'scapabilities within the cloud infrastructure itself. Testingis a periodic activity and requires new environments tobe set up for each project [14]. Web applications mustbe tested for multiple operating systems and updates,multiple browser platforms and versions, different typesof hardware and a large number of concurrent users tounderstand their performance in real-time [15].

CloudComputing is growing at a rapid pace. With the adventof this technology, there is bound to be an increase indemand for Cloud Testing. New cloud test should bebased on an e-commerce scenario (i.e., a web-shop) and define web interactions as test drivers. Cloud computing is on demand as it offers dynamic flexible resource allocation for reliableand guaranteed services in a pay-as-you-use manner to public. In cloud computing, a cloudresource consumer can request a number of cloud resources simultaneously. So there must bea provision that all resources are made available to requesting cloud resource consumers in anefficient manner to satisfy their need**.** Due to the fact that there is a pool of cloud users, itrequires high security and availability through resource allocations. The cloud consumers alsoneed to gain profit and revenue maximization.

Mathematical models demonstrate that to achieve optimal performance in a cloud infrastructure, the slowest node's response time should be no more than three times that of the fastest node. Mathematical modeling and analysis is an attractive tool for providing an understanding of the interdependencies involved in cloud computing. It is particularly suitable for identifying optimal values and equilibrium and predicting behavior. Mathematical models can be used to guide future deployment, allocation, and upgrades of cloud infrastructure to achieve optimal utility effectiveness.

V. CONCLUSION

The exponential growth of cloud computing has resulted in a dire need for metrics that can measure theperformance characteristics of cloud applications.The traditional performance metrics for performance testing of cloud computing is not enough because of virtualized environment. In this paper, the concept of cloud computing and its essential characteristics along with deployment models has been discussed. Performance testing in cloud computing has been analyzed on the basis of their characteristics such as pay per use, elasticity, fault tolerance and scalability. Traditional approach for performance testing in cloud computing is also being discussed. The importance and benefit of using mathematical models for performance testing in cloud computing are also explained in this paper.

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