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Cloud-based quality assurance

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Abstract
Software Performance testing is a means of Quality Assurance. It involves testing software applications to ensure they work well under expected workload. Performance testing uncovers what needs to be improved before the application/product goes to market. It is a type of non-functional testing performed to determine the system parameters regarding responsiveness and stability under various workloads. There are many examples that show a loss of revenue due to the poor response time of application which is due to the absence of performance testing during SDLC. With the ever-increasing demands for the IT needs of businesses, it is also important for data centers to deliver data migration cost effectively especially when faced with the demands from remote office back up, outsourcing, data center moves, and cloud computing. Today, prime challenges with performance testing are the cost of setting up the required infrastructure needed for executing the load & stress test on the application being developed. Setting up the test bed by purchasing the computing hardware, configuring the hardware & software with the precise setting and managing the whole environment, these tasks need significant time & cost. Enterprises need a cost-effective solution for performing load testing. A one-stop solution for this problem is cloud.

Keywords: environment, hardware & software

Introduction
IT services have been transformed by "Computing" offered as a utility by a technology "Cloud Computing" these days. This has changed and in fact, will continue to change both the software and hardware aspects in a major way depending on the requirements of Cloud infrastructure and its increasing popularity. Cloud computing models help to realize business agility within an organization. Performance testing is mandatory for applications to perform as expected in the real world. Business-critical applications need thorough testing to ensure they can withstand stresses and strains of varying demands. Popular fuzz words of these days are Performance testing, load testing, tuning, and monitoring in the Cloud. "Performance "in general refers to an application's response time, throughput, resource utilization, etc.

The use of the traditional practice of performance requires a significant investment of money, time and resources which serves as a barrier to adoption. This, in turn, forces some organizations to limit the performance testing they undertake. Traditional on-premise testing can no longer deliver the necessary level of performance assurance that is necessary to compete in today's global marketplace. Cloud-based performance testing offers a way to test across various platforms and from multi-geo locations. Day by day, Cloud Computing is evolving, and the Cloud infrastructure is the single largest computing infrastructure that exists today. Deploying applications in the Cloud be it web or mobile, offers serious benefits. The single most important benefit offered is Scalab ility. Applications deployed in a Cloud environment can harness the power of thousands of computers whenever needed and, as a result, the performance of the application can increase significantly. This, in turn, increases customer loyalty and better revenue.

Cloud and Cloud Services
The Cloud is just a metaphor for the Internet. Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. In simplest terms, Cloud computing means storing and accessing data and programs over the Internet instead of your computer's hard drive. It is a model for enabling on-demand access to a shared pool of configurable computing resources (e.g., computer networks, servers, storage, applications, and services), which can be rapidly provisioned and released with minimal management effort.

A Cloud Service is a service that is made available to users on demand via the Internet from a cloud computing provider's servers as opposed to being provided from a company's on-premises servers. These services are designed to provide easy, scalable access to applications, resources and services, and are fully managed by a cloud services provider.

Service Models
The services offered by Cloud Computing provider can be categorized into three main service models which are as follows:

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service(IaaS)

Software as a Service (SaaS)

- The SaaS model eliminates the need to install and run the application on the cloud user's computers
- Here the cloud providers install and operate application software in the cloud
- Cloud users access the software from cloud clients
- Users have access to application software and databases. The applications are accessible from various client devices either through client interface (web browser
- e.g., web-based email), or through a program interface
- Cloud providers manage infrastructure and platforms that run the applications
- The consumers do not manage or control the underlying cloud infrastructure (including network, servers, operating systems, storage, or even individual application capabilities)
- However limited access may have been provided to specific application configuration settings may simplify maintenance and support

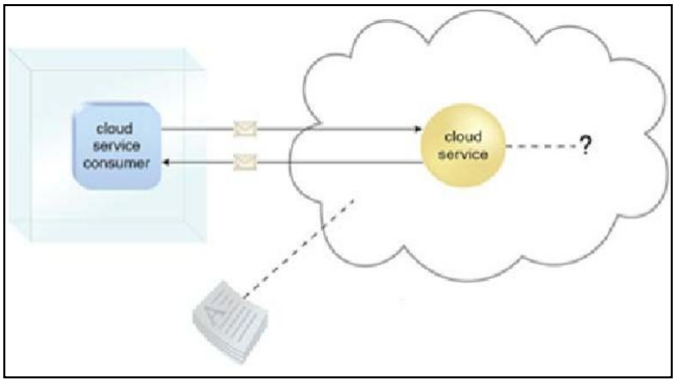


Fig 1: The cloud service consumer is given access to the cloud service contract, but not to any underlying IT resources or implementation details

Platform as a Service (PaaS)

- Represents a pre-defined "ready-to-use" environment typically comprised of already deployed and configured IT resources
- Cloud providers deliver a computing platform
- The Computing Platform typically includes an operating system, programming- language execution environment, database, and web server
- Application developers can develop and run their software solutions on a cloud platform
- The cost and complexity of buying and managing the underlying hardware and software layers is eliminated
- Consumers can then deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider
- Consumers do not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but have control over the deployed applications and possibly configuration settings for the application- hosting environment
- Examples include Microsoft Azure and Google App Engine

A few reasons for investing in a PaaS environment include

- Cloud consumer wants an extension of on-premise environments into the cloud for scalability and economic purposes.
- Cloud consumer uses the ready-made environment to entirely substitute an on-premise environment.
- Cloud consumer wants to become a cloud provider and deploys its cloud services to be made available to other external cloud consumers

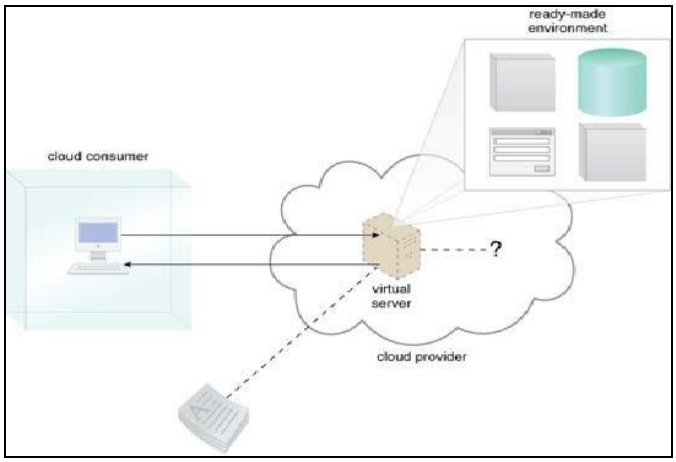
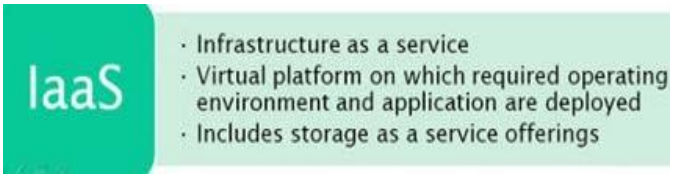


Fig 2: A cloud consumer is accessing a ready-made PaaS environment. The question mark indicates that the cloud consumer is intentionally shielded from the implementation details of the platform



Infrastructure as a Service (IaaS)

- Represents a self-contained IT environment comprised of infrastructure-centric IT resources that can be accessed and managed via cloud service-based interfaces and tools
- Providers offer computing infrastructure – hardware, network, connectivity, operating systems and virtual machines and other
- IaaS-cloud providers supply these resources on-demand from their large pools of equipment installed in data

centers.

- Consumers are provided for processing, storage, networks, and other fundamental computing resources
- Consumers can deploy and run arbitrary software, which can include operating systems and applications
- Here also, consumers do not manage or control the underlying cloud infrastructure
- However, consumers have control over operating systems, storage, deployed applications and possibly limited control of select networking components, e.g., host firewalls
- For wide-area connectivity, customers can use either the Internet or dedicated VPNs to deploy their applications.

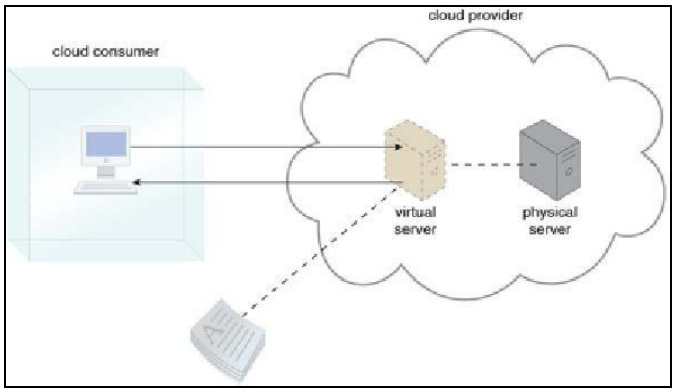


Fig 3: A cloud consumer is using a virtual server within an IaaS environment

Cloud deployment models

Private Cloud

A private cloud is owned by a single organization. Private clouds enable an organization to use cloud computing technology as a means of centralizing access to IT resources by different parts, locations, or departments of the organization.

The use of a private cloud can change how organizational and trust boundaries are defined and applied. The actual administration of a private cloud environment may be carried out by internal or outsourced staff.

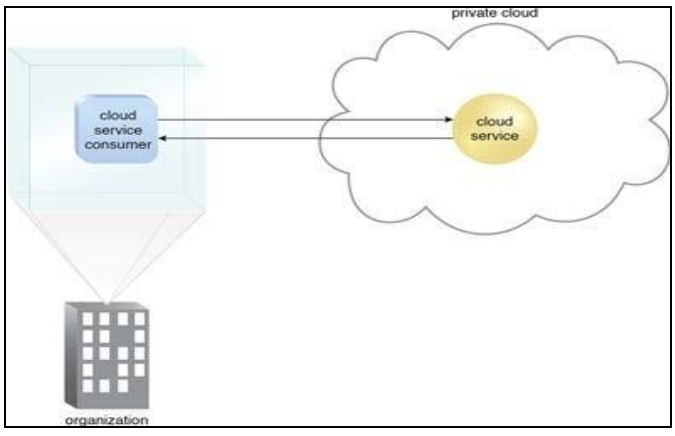


Fig 4: Here a cloud service consumer accesses a cloud service hosted on the same organization's private cloud via a VPN

In this deployment model, the same organization is technically both the cloud consumer and cloud provider.

- As a Cloud Provider: A separate organizational department typically assumes the responsibility for provisioning the cloud
- As a Cloud Consumer: This includes the departments requiring access to the private cloud

The benefits of private cloud are

- Higher Privacy and Control
- Improved Reliability
- More Control
- Energy and Cost Efficient

Public Cloud

A public cloud is a publicly accessible cloud environment owned by a third-party cloud provider. Here the services are rendered over a network that is open for public use. The cloud provider is responsible for the creation and on-going maintenance of the public cloud and its IT resources.

Generally, public cloud service providers like Amazon Web Services (AWS), Microsoft and Google own and operate the infrastructure at their data center, and access is generally via the Internet.

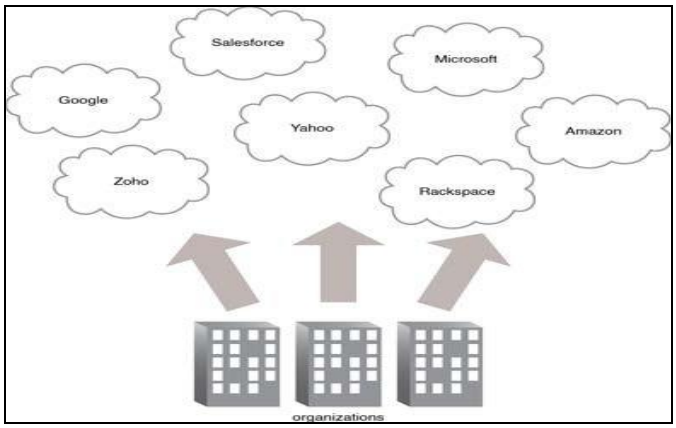


Fig 5: Organizations act as cloud consumers when accessing cloud services and IT resources made available by different cloud providers.

Hybrid Cloud

A hybrid cloud comprises two or more different cloud deployment models. For example, a cloud consumer may choose to deploy cloud services processing sensitive data to a private cloud and other, less sensitive cloud services to a public cloud. The result of this combination is a hybrid deployment model. Hybrid cloud is a composition of two or more clouds (private, community or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models. Hybrid cloud can also mean the ability to connect collocation, managed and dedicated services with cloud resources. This deployment model allows one to extend either the capacity or the capability of a cloud service, by aggregation, integration or customization with another cloud service. Hybrid deployment architectures can be complex and challenging to create and maintain due to the potential disparity in cloud environments and the fact that management responsibilities are typically split between the

private cloud provider organization and the public cloud provider.

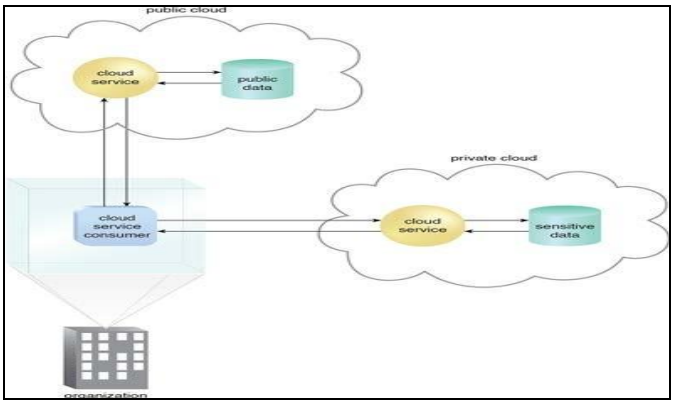


Fig 6: An organization using a hybrid cloud architecture that utilizes both a private and public cloud

Community Clouds

A community cloud is similar to a public cloud except that its access is limited to a specific community of cloud consumers. The community cloud may be jointly owned by the community members or by a third-party cloud provider that provisions a public cloud with limited access. The member cloud consumers of the community typically share the responsibility for defining and evolving the community cloud. Membership in the community does not necessarily guarantee access to or control of all the cloud's IT resources. Parties outside the community are not granted access unless allowed by the community.

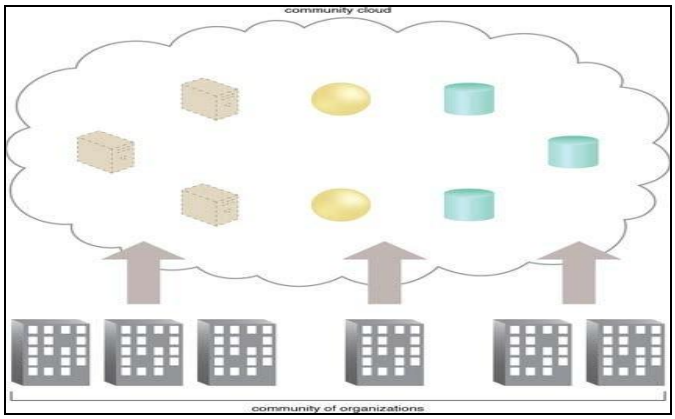


Fig 7: Organizations accessing IT resources from a community cloud

Other deployment models

Additional variations of the four base cloud deployment models can exist which includes:

Virtual private cloud

Also known as a "dedicated cloud" or "hosted cloud," this model results in a self-contained cloud environment hosted and managed by a public cloud provider, and made available to a cloud consumer.

Inter-Cloud

This model is based on an architecture comprised of two or more inter-connected clouds.

Internal lab testing

The testing model involves various components such as the performance testing tools and the system under test that are deployed 'on-premise,' within a local environment. In most cases, performance testing is done in a lab environment. This lab is normally a subset of the production environment. The lab requires a copy of infrastructure, servers, hardware and software from the production to host the system under test, and the performance testing tools.

Setting up such a lab requires considerable investment and effort, and the management of overheads such as maintenance costs. An organization set up such a lab will need to hire administrators to maintain and support the lab. This may further involve additional cost for training the resources.

The other important aspect we need to consider is that the on-premise approach does not measure up to the actual replica of the geographical distribution of users and their behavior. It can answer the queries regarding performance or capacity with a good degree of accuracy and highlight the main performance bottlenecks. However, we may ignore certain aspects such as network latency and behavior of network infrastructure. So, we might not be testing the actual user experience. Because of the versatile demands of the current market, its complexity and the dynamic nature of applications, performance testing has become a challenging task.

Why cloud for performance testing?

The enormous increase in Internet traffic, concerning the number of users as well as in the size of data, has resulted in an application getting hits from all corners of the world. To tackle all the users, the performance of the application needs to be measured in peak traffic. So it has become essential to test the application using higher concurrency levels. But one of the key constraints is that performance testing demands extensive capital investments in hardware.

- Cloud is a good choice for organizations that do not want to have a full dedicated investment in testing infrastructure, as it fulfills all test environment needs and requirements
- Cloud computing helps in achieving enough test coverage while minimizing the investment and configuration costs for any company
- The usage of right environment for testing will also help in controlling the costs by enabling defect detection earlier in the life cycle

According to various research reports, 30 percent of the bugs in production is due to the incorrect test environment configurations. The study also indicates that the efforts involved in fixing these defect leakages are huge.

- With the Cloud-based rental and pay-as-you-go model, the testing team is provided with a test lab for the required timeframe. Organizations can shorten the provisioning time as cloud enables provisioning of test servers on an on-demand basis
- Cloud model amplifies elasticity in the application platform. This implies that the actual resources used by the application may grow or shrink based on the

application load
- The Cloud makes it possible to test during the up-scaling and down-scaling of applications
- With Cloud, distributed teams can share the same environment and use it for testing purposes

Benefits of performance testing in the cloud

Performance testing and Load testing are essential for all applications hosted in a Cloud environment. For web applications and mobile apps, the main challenge is to test both the internal application (running internally) and the customer-facing application (running in production). Using a Cloud-specific approach, both the internal and production applications can be tested easily and in an environment which has been designed to mimic realistic deployment conditions. A small subset of production applications and data sets is tested in an internal testing environment.

Cloud performance testing infrastructure supports the exact scaling, as it appears in a real production environment. As a result, testing generates the actual performance report (considering real-time traffic) instead of a subset of users. Although all levels of testing can be performed in cloud infrastructure, performance testing benefits greatly from cloud environments.

Flexibility

Different levels of tests can be executed on discrete environments at the convenience of an enterprise. Performance testers no longer have to wait until the end of the testing phase to move to a production-like environment for their performance and stress tests. Cloud-based infrastructures are extremely well-suited to generating the peak demands and scalability required for enterprise performance testing.

Test Globally

Performance testing using Cloud enables the performance team to evaluate the applications' global readiness by replicating virtual users in a variety of different locations to ensure the application and website can handle users far and wide.

Testing at scale

Cloud-based testing providers offer a cost-effective means of testing applications at scale as opposed to internal lab environment that simulates a small subset of the production environment. Instead of testing an application against a portion of users and extrapolating that data to scale with a production environment, the cloud-testing provider can help to test the application against the actual number of expected users.

Simplicity

The cloud model provides bug fixing environments that can be launched as soon as the configuration is completed.

Comprehensive Testing

End-to-end tests can be performed in the cloud. All the necessary components can be published in the cloud to create the complete chain of systems. This ensures the overall business process gets tested. Also, businesses may need to test multiple routes to a system for completeness considering the growing number of applications now on a variety of handheld mobile devices. By implementing a performance testing solution via the cloud, the IT department can more effectively and affordably manage heavy loads on the device's website and applications.

Cost Reduction

Cloud environments could be enabled and disabled at will which greatly reduces the cost of environmental management. Cost reduction is the major factor influencing companies to choose Cloud. Cloud Testing leverages the cloud infrastructure, minimizing the unit cost of computing and increase the efficiency of performance testing.

According to IDC survey reports, economic benefits are the key drivers of cloud adoption. The report on cloud-enabled testing service providers' reveals that the cost savings usually range from 40% to 70%.

Public cloud allows enterprises to shift to a flexible operating expenditure model. For Private cloud, infrastructure can be deactivated once the testing process is complete. This frees enterprises from incurring expensive operational costs.

Greener Testing

Cloud computing capabilities make it significantly greener than traditional models, and this is true for the testing process. By sharing cloud resources for test infrastructure, enterprises can use IT resources on demand and eliminate waste.

Consumers using cloud infrastructures can minimize energy use and deliver environmental savings in carbon dioxide of around 55%.

Greater Control

Cloud-based environments provide greater control on test execution, analyze application performance and find bottlenecks while the tests are running. It allows performance test engineers to ascend from a few thousand to millions of concurrent users to evaluate breaking points of an application.

This part of the article provides small insights about data migration of database and applications in cloud

Risks involved in Data Migration Process

- Data Loss Risk: During the migration process, the business objects are missed in the Target/New application, and sometimes extra records are found in the Target/New application.
- Semantics Risk: When the migration is done efficiently, but some units present in few fields are not considered resulting in the inconsistency in data. So, it may happen that units in new application are different from the source application.
- Data Corruption Risk: This risk occurs when some business rules or validations are applied to the Target applications. Due to this unwanted data gets dumped into the database of the new application because of this application crashes or does not work.
- Application Stability Risk: This type of risk happens target application is not stable due to improper coding or improper coding of business development.

- Parameterization Risk: This risk usually occurs due to the target application. If the target application has few restrictions, like it does not support few platforms, etc., it can become incompatible with the data migration programs.

Mitigation of the risks

- Data loss risk can be mitigated by performing completeness tests. In this the process, the count of source and target is taken and compared to ensure that complete data is migrated from source to target.
- Semantic risks can be overcome or minimized using any one or combination of the techniques mentioned below:

1. Appearance tests check the presence of objects on the front-end, i.e. User Interface (UI) of the application.
2. Processability test is used to make sure that there is a successful interaction between the target application and the newly migrated data.
3. Integration tests are used when an application is not independent but is interlinked with other applications as well.

- Data corruption risks can be mitigated by using the testing techniques like appearance tests, processability tests, and integration tests.
- Parameterization risk mitigation can be covered by the combination of testing techniques used to address the completeness, the semantics, and the corruption risks.

Project implementation of data migration in cloud

We have successfully implemented the Data Migrations concepts for the migrations of Applications from Legacy System to Cloud and Data Migration of Databases from Oracle 10g to 11g in Cloud. This was carried out in two main phases which were further divided into sub-phases and gradually moved to the cloud. This was done in utter cautions as applications were complex in nature and many clients to that project were involved in this transition.

In the 1st phase, all the legacy system applications in UNIX boxes mainly in C++ code were moved to JAVA based code then moved to Cloud servers. Baselines for legacy applications were created by taking as snapshots of the screening step by step, and test results were consolidated by running automation regression pack. Once applications were migrated to Cloud Sanity Test was performed GUI screens were compared with old URL then Database testing was done to check correct results are getting stored.

In the 2nd phase, it was sub-divided into smaller phases for smoother transitions of the databases, servers, applications, etc. working in cloud-like:

- Databases were migrated from Oracle 10g to Oracle 11g
- These databases of Oracle 11g were migrated to Cloud environment of System Test, UAT, PROD
- UNIX boxes were migrated from old server to new server then to Cloud environment against Oracle 10g database later it was replaced by Oracle 11g database.
- Migration of all the Applications with Oracle 11g database to Cloud servers.

Baselines were created for Oracle 10g taking the screenshot of the table structure, use of query to get the table structure; count of records was taken, existing files were run against the existing system to check whether it's in working state and get the desired results saved in appropriate place. Checking the connectivity of Databases whether they are able to connect and verify the tables with proper data if no data available copied data from PROD environment. Checking the existing Files has appropriate test data which will be used against both existing systems with old DB and a new system with new DB in Cloud. For all test activities, the test evidence is generated manually, documenting and use of automation tool for test results.

Once Migration takes place we compare the GUI screens from previous phase and test results. Compare the test results of DB results manually, ETL testing was performed to check the data flows in DB, files getting created in a defined path, the user can pull those files with no issue. Web services testing were done by SOAP tool old results, and new results were compared, found no difference. Used internal tool project specific to compare the old test results to new test results and hence no difference was found. This testing activity was done in all the environments of Cloud, i.e., System Test, UAT, PROD, and LIVE. The approach was like accessibility to these environments differs and handled differently by the different teams.

Testing the oracle database in cloud

1. Create a controlled version of the migrated database in Cloud.
2. Design a set of test cases that you can use to test the Oracle database from unit to system level. The test cases should:

a. Ensure the following:

- All the users in the source database have migrated successfully
- Privileges and grants for users are correct
- Tables have the correct structure, defaults are functioning correctly, and errors did not occur during mapping or generation

b. Validate that the data migrated successfully by doing the following:

- Comparing the number of rows in the Oracle database with those in the source database
- Calculating the sum of numerical columns in the Oracle database and compare with those in the source database

c. Ensure that the following applies to constraints:

- You cannot enter duplicate primary keys
- Foreign keys prevent you from entering inconsistent data
- Check constraints prevent you from entering invalid data

d. Check that indexes and sequences are created successfully.

e. Ensure that views migrated successfully by doing the following:

- Comparing the number of rows in the Oracle database with those in the source database
- Calculating the sum of numerical columns in the Oracle database and compare with those in the source database

f. Ensure that triggers, procedures, and functions are migrated successfully. Check that the correct values are returned for triggers and functions.

3. Run the test cases against the migrated database.

4. Create a report that evaluates the test case results.
   These reports allow you to evaluate the data to qualify the errors, file problem reports, and provide a customer with a controlled version of the database.
5. Test Cases are passed:
   If all tests in the test cases pass or contain acceptable errors, the test passes. If acceptable errors occur, document them in an error report that you can use for audit purposes.
6. Test Cases are failed:

a) Identify the cause of the error.
b) Identify the test cases needed to check the errors.
c) Logon issue on the controlled version of the migrated database code in the problem report.
d) Add the test case and a description of the problem to the incident tracking system of your organization, which could be a spreadsheet or bug reporting system

7. Identify acceptance tests that you can use to make sure the Oracle database is an acceptable quality level.

Testing the migrated applications in cloud

1. Understand the concepts of the requirements and business cases for the applications to be migrated.
2. Create a baseline for all the applications which will be migrated to the Cloud.
3. Design a set of test cases/automated test scripts that you can use to test the Applications in Cloud. The test cases/ automated test scripts should:

a. Validate that all the applications are working fine by performing sanity testing to catch early issues.
b. Running the Automated Regression pack to check all the test scenarios are covered.
c. Manual Regression pack is also run if no automation pack available
d. Validate that the data migrated successfully by doing the following: o Comparing the baselines taken earlier from Legacy system to the New system
e. Ensure the following tests are performed:

- Compatibility test- Verify the support of the required libraries and APIs (if any) under the cloud platform.
- Network connectivity test- Verify the connectivity between client computers and web servers, web servers, and application servers, and application servers and database servers, etc.
- Functional test-Verify against the system specifications or requirements on functionality.
- Performance and Load test- Verify that the required performance of the application can be achieved under the prescribed workload.
- Failover test-Verify the resilience functions of databases servers cluster, application servers, web servers, global load balancer, etc.
- Stress and Elasticity test- Verify the elasticity of the cloud platform under extreme workloads.
- Security Risk Assessment and Audit (SRAA)-Assess the vulnerability of the application and cloud platform.

4. Run the test cases against the migrated applications in the entire Cloud environment specified in Migration Test Strategy (System Test and UAT).
5. For PROD and LIVE environment cutover schedule: Ensure the following:

- Few applications are migrated and tested in one branch of cloud server then another time another set of application taken into another branch for migration.
- Make sure few cloud servers are chosen for migration as it might lead to confusion and managing will be difficult.

6. Create a report that evaluates the test case results.

7. **Test cases are passed**
   If all tests in the test cases pass or contain acceptable errors, the test passes. If acceptable errors occur, document them in an error report that you can use for audit purposes.

8. **Test cases are failed**

a. Identify the cause of the error.
b. Identify the test cases needed to check the errors.
c. Log an issue in the bug reporting system and mentioned in the problem report.

9. Identify acceptance tests that you can use to make sure the Application Migrated is an acceptable quality level.

Conclusion

The IT industry has taken cloud computing from an emerging technology to an essential scalable and flexible networking solution. Moving testing to the cloud must be considered as a strategic initiative. The cost of the on-premise model (internal lab testing) should be evaluated with that of cloud infrastructure, and then the enterprises can start small with cloud-based performance testing to see the benefits such as

- Testing at both typical and peak traffic levels, from hundreds of users to millions
- Generating geographically dispersed load
- Lower cost enabled by renting hardware, and using an on-demand service, allows testers to respond to accelerated development cycle times by making agile performance testing a realistic alternative testing live web-based applications in production and from outside the firewall instead of testing a fraction of expected load in lab and then extrapolating what those results would mean when actual load hits the site

According to a report by Cisco Systems Inc., companies are adopting cloud architectures at such a rapid rate that cloud traffic will account for 92% of the globe's total data center traffic by 2020.

Web applications are exposed to a much larger potential audience, and the failure or poor performance of an application has a direct impact on the perception of the brand and, potentially, revenue. As Performance testing demands extensive capital investments in hardware, Cloud is the good choice for organizations that do not want to have a full dedicated investment in testing infrastructure, as it fulfills all test environment needs and requirements. Performance testing from the cloud gives a complete understanding of the final user experience and drastically reduces investment and configuration costs.

Migration projects of any size require careful planning. Assessing its current portfolio of applications can help an organization understand the challenges, complexity, and level of effort required to have its databases migrated to Cloud and

applications migrated to Cloud. Many tools facilitate database and application migrations. These tools differ in the level of automation they provide in migrations and in the accuracy of the migrated SQL statements. Performing proofs of concept with these tools to better understand their capabilities will be beneficial in the long run for large migration projects.

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