Program : **B.E**

Subject Name: **Soft Computing**

Subject Code: **CS-8001**

Semester: **8th**

Subject Notes
CS 8002 - Cloud Computing

Unit-2

Cloud Computing Reference Model:

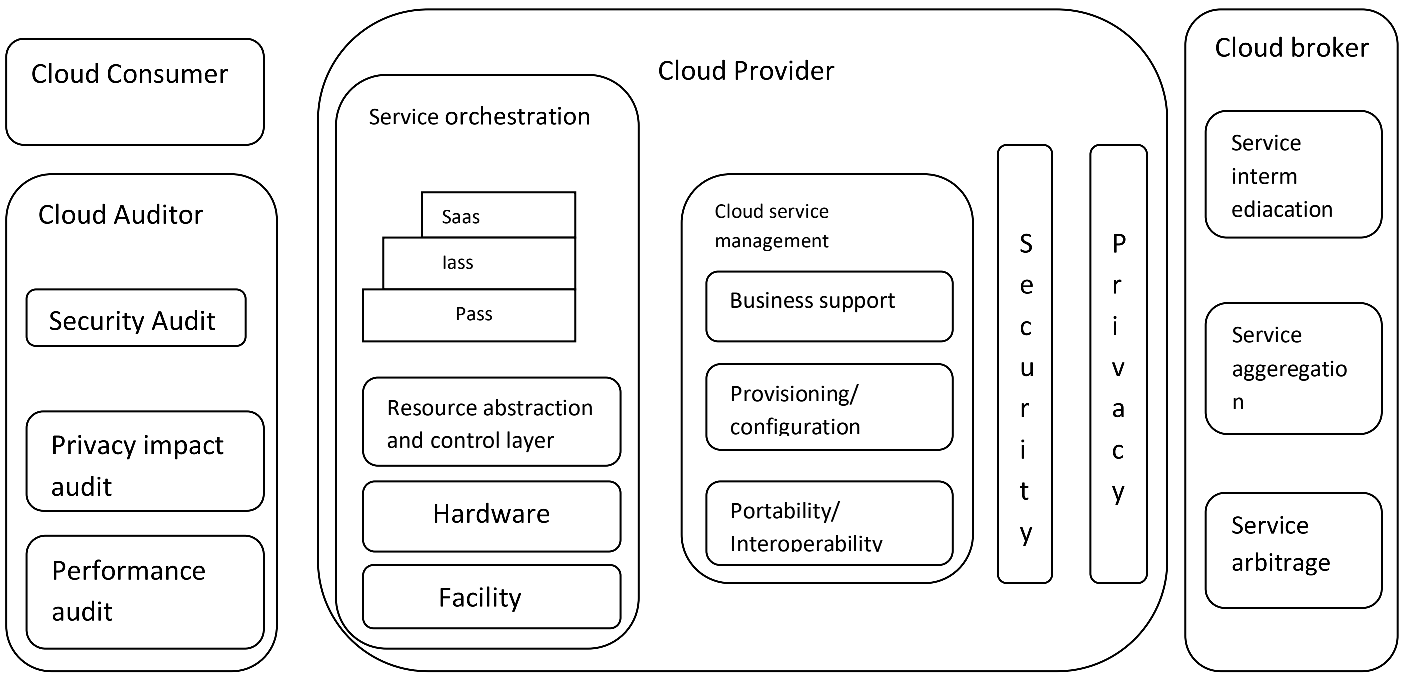

Figure: 2.1 Cloud Computing Reference Model

The cloud ecosystem for beginners: A data center view

From a cloud service provider point of view, data center giants like IBM, Google, Microsoft, and Amazon that have massive infrastructure at their disposal, use technologies such as virtualization, service-oriented architecture to “rent out” infrastructure to small and medium businesses (SMB) that appear to constitute a fairly large chunk of the customers.

Similarly, from a cloud consumer point of view, smaller businesses can reduce up-front infrastructure capital and maintenance costs by using the infrastructure (compute, memory, and storage) offered by the cloud providers. This can also reduce or keep their in-house infrastructure footprint or inventory under control.

IaaS forms the primary service delivery model, the others being software (SaaS) and platform services (PaaS). The primary use of IaaS is to run development and test, and production workloads and applications. These workloads run on the machines residing in the cloud data centers. These public cloud data centers reside in remote locations. From a cloud service consumer perspective, the user gets direct access to a machine in the cloud as if it were in the user’s own backyard, however connected through the Internet using a remote connection (remote desktop connection or through SSH). The machine is characterized by set of resources (CPU, memory, and storage), operating system and software, which are requested as per requirements by the user. The users may similarly use the SaaS and PaaS models to use readily available software, and develop applications on platforms respectively.

Some examples are as follows:

- IaaS providers: IBM SmartCloud Enterprise, Amazon Elastic Compute Cloud (EC2), RackSpace

  Hosting, Microsoft
- SaaS providers: Google, Microsoft, SalesForce, Yahoo
- PaaS providers: Google, Microsoft, TIBCO, VMware, Zoho

Now we shift our attention to how a cloud service provider delivers these services. First, we need to understand how virtualization acts as a key driver for cloud computing.

Hardware virtualization is a technology that enables the creation of multiple abstract (virtual) machines on the underlying physical hardware (bare metal). Every virtual machine (VM) has a set of resources (CPU, memory, storage), which forms a subset of the parent physical machine resources. You can assign resources to your VM based on your requirements. This also means that multiple VMs when packed together on a single piece of hardware helps us achieve server consolidation (optimally packing multiple VMs) thereby reducing server sprawl. Server sprawl was observed when companies used the traditional model of deploying a single heavy stand-alone application per physical server (1:1 — one application to one server). This, over the years, has resulted in increased capital and operational costs. Virtualization helps in consolidating multiple applications and aims to achieve optimum utilization of a physical hardware's underlying resources. From a cloud service provider's angle, physical machines in the data center are virtualized so as to deliver infrastructure resources to customers via virtual machines. Read more about hardware virtualization figure 2.1.

A cloud is a virtualized data center to achieve the following objectives:

- Elasticity: Ability to scale virtual machines resources up or down
- On-demand usage: Ability to add or delete computing power (CPU, memory) and storage according to demand
- Pay-per-use: Pay only for what you use
- Multitenancy: Ability to have multiple customers access their servers in the data center in an isolated manner

Let's look at the components that make up a "cloud." To understand this section better, think from the perspective of a cloud service provider so as to understand the components required to deliver cloud services. This perspective throws light on the data center, giving you an insight into how a cloud data center is structured. Two important terms in this context are management (managed-from) environment and managed (managed-to) environment. These terms inexplicitly describe the roles of a service provider and the service consumer.

The management environment is the central nervous system equivalent of the cloud; it manages the cloud infrastructure. This environment manages the infrastructure that is dedicated to the customers. The environment consists of components required to effectively deliver services to consumers. The various services offered span from image management and provisioning of machines to billing, accounting, metering, and more. The environment is characterized by hardware and software components; realized by powerful computer servers, high speed network, and storage components. The cloud management system (CMS) forms the heart of the management environment along with the hardware components.

The managed environment is composed of physical servers and in turn the virtual servers that are "managed-by" the management environment. The servers in the managed environment belong to a customer pool; where customers or users can create virtual servers on-demand and scale up/down as needed. These virtual servers are deployed from the pool of available physical servers.

In short, the management environment controls and processes all incoming requests to create, destroy, manage, and monitor virtual machines and storage devices. In the context of a public cloud, the users get direct access to the VMs created in the "managed" environment, through the Internet. They can access the machines after they are provisioned by the management layer.

User makes a request to create a VM by logging onto the cloud portal.

The request is intercepted by the request manager and is forwarded to the management environment.

The management environment, on receiving the request, interprets it and applies to it provisioning logic to create a VM from the set of available physical servers.

External storage is attached to the VM from a storage area network (SAN) store during provisioning in addition to the local storage.

After the VM is provisioned and ready to use, the user is notified of this information and finally gains total control of the VM. The user can access this VM through the public Internet because the VM has a public IP address.

Similar to this workflow, users can decommission and manage their servers according to their needs. They can also create new images, store snapshots of their system, and so on.

Smart Ways Cloud Computing Can Help Organizations to Become Eco-Friendly

Tons of electronic waste ends up in the landfills all over the world, poisoning the earth and polluting our ecosystem – every single day. At the same time, a lot of power is used to feed the insatiable needs of the IT industry. Well, in the current scenario, where every business organization is doing all it can to reduce carbon footprints, cloud computing seems like a great option. It is perhaps, one of the most modern and advanced approaches to going green without compromising on business performance. Even the United Nations endorses it as an effective measure in reducing the world's carbon footprint. By moving over to the cloud, any company, big or small, can do their bit and making the planet greener and at cheaper cost.

1. By enabling remote working

While setting up a new plant in a remote location, a company would have to deploy their own experts. This means, exponential cost in flying the required personnel to the field and back till the work is complete. Since, airplanes burn tonnes of greenhouse gases, frequent flying is not the best way to go green. All this unnecessary travelling can be avoided by investing in cloud computing, which will allow your employees to work from anywhere.

2. By reducing the usage of paper

In a traditional office setup, large amount of paper is wasted in excessive documentation and printing.

But, with the help of cloud computing, an organization can save a lot of trees from being cut down. In a virtual office, each and every piece of information is accessible via internet at any time. So, there is no need for printed reports, memos or brochures. And, a paperless office is a sure way to go green.

3. By lowering power consumption

A study conducted in the United States, in 2007, reported that up to 60 per cent of office PCs are left on overnight, resulting in 19.82 billion kWh5 of electricity wastage and 14.4 million tonnes of associated carbon dioxide emissions. With cloud computing, any business can save a lot on the utility bills, as there is no need to invest in hardware and other systems that would need round-the- clock maintenance. This would make a huge difference in the power consumed by the company.

4. By cutting down the office space requirement

The adoption of cloud computing would mean that all your employees have remote access to all the data. More than one employee can work on the same file simultaneously making it possible for

them to communicate and share information. Thus, a company can save huge amount of investment in procuring a large office space and maintaining large servers.

5. By ensuring efficient management of resources

For most businesses, utilizing their servers to full capacity is not always possible. When there is a peak in the data load, in-house data centers would need extra servers to handle it efficiently. And, when there would a fall, then the additional servers would become idle. This is neither good for the organization nor for the environment. A cloud service provider has a large number of clients and is fully equipped to handle such issues. So, peaks of data load can be easily handled by allocating resources where needed. This would mean fewer machines, and less energy consumption.

Companies that adopt cloud computing could lead the way in making the IT industry more sustainable and significantly greener.

The delivery of dynamic, cloud-based infrastructure, platform and application services doesn't occur in a vacuum. In addition to best practices for effective administration of all the elements associated with cloud service delivery, cloud service management and cloud monitoring tools enable providers to keep up with the continually shifting capacity demands of a highly elastic environment.

Cloud monitoring and cloud service management tools allow cloud providers to ensure optimal performance, continuity and efficiency in virtualized, on-demand environments. These tools -- software that manages and monitors networks, systems and applications -- enable cloud providers not just to guarantee performance, but also to better orchestrate and automate provisioning of resources.

Cloud monitoring tools, specifically, enable cloud providers to track the performance, continuity and security of all of the components that support service delivery: the hardware, software and services in the data center and throughout the network infrastructure.

Through successful cloud service management and monitoring, cloud providers can use service quality to differentiate themselves in what remains a crowded and noisy marketplace.

Through successful cloud service management and monitoring, cloud providers can use service quality to differentiate themselves in what remains a crowded and noisy marketplace. Effective cloud service management also helps lower the risk of frequent cloud outages that can jeopardize security systems. Using these tools also supports greater operational efficiency, helping cloud providers minimize costs and maximize profit margins. However, achieving these goals can be difficult in a complex virtual delivery environment where visibility and control are limits.

Cloud Service Management

Cloud service management shares some basic principles with traditional IT service management (ITSM). Cloud management tools help providers administrate the systems and applications that facilitate the on-demand service delivery model. The goal of these practices is to improve the efficiency of the cloud environment and achieve a high level of customer satisfaction.

Essentially, cloud service management takes the customer perspective as the measure of service assurance and manages all the individual IT resources in a way that will support that. This involves adjusting the operations and policies, as necessary, of all the assets in the virtual environment that support and affect the on-demand service delivery model. Such assets include servers, software and services that provide access and connectivity to these cloud services.

The core elements of cloud service management mirror those of traditional ITSM -- including cloud service-level agreement (SLA) management, cloud capacity management, availability management and billing -- and are applied to administrate a cloud delivery environment in a systemic way. These processes are supported with tools that track provisioning and change management, configuration management, release management, incident management, performance management and service continuity. Customers are supported directly and indirectly through a help desk function. Cloud service management is complemented by monitoring software that tracks operational information and feeds that data to the appropriate management resource.

Given the elastic, highly virtualized nature of cloud environments, there are some key differences in approaches to cloud service management and conventional IT service management. The two disciplines have different objectives, requiring tools that emphasize their individual requirements. Whereas the goals of traditional ITSM are effective SLA management, improved performance and streamlined billing, the goal of cloud service management is to orchestrate resources for fast provisioning, effective capacity management and ongoing service stability. Automation is vital to ensure efficiency and reduce costs.

Cloud service management shares all of the obstacles to managing any IT environment -- event correlation, incident prioritization, capacity management and performance management -- plus the unique challenges of a dynamic virtual environment. Visibility remains a common challenge in managing highly elastic and complex virtual systems that function at a tremendous scale.

Despite the challenges, cloud providers must implement management processes and use best practices to optimize efficiency, improve performance and, ultimately, maximize customer satisfaction. The highly competitive nature of the cloud market requires providers to focus on delivery in order to not just survive, but to thrive.

Types of cloud computing

- **Public Clouds**

A public cloud is basically the internet. Service providers use the internet to make resources, such as applications (also known as Software-as-a-service) and storage, available to the general public, or on a 'public cloud. Examples of public clouds include Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google AppEngine and Windows Azure Services Platform.

For users, these types of clouds will provide the best economies of scale, are inexpensive to set-up because hardware, application and bandwidth costs are covered by the provider. It's a pay-per-usage model and the only costs incurred are based on the capacity that is used.

There are some limitations, however; the public cloud may not be the right fit for every organization. The model can limit configuration, security, and SLA specificity, making it less-than-ideal for services using sensitive data that is subject to compliancy regulations.

- **Private Clouds**

Private clouds are data center architectures owned by a single company that provides flexibility, scalability, provisioning, automation and monitoring. The goal of a private cloud is not sell "as-a-service" offerings to external customers but instead to gain the benefits of cloud architecture without giving up the control of maintaining your own data center.

Private clouds can be expensive with typically modest economies of scale. This is usually not an option for the average Small-to-Medium sized business and is most typically put to use by large enterprises. Private clouds are driven by concerns around security and compliance, and keeping assets within the firewall.

- **Hybrid Clouds**

By using a Hybrid approach, companies can maintain control of an internally managed private cloud while relying on the public cloud as needed. For instance during peak periods individual applications, or portions of applications can be migrated to the Public Cloud. This will also be beneficial during predictable outages: hurricane warnings, scheduled maintenance windows, rolling brown/blackouts.

The ability to maintain an off-premise disaster recovery site for most organizations is impossible due to cost. While there are lower cost solutions and alternatives the lower down the spectrum an organization gets, the capability to recover data quickly reduces. Cloud based Disaster Recovery (DR)/Business Continuity (BC) services allow organizations to contract failover out to a Managed Services Provider that maintains multi-tenant infrastructure for DR/BC, and specializes in getting business back online quickly.

Models of cloud computing

- **Infrastructure as a Service (IaaS):**

Infrastructure as a Service, sometimes abbreviated as IaaS, contains the basic building blocks for cloud IT and typically provide access to networking features, computers (virtual or on dedicated hardware), and data storage space. Infrastructure as a Service provides you with the highest level of flexibility and management control over your IT resources and is most similar to existing IT resources that many IT departments and developers are familiar with today.

- **Platform as a Service (PaaS):**

Platforms as a service remove the need for organizations to manage the underlying infrastructure (usually hardware and operating systems) and allow you to focus on the deployment and management of your applications. This helps you be more efficient as you don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running your application.

- **Software as a Service (SaaS):**

Software as a Service provides you with a completed product that is run and managed by the service provider. In most cases, people referring to Software as a Service are referring to end-user applications. With a SaaS offering you do not have to think about how the service is maintained or how the underlying infrastructure is managed; you only need to think about how you will use that particular piece software. A common example of a SaaS application is web-based email where you can send and receive email without having to manage feature additions to the email product or maintaining the servers and operating systems that the email program is running on.

Cloud Eco Systems

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Cloud Analytics

Information is a strategic asset. Companies acknowledge that value and are collecting huge volumes of data, from all possible sources. But very few companies can leverage that data to their competitive advantage. Challenges range from data accuracy and completeness to speed and complexity of implementing analytics.

An even bigger issue is that, once implemented, analytics remains so disconnected from operations that it is almost irrelevant. The insights revealed are generally at an aggregate level and provide information that is merely “good to know” and seldom actionable by operational teams.

Today, cloud and mobile technologies are providing enterprises of all sizes with opportunities to use big data and analytics to make better, data-driven decisions. New-generation platforms (cloud, big data, and analytics) bring analytics and operational applications together to deliver demonstrable ROI.

Cloud computing allows organizations to consolidate data from all sources, across all communication channels, and do it at a big data scale. Without cloud, collecting data from all internal applications, social networks, devices, and data subscriptions would be cost prohibitive for most organizations. On-premise big data deployments could involve significant operational risks and expensive infrastructure. The ongoing maintenance of on-premise systems itself would be daunting enough to discourage many organizations.

Let’s consider some of the advantages that cloud offers over on-premise data analytics implementations.

- **Robust Data Foundation**

Bringing together reliable data for analytics has always been a challenge. Analytics are not accurate if data is scattered, stale, and incomplete. Many of your applications and data sources, such as social and third-party data subscriptions, are in the cloud. In this environment, creating an on-premise data store is less than optimal. A cloud-based data management platform makes it easier for companies to blend data from all such sources and helps match, merge, and clean data. Real-time access to social and third-party data sources and real-time data stewardship enabled by cloud solutions keeps your data current, complete, and clean.

- **Fast Time to Value**

A modern data-management platform brings together master data management and big data analytics capabilities in the cloud so that business can create data-driven applications using the reliable data with relevant insights. The principal advantage of this unified cloud platform is faster time-to-value, keeping up with the pace of business. Whenever there is a need for a new, data-driven decision management application, you can create one in the cloud quickly. There is no need to setup infrastructure (hardware, operating systems, databases, application servers, analytics), create new integrations, or define data models or data uploads. In the cloud, everything is already set up and available. Use cases are limited only by your imagination. Sales operation teams can create better alignments and account planning applications, marketing teams can create segmentation for campaign planning, contact centers can uncover up-sell and cross-sell opportunities, and strategy groups can simulate pre and post-merger scenarios.

- **Improved Collaboration**

On-premise and disconnected systems make it tedious to develop analytical models collaboratively and to share the insights. Team members use emails and printouts to discuss ideas and consolidate feedback manually. Development takes time; many inputs are lost, and many members with valuable ideas are never included. The situation is even more complicated in globally distributed teams. Teams cannot learn from each other, and they spend expensive resources duplicating analytics already performed by others.

In cloud-based big data analytics, groups collaborate on data incubation and analytics design and share insights across departments, across the globe. Insights are available in real time and, when included within operational applications, are actionable immediately. For example, marketing findings are not locked in marketing systems, but shared with all customer-facing teams. The information gathered by sales in the field is not left in spreadsheets, but is fed back to marketing, in a closed-loop, to improve the customer experience.

- **Quicker Adoption**

On-premise applications historically have seen slow adoption rates. Even after investment in training and skills development, utilization remains low and many applications are reduced to shelfware.

Built on the self-learning paradigm and user experience similar to consumer applications, cloud-based applications are easy to use and promote fast adoption. The cloud facilitates democratization of analytics across the organization, increasing the access and utilization. When insights from cloud-based analytics are presented within online operational applications, adoption improves even further. Users do not have to create one-off reports or log into separate systems to “run analytics.” It is just available within the current task. Data-driven applications in the cloud can be readily accessible to everyone from any place, any time, on any device.

- **Scalability and Elasticity**

Another big benefit of analytics in the cloud is on-demand computational power. Whether it is a Fortune 500 company or small to medium business, they can access similar analytic resources. With on-premise installations, there is always a risk of over-spending or underestimating the computing needs. Adding servers is not easy, and reducing them is equally agonizing.

Elasticity in cloud computing has taken that uncertainty out of the equation. With cloud technologies, you can start small and expand as your business needs grow, and scale back if your strategy changes. You can access higher compute power on demand if you are running complex analysis, and scale back once you are back on a routine.

- **Lower Total Cost of Ownership**

Companies are painfully aware of maintenance, upgrades, and migrations required by on-premise analytics platforms. Every 18 months or so, there is a massive effort to upgrade to a newer version. Not only is this costly, it affects business continuity. Not every new feature is backward compatible; businesses often end up struggling to redesign reports, redefine analysis, and redo integrations.

With cloud-based modern data management platforms with big data analytics, applications are always current. There are no upgrade issues, and enabling new capabilities requires minimal IT intervention. Companies can enjoy new features multiple times a year without big investments or downtime.

Reliable data is the foundation of analytics. If the data is not correct, complete, or current, you cannot expect much from the analytics. Cloud-based data management as a service helps organizations to blend master data and big data across all domains and formats, from all internal, third-party, and social media sources, to form a complete view of the business. This union of data, operations, and analytics, in a closed-loop, provides an unprecedented level of agility, collaboration, and responsiveness. All made possible by cloud technologies.

Cloud Interoperability & Standards

Interoperability in cloud computing has the same problems as interoperability between homegrown applications and commercial software, or between different commercial software. These problems in the cloud are widely recognized but standards bodies turned to them only recently. The world of cloud is a bit wilder than the world of applications because clouds currently offer an opportunity for cloud providers to lock in new, and not technically savvy, business customers.

- **Avoid synchronous communications between clouds**

Try to avoid synchronous communication between clouds as much as possible. Engage an acquire-store-resend model. You will pay some performance penalties but avoid binding the life cycles of your applications with the life cycles of SaaS. The goal of this preference is to achieve a loose coupling between clouds while maintaining some resiliency to changes in connectivity and location.

- **Monitor the connections**

Monitor connections in the integration hub at all available levels. Reserve a mechanism for an automated acquiring of lost connections. Compare monitored metrics against your contract (SLA) with the SaaS provider, and act actively on any discrepancies.

- **Pay attention to the interactions**

Like in any service-oriented ecosystem, put the maximum attention on semantics and ontologies of operations and data involved in the interactions between clouds. You will see that the informational aspects, not only formats, are crucial for all emerging cloud standards. Information "translation" in the cloud integration hub is a must-have feature.

- **Minimize the interactions**

Keep the number of interactions between clouds to the bare minimum but use coarse-grained interfaces. Watch for an availability of such interfaces in the selected SaaS and create a service layer on the top of your own applications if they do not support such granularity.

- **REST is best**

In line with the last note, try to model the application landscape in both clouds as a landscape of resources. This will allow you to minimize data volumes moved between clouds and construct a RESTful interaction solution. However, do not discard simple XML over HTTP and similar cheap mechanisms. More sophisticated integration is available through innovative services like cloud integration from Boomi or Cast Iron, which allow the Internet to be seen as an enterprise service bus (ESB) of sorts.

- **Do it yourself with security**

Do not trust any declarations of SaaS providers regarding security. Protect your channel to SaaS from the integration hub (this is one of the major roles of having such hub) with all security means your corporate policies specify. If your applications are deployed in another cloud, the communication channel with this one has to be equally protected.

Cloud Business Process Management

Business Process Management and the automation it delivers are key to operational efficiency. But, BPM also drives more growth, manages governance, risk, and compliance, and improves customer and employee engagement. What's not to love?

- **Design**

Model processes that drive powerful apps with a low-code process modeler driven by BPMN-notation.

- **Execute**

Create process automation that can transform your business. Eliminate reliance on old-school paper forms and speed operations.

- **Manage**

Dynamic Business Rules embed process automation in your apps, ensuring consistency and reinforcing organizational structure.

- **Optimize**

Automated testing, predictive analytics, dynamic reporting, business activity monitoring, and more keep your processes continually optimized and your apps in tip-top shape.

Advantages of Cloud-based BPM

Cloud-based BPM lets you "test the waters." Even if you are 100% convinced that adopting BPM will be a good move for your business (and we're 100% it will be), using BPM in the cloud allows you to try it without making an all-in commitment. If you find managing business processes manually and on-premises works better for you, you haven't made significant investments that cannot then be recouped.

Cloud-based BPM saves you money. Because you will be using BPM software as a service (Saas) that is delivered from the cloud, you will not be building a large and complicated IT infrastructure. No infrastructure to build also means no infrastructure to maintain. And you "pay as you go" – per-use or subscription pricing takes the place of a sizeable up-front investment.

Cloud-based BPM saves you time. The lack of any large internal infrastructure means you'll be able to roll out business process management in your organization quite rapidly. This faster time to market boosts investor confidence. And because cloud-based apps and data are easier to coordinate, the processes you manage will be more efficient.

Cloud-based BPM encourages collaboration. Cloud computing erases borders that once hindered teamwork. A survey from RW3 CultureWizard finds that 41% of all corporate teams never meet in person, and 48% of respondents report that over half of their corporate teams include members in other countries. Understanding business processes that are managed from the cloud results in understanding how this kind of borderless productivity is now possible.

Cloud-based BPM equips you to go mobile. Mobile technology is transforming the way we work. In 2015, about 35% of workforce members worldwide were working on-the-go, from mobile devices—and they weren't just checking email or managing their calendars. More and more, they were managing business processes. Market research company Technavio predicts mobile BPM will grow at an annual rate of almost 21% between now and 2020.

Testing the Cloud: Definitions, Requirements, and Solutions

The virtualized data center, whether within the enterprise or located at a cloud service provider, must be properly provisioned in order to provide the necessary functions and performance of cloud-based applications. Testing of cloud services has some familiar aspects and some new challenges. Even though they will be used in a cloud environment, the basic components that populate the data center need to be tested for functionality, performance, and security. This is complemented with testing of the data center and end- to-end services.

At the network interconnectivity infrastructure level, testing must validate:

- Routers
- Switches, including fibre channel forwarders
- Application delivery platforms
- Voice over IP (VoIP) gateways

At the server and storage infrastructure level, testing must validate:

- Data center capacity
- Data center networks
- Storage systems

- Converged network adapters

At the virtualization level, testing must validate:

- Virtual hosts
- Video head ends
- VM instantiation and movement

At the security infrastructure level, testing must validate:

- Firewalls
- Intrusion Prevention Systems (IPS)
- VPN gateways

Network Interconnectivity Infrastructure Level

- Routers
- Switches, including fibre channel forwarders
- Application delivery platforms
- Voice over IP (VoIP) gateways

Each of the networking components used within the data center must be thoroughly tested for conformance to standards, functionality, interoperability, performance, and security before deployment. This type of testing is the bread and butter of network testing companies such as Ixia.

Ixia's test solutions cover the wide range of data center network testing. Ixia's chassis house up to 12 interface cards, which include Ethernet speeds from 10Mbps to 100Gbps; high-density solutions for 1Gbps and 10Gbps are available. Direct fibre channel interfaces are used for storage area network (SAN) testing. Each test port is backed by substantial special-purpose traffic generation hardware, and substantial compute power and memory.

Security Testing

Network security in a cloud environment is particularly important. Classical data centers can secure their facilities through the "front door" that connected them to the Internet or other corporate sites. Not so in a cloud environment. Each cloud computing and storage component can be located at a different physical location and connected over the Internet or private networks. Each of the connections is a potential security risk.

A number of dedicated security appliances are in widespread use, protecting enterprises and data centers worldwide. The culmination of the development of these devices is

the unified threat management (UTM) system that encompasses the roles of firewalls, intrusion prevention systems, anti-virus, anti-spam, and data loss prevention.

Virtual security applications are becoming widespread in the cloud environment. These software-only, VM-aware implementations of security functions are distributed between components of cloud applications. They serve to protect each component from other traffic on shared networks and other

VMs on virtualized servers.

Regardless of whether they are physical or virtual and where they are placed in the data center, security mechanisms must be tested thoroughly in three dimensions:

- **Effectiveness** – do the security mechanisms effectively defend against the attacks they were designed to prevent?
- **Accuracy** – does it produce any false positives?
- **Performance** – do the security mechanisms pass an acceptable amount of traffic? The last category is extremely important. Security devices have a difficult job to do watching all traffic on high speed links, inspecting for malware, fending off denial of service attacks, etc. They must be able to find and prevent attacks when processing large amounts of traffic. Likewise, they must pass an acceptable amount of "normal" when under heavy attack. A security device that cannot prevent penetration when under full load is easily defeated. A security device that blocks critical business applications when under attack has effectively been defeated.

Testing of network security devices requires a number of techniques, which will be discussed in the next few sections:

- Known vulnerability testing
- Distributed denial of service

Each cloud computing and storage component can be located at a different physical location and connectd over the Internet or private networks. Each of the connections is a potential security risk.

- Line-rate multiplay traffic
- Encrypted traffic
- Data leakage testing

- Known Vulnerability Testing

Known vulnerability testing is the cornerstone of network security device testing. Attacks are mounted against security mechanisms by using a large database of known malware, intrusions, and other attacks. A number of organizations exist to maintain this list. One leading organization is the U.S. National Vulnerability Database maintained by the National Institute of Standards and Technology (NIST). The Mitre Corporation provides access to this database, called the CVE—Common Vulnerabilities and Exposures. As of May 2010, more than 42,000 vulnerabilities are listed, with more than 15 added on a daily basis.

Proper security testing requires that a number of known vulnerabilities be applied to security devices at a significant percentage of line-rate. The device under test (DUT) should properly reject all such attacks, while maintaining a reasonable rate of transmission of "good" communications.

In addition, known vulnerabilities must be applied using the wide variety of evasion techniques. The combination of thousands of known vulnerabilities and dozens of evasion techniques requires that a subset of all possibilities be used for testing. Test tools offer representative samples, including special cases for newly published vulnerabilities.

- Distributed Denial of Service

Denial of service attacks often use large numbers of computers that have been taken over by hackers. Those computers, called “zombies”, use dozens of attack techniques designed to overload network and security devices. This type of testing requires test equipment capable of simulating thousands of computers.

Devices must be tested to ensure that none of the denial of service attacks, singly or in combination, is able to disable the device. In addition, the ability of the DUT to accept new connections and provide an acceptable level of performance must be measured.

Testing and the Cloud

While many companies are approaching cloud computing with cautious optimism, testing appears to be one area where they are willing to be more adventurous. There are several factors that account for this openness toward testing in the cloud:

• Testing is a periodic activity and requires new environments to be set up for each project. Test labs in companies typically sit idle for longer periods, consuming capital, power and space. Approximately 50% to 70% of the technology infrastructure earmarked for testing is underutilized, according to both anecdotal and published reports.

• Testing is considered an important but non-business-critical activity. Moving testing

to the cloud is seen as a safe bet because it doesn’t include sensitive corporate data and has minimal impact on the organization’s busi- ness-as-usual activities.

• Applications are increasingly becoming dynamic, complex, distributed and compo-nent-based, creating a multiplicity of new challenges for testing teams. For instance, mobile and Web applications must be tested for multiple operating systems and updates, multiple browser platforms and versions, different types of hardware and a large number of concurrent users to understand their performance in real-time. The conventional approach of manually creating in-house testing environments that fully mirror these complexities and multiplicities consumes huge capital and resources.

Operational Challenges

Despite the bright upside, cloud-based testing has its limitations, too. Organizations must contend with a different set of challenges in their quest to reap cloud’s benefits.

• **Lack of standards**: Presently, there are no universal/standard solutions to integrate public

cloud resources with user companies’ internal data center resources. Public cloud providers have their own architecture, operating models and pricing mechanisms and offer very little interoperability. This poses a big challenge for companies when they need to switch vendors.

• **Security in the public cloud:** Security in the public cloud is still a major concern, and encryption techniques currently available today are considered insufficient. Procedures are being developed to improve security and performance in the public cloud. For instance, service providers are developing virtual private clouds and client partitions. The main cause for concern is that the data may be stored in a remote location beyond an organization’s legal and regulatory jurisdiction.

• **SLAs**: Terms and conditions of cloud service are sometimes hard to understand, misleading and biased toward the vendor. Such areas include clauses governing data integrity, data preservation, data location and transfer, according to a study by The Center for Commercial Law

Studies at Queen Mary, University of London 2010. Companies would do well to be diligent and proactive in sorting through these issues with their vendors.

• **Infrastructure**: Some cloud providers offer only limited types of configurations, technology, servers and storage, networking and bandwidth, making it difficult to create real-time test environments.

• **Usage**: Improper usage of cloud-based test environments can increase costs. Even though some vendors offer pay-as-you-go cloud- based testing services, this approach can be expensive or out of sync with requirements, particularly if user estimates are too conservative or wildly overblown. Companies that apply pay-as-they-go approaches must first perfect their cost models or apply process-driven estimates rather than utilizing projections that are unsupported by data.

• **Planning**: Testing teams should rigorously plan their test environments, from utilization periods through disassembly. They should also be aware of the associated expenses, such as cost of encrypting data, before putting testing in a cloud environment, since these requirements will consume additional CPU and memory. It's important to monitor utilization of cloud resources to avoid over-usage and over-payment.

• **Performance**: As public clouds are shared by numerous users, there may be cases where a company might have to wait for the required bandwidth. There may also be cases where a service provider may suddenly announce disruption of service due to a maintenance window or network outage. Some of these issues can be resolved by working closely and proactively with the service provider.

Why is Cloud Testing Important?

Comparing with current software testing, cloud-based testing has several unique advantages listed below.

• Reduce costs by leveraging with computing resources in clouds – This refers to effectively using virtualized resources and shared cloud infrastructure to eliminate required computer resources and licensed software costs in a test laboratory.

• Take the advantage of on-demand test services (by a third-party) to conduct large-scale and effective real-time online validation for internet- based software in clouds.

• Easily leverage scalable cloud system infrastructure to test and evaluate system (SaaS/ Cloud/Application) performance and scalability.

IBM reported the experience on cloud testing in small business division, where a flexible and cost-efficient cloud-based development and testing environment is implemented, and cloud testing has demonstrated the following major benefits in [19].

• Reduce its capital and licensing expenses as much as 50% to 75% using virtualized resources.

• Reduce operating and labor costs as much as 30% to 50% by automating development and testing resource provisioning and configuration.

• Shorten its development and testing setup time from weeks to minutes.

• Improve product quality and reduce the detected defects by as much as 15% to 30%.

• Help to accelerate cloud computing initiatives with IBMCloudBurst™ implemented through

QuickStart services.

Forms of Cloud-Based Software Testing

There are four different forms of cloud-based software testing. Each of them has different focuses and objectives.

- **Testing a SaaS in a cloud** – It assures the quality of a SaaS in a cloud based on its functional and non-functional service requirements.
- **Testing of a cloud** – It validates the quality of a cloud from an external view based on the provided cloud specified capabilities and service features. Cloud and SaaS vendors as well as end users are interested in carrying on this type of testing.
- **Testing inside a cloud** - It checks the quality of a cloud from an internal view based on the internal infrastructures of a cloud and specified cloud capabilities. Only cloud vendors can perform this type of testing since they have accesses to internal infrastructures and connections between its internal SaaS(s) and automatic capabilities, security, management and monitor.
- **Testing over clouds** – It tests cloud-based service applications over clouds, including private, public, and hybrid clouds based on system- level application service requirements and specifications. This usually is performed by the cloud-based application system providers.

Test Type	Testing focuses	Cloud/SaaS-Oriented Testing inside a Cloud	Online Application-Based Testing on a Cloud	Cloud-Based Application Testing over Clouds
Service Function Testing	GUI-based and API- based service functions	Testing SaaS/Cloud-based service functions inside a cloud	Testing online-based application service functions on a cloud	Testing cloud-based application service functions over a cloud
Integration Testing	SaaS interactions and Cloud connections	Vendor-specific component and service integration inside a private/public cloud	Integration between online clients and back-end servers on a cloud	- End-to-end application integration over clouds - Integration with legacy systems over clouds
API and Connectivity Testing	API interfaces and connectivity protocols (HTTPS, REST, SOAP, RMI)	SaaS/Cloud API & connectivity testing in a cloud	Testing user-centered service APIs and connectivity on a cloud	Testing application service APIs and connectivity over clouds
Performance & Scalability Testing	Performance and scalability based on a SLA	SaaS/Cloud performance and scalability testing in a cloud based on the given SLA	User-oriented application performance and scalability testing on a cloud	End-to-end system-level performance and scalability inside/on/over cloud based on a given SLA

Security Testing	SaaS/Application data, processes, functions, and user privacy	SaaS/Cloud security features and user privacy in a cloud	User-oriented security and privacy on a cloud	System-level end-to-end security over clouds
Interoperability & Compatibility Testing	Validate different client interfaces and technologies and diverse compatibilities on different platforms and browsers	Testing Cloud/ SaaS compatibility, connectivity protocols and UI/client technologies inside a cloud	Testing user-centered interoperability, compatibility of platforms/ OS/browsers, and client technologies on a cloud	Testing application compatibility, end-to- end interoperability and application connectivity to legacy systems over clouds
Regression Testing	Changed & impacted SaaS/Cloud service features and related APIs/	Cloud/SaaS-oriented regression testing inside a cloud	User-centered re-validation on a cloud	End-to-end application system regression over clouds

Table: 2.1 Forms of Cloud Based Testing

New Requirements and Features in Cloud Testing

There are four new requirements and features in cloud testing.

- **Cloud-based testing environment** – This refers to use a selected cloud infrastructure (or platform) as a base to form a test bed equipped with diverse and scalable computing resources, system infrastructures, and licensed tools, which are allocated using auto-provision based on static/ dynamic requests. Both virtual and physical computing resources can be included and deployed inside.
- **Service-level-agreements (SLAs)** – In cloud computing, all clouds, SaaS, and applications usually provide diverse services to their end users and customers with well-defined service-level-agreement. Naturally, these agreements will become a part of testing and quality assurance requirements, such as system reliability, availability, security, and performance.
- **Price models and service billing** – Since utility computing is one of basic concepts and features in cloud computing, so price models and utility billing becomes basic parts and service for testing as a service. In other words, required computing resources and infrastructures (including tools), and testing task services will be charged based on pre-defined cost models and
- **Large-scale cloud-based data and traffic simulation** - Applying and simulating large-scale online user accesses and traffic data (or messages) in connectivity interfaces is necessary in cloud testing, particularly in system-level function validation and performance testing.

	Internet-Based Software Testing (i.e. Distributed/Web-Based System Infrastructure)	Cloud-Based Software Testing

Primary Testing Objectives	- Assure the quality of system functions and performance based on the given specifications - Check usability, compatibility, interoperability.	- Assure the quality of functions and performance of SaaS , Clouds, and applications by leveraging a cloud environment - Assure the quality of cloud elasticity & scalability based a SLA
Testing as a service	- In-house internal software testing as engineering tasks	- Real-time on-demand testing service offered by a third-party - Online testing service based on a pre-defined SLA
Testing and Execution Time	- Offline test execution in a test lab. - Testing a product before its delivery	- On-demand test execution by third-parties; - Online test execution in a public cloud; - Offline test execution in a private cloud
Testing Environment	- A pre-fixed and configured test environment in a test lab. with purchased hardware and/or software	- An open public test environment with diverse computing resources - A scalable private test environment in a test lab.
Testing Costs	- Required hardware costs and software (license) costs - Engineering costs in a test process	- Based on a pre-defined service-level-agreement (SLA) - TaaS and Cloud testing service costs (pay-as-you-test) - Engineering costs in SaaS/Cloud/application vendors
Test Simulation	- Simulated online user access - Simulated online traffic data	- Virtual/online user access simulation - Virtual/online traffic data simulation
Function Validation	- Validating component functions and system functions as well as service features	- SaaS/Cloud service functions, end-to-end application functions - Leveraged functions with legacy systems
Integration Testing	- Function-based integration - Component-based integration - Architecture-based integration - Interface/connection integration	- SaaS-based integration in a cloud - SaaS integration between clouds - Application-oriented end-to-end integration over clouds - Enterprise-oriented application integration between SaaS/Cloud and with legacy systems
Security Testing	Aim to the following targets: - Function-based security features - User privacy - Client/server access security - Process access security - Data/message integrity	Aim to the following targets: - SaaS/Cloud security features, including monitor and measurement - User privacy in diverse web clients - End-to-end application security over clouds - SaaS/Cloud API and connectivity security - Security testing with virtual/real-time tests in a vendor's cloud
Scalability & Performance Testing	- Performed a fixed test environment - Apply simulated user access, ,messages, and test data - Online monitor and evaluation	- Performed in a scalable test environment based on a SLA - Apply both virtual and real-time online test data - Online monitor, validation, and measurement

Table: 2.2 Comparison of Cloud Testing

A comparison view about cloud testing products, solutions and services from four major players:

	PushtoTest http://www.pushtotest.com/	Cloud Testing http://www.cloudtesting.com/	SOASTA http://www.soasta.com/	iTKO http://www.itko.com/
Testing Products	- Test Maker	- Cross browser testing - Website archiving - Function testing	CloudTest™ supports test recording, editing, assembly, monitoring, and integrated Analytics	LISA product suite: LISA VirtualizeTM LISA Test LISA Validate LISA Pathfinder
Test Services	- PushTotest, TestOnDemand	- Function test service - Cross browser testing - Website archiving service	- CloudTest On-Demand - CloudTest Appliances	Education and consulting service on cloud-based application testing
Function Testing	Web-Based, RIA-based, and SOA-based function testing	Script-based function testing support for testers, developers, and website managers	Visual and UI-based function testing	- Automatic GUI testing, codeless testing, continuous and event-based validation
Test Development	- Record/playback, unit test, - object/component oriented test development	- Script-based test development - Web-based record/replay	- Test editing and test assembly with tools - Visual web-based record, capture, filtering and automated test clip creation	- Virtualized and codeless test development - Build executable tests by integrating with existing test repositories.

Table: 2.3 Comparison of Cloud testing products

Fault Tolerance Techniques and Comparative Implementation in Cloud Computing

Fault tolerance aim to achieve robustness and dependability in any system. Based on fault tolerance policies and techniques we can classify this technique into 2 types: proactive and reactive. The Proactive fault tolerance policy is to avoid recovery from fault, errors and failure by predicting them and proactively replace the suspected component means detect the problem before it actually come. Reactive fault tolerance policies reduce the effort of failures when the failure effectively occurs. These can be further classified into two sub-techniques error processing and fault treatment. Error processing aims at removing errors from the computational state. Fault treatment aims at preventing faults from being re- activated.

Fault tolerance is carried out by error processing which have two constituent phases. The phases are “effective error processing” which aimed at bringing the effective error back to a latent state, if possible before occurrence of a failure and “latent error processing” aimed at ensuring that the error does not become effective again.

EXISTING FAULT TOLERANCE TECHNIQUES IN CLUD COMPUTING

Various fault tolerance techniques are currently prevalent in clouds:

- **Check pointing**

It is an efficient task level fault tolerance technique for long running and big applications .In this scenario after doing every change in system a check pointing is done. When a task fails, rather than from the beginning it is allowed to be restarted that job from the recently checked pointed state.

- **Job Migration**

Some time it happened that due to some reason a job can- not be completely executed on a particular machine. At the time of failure of any task, task can be migrated to another machine. Using HA-Proxy job migration can be implemented.

- **Replication**

Replication means copy. Various tasks are replicated and they are run on different resources, for the successful execution and for getting the desired result. Using tools like HA-Proxy, Hadoop and AmazonEc2 replication can be implemented.

- **Self- Healing**

A big task can divided into parts .This Multiplication is done for better performance. When various instances of an application are running on various virtual machines, it automatically handles failure of application instances.

- **Safety-bag checks**

In this case the blocking of commands is done which are not meeting the safety properties.

- **S-Guard**

It is less turbulent to normal stream processing. S- Guard is based on rollback recovery. S-Guard can be implemented in HADOOP, Amazon EC2.

- **Retry**

In this case we implement a task again and gain. It is the simplest technique that retries the failed task on the same resource.

Virtual Desktop Infrastructure

As the size of your enterprise increases, so does the scope of its technical and network need? Something as seemingly simple as applying the latest OS hotfixes, or ensuring that virus definitions are up to date, can quickly turn into a tedious mess when the task must be performed on the hundreds or thousands of computers within your organization.

- **VDI Allows One to Manage Many**

A virtual desktop infrastructure (VDI) environment allows your company's information technology pros to centrally manage thin client machines, leading to a mutually beneficial experience for both end-users and IT admins.

- **What is VDI?**

Sometimes referred to as desktop virtualization, virtual desktop infrastructure or VDI is a computing model that adds a layer of virtualization between the server and the desktop PCs. By installing this virtualization in place of a more traditional operating system, network administrators can provide end users with 'access anywhere' capabilities and a familiar desktop experience, while simultaneously heightening data security throughout the organization.

Some IT professionals associate the acronym VDI with VMware VDI, an integrated desktop virtualization solution. VMware VDI is considered the industry standard virtualization platform;

VDI Provides Greater Security, Seamless User Experience Superior data security: Because VDI hosts the desktop image in the data center, organizations keep sensitive data safe in the corporate data center—not on the end-user's machine which can be lost, stolen, or even destroyed. VDI effectively reduces the risks inherent in every aspect of the user environment.

More productive end-users: With VDI, the end-user experience remains familiar. Their desktop looks just like their desktop and their thin client machine performs just like the desktop PC they've grown comfortable with and accustomed to. With virtual desktop infrastructure, there are no expensive training seminars to host and no increase in tech support issues or calls. End- user satisfaction is actually increased because they have greater control over the applications and settings that their work requires.

Other Benefits of VDI

- Desktops can be set up in minutes, not hours
- Client PCs are more energy efficient and longer lasting than traditional desktop computers
- IT costs are reduced due to a fewer tech support issues
- Compatibility issues, especially with single-user software, are lessened
- Data security is increased

Web Resources:

http://www.asigra.com/blog/cloud-types-private-public-and-hybrid

http://www.globaldots.com/cloud-computing-types-of-cloud/

https://fedoraproject.org/wiki/OpenStack

https://aws.amazon.com/types-of-cloud-computing/

