

Cloud Computing: Emergence, Evolution and Future in India

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Abstract—This paper broadly covers Cloud Computing – the different service models, its emergence, how is it relevant against the backdrop of the emerging Indian market and how can this technology be tapped so that its potential is leveraged to capacity for technological growth in the country. Cloud computing as a concept has been around for quite some time, but the recent years have seen it being utilized in various walks of life considering the various advantages it has. India is gradually becoming the forerunner in use and propagation of Cloud technology. This paper aims at outlining the crux of this technology, the key characteristics and to look for areas of improvement where the technology can be used and can be improved in the future.

Index Terms – Cloud Computing, History, PaaS, IaaS, SaaS, Advantages, Characteristics, Evolution, Future in India.

1 INTRODUCTION

Cloud computing broadly describes off-premise, on-demand computing where the end-user is provided, computing resources, and services (including operating systems and infrastructure) by cloud services provider via the Internet. The hosting industry came out of the need for software and computing services that were managed internally, but were made more economical and accessible through the economies of scale of a hosted implementation. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.[1]

Cloud computing typically uses the internet to deliver off premises where the user of the services is only involved in usage rather than knowing and understanding how exactly these services function. The emergence of cloud over the years has brought into the picture a paradigm switch where the consumer inclination is more towards how to harness the capability of a technology rather than being involved in the technical know-how of it. It has also brought about a new model where in the consumer tries to reduce the initial cost of setting by opting for the more feasible and easier pay-as-you-go costing

model.

2 EMERGENCE

Cloud might seem like a relatively new term, but its gradual evolution had begun back in the 1950s with the onset of mainframe computing where multiple users could use the computing capabilities of a single central computer through dumb terminals. This was a far economical option than purchasing multiple mainframes.

In the 1970s, the concept of virtualization came into existence. Using virtualization software like the VMware, it was possible to run multiple operating systems in isolated environment. This took mainframe shared resource concept to the next level by provisioning multiple virtual computers within a single physical resource.

In the 1990s, evolution of cloud computing took another leap in the form of virtualized private network. Before VPN came into being, the telecommunication service providers offered services on a point-to-point basis. The emergence of VPN allowed having the same quality of data services as a dedicated connection but at a reduced cost. With VPN, telecommunication service providers were spared the cost of investing in physical infrastructure for more users, instead they could not harness the existing infrastructure by providing shared access. Over the years, cloud computing has taken on a more sophisticated role going from Grid computing, utility computing to Software as a Service; providing anywhere, anytime access to IT services.

Cloud computing has evolved through a number of phases which include grid and utility computing, application service provision (ASP), and Software as a Service (SaaS). But the overarching concept of delivering computing resources through a global network is rooted in the sixties. The idea of an "intergalactic computer network" was introduced in the

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sixties by J.C.R. Licklider, who was responsible for enabling the development of ARPANET (Advanced Research Projects Agency Network) in 1969.

His vision was for everyone on the globe to be interconnected and accessing programs and data at any site, from anywhere, explained Margaret Lewis, product marketing director at AMD. "It is a vision that sounds a lot like what we are calling cloud computing."

Since the sixties, cloud computing has developed along a number of lines, with Web 2.0 being the most recent evolution. However, since the internet only started to offer significant bandwidth in the nineties, cloud computing for the masses has been something of a late developer. One of the first milestones in cloud computing history was the arrival of Salesforce.com in 1999, which pioneered the concept of delivering enterprise applications via a simple website. The services firm paved the way for both specialist and mainstream software firms to deliver applications over the internet. The next development was Amazon Web Services in 2002, which provided a suite of cloud-based services including storage, computation and even human intelligence through the Amazon Mechanical Turk.

Another big milestone came in 2009, as Web 2.0 hit its stride, and Google and others started to offer browser-based enterprise applications, though services such as Google Apps. The most important contribution to cloud computing has been the emergence of "killer apps" from leading technology giants such as Microsoft and Google. When these companies deliver services in a way that is reliable and easy to consume, the knock-on effect to the industry as a whole is a wider general acceptance of online services. [9]

3 MODELS OF CLOUD COMPUTING

Cloud Computing is based on two basic models - Service Model and Deployment Model, which in turn can be classified further as under:

3.1 Service Models

The three service models or layers are completed by an end user layer that encapsulates the end user perspective on cloud services. Cloud Computing Services are provided in 3 fundamental service models:

3.1.1 Infrastructure as a Service (IaaS)

In this model, the role of the service provider is to provide the basic infrastructure necessary for hosting cloud applications. The subscriber has control over the processing, storage and platform related choices. This is the most basic form of cloud computing where the end user still controls most of the resources. This model is best suited for applications where the end user only needs infrastructural resources from the cloud. Common examples can be: Rackspace Cloud, Amazon Cloud formation.

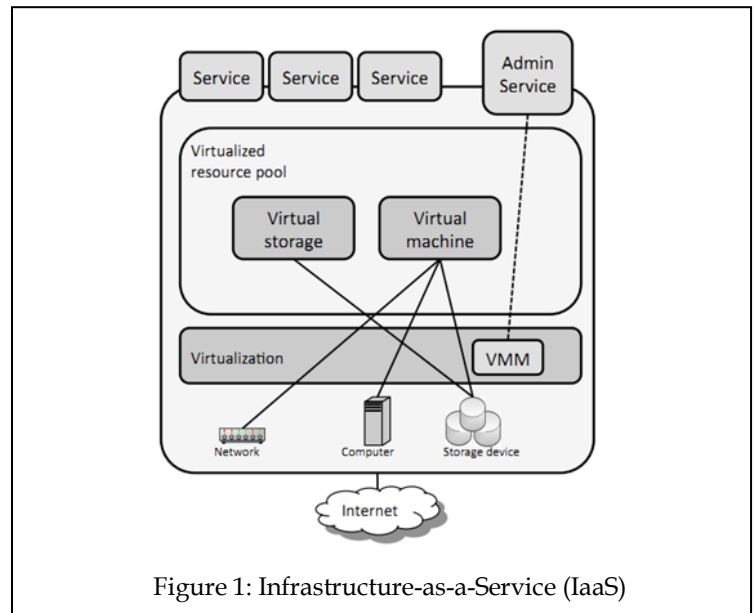


Figure 1: Infrastructure-as-a-Service (IaaS)

3.1.2 Platform as a Service (PaaS)

In this model, the consumer seeks related to infrastructure as well as operating system and storage from the service provider. The consumer uses these resources for deploying consumer created or acquired applications. This model puts the consumer in control of only the application without having to worry about the platform and the infrastructure that is being used for deployment of the application. Examples include: Amazon Engine, Windows Azure, etc.

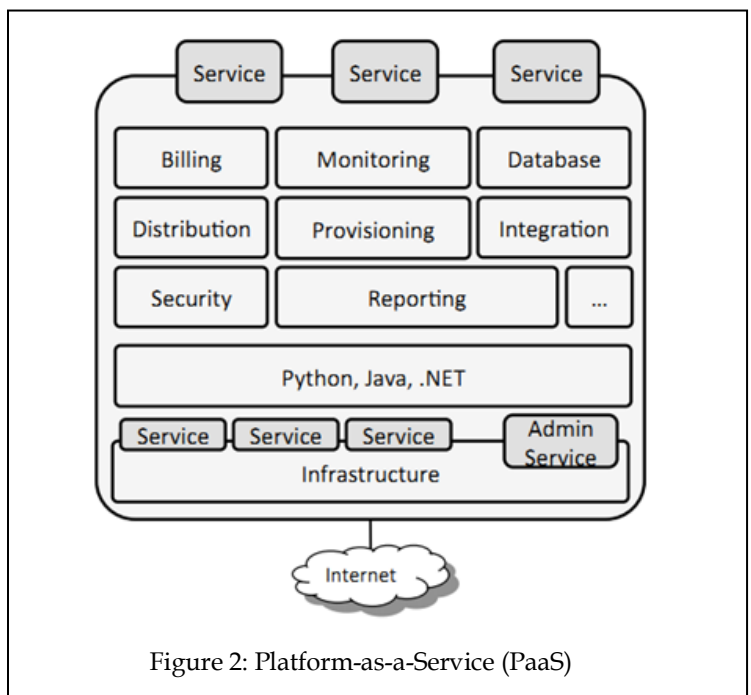


Figure 2: Platform-as-a-Service (PaaS)

3.1.3 Software as a Service (SaaS)

This model is what can be described as leveraging cloud potential to capacity. In this model, the consumer uses the application provided by the service provider. The consumer does not control infrastructure, platform or the software. The consumer only uses the software as an end product and pays as per the usage. Examples are Microsoft Office 365, Google Apps, and Salesforce.com.

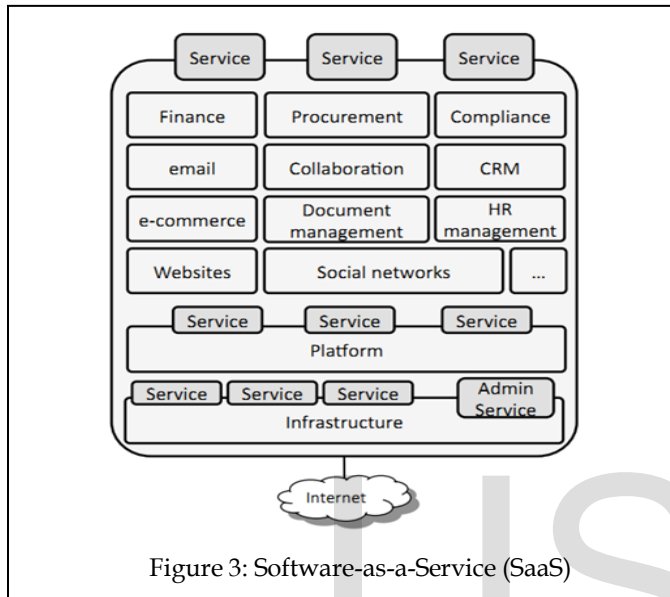


Figure 3: Software-as-a-Service (SaaS)

3.2 Deployment Models

Cloud services can be deployed in different ways, depending on the organizational structure and the provisioning location. Deployment Models in Cloud:

3.2.1 Private Cloud

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers. Private cloud computing systems emulate public cloud service offerings within an organization's boundaries to make services accessible for one designated organization. Private cloud computing systems make use of virtualization solutions and focus on consolidating distributed IT services often within data centers belonging to the company. The chief advantage of these systems is that the enterprise retains full control over corporate data, security guidelines, and system performance. In contrast, private cloud offerings are usually not as large-scale as public cloud offerings resulting in worse economies of scale. Undertaking a private cloud project requires a significant level and degree of engagement to virtualize the business environment, and requires the organization to reevaluate decisions about existing resources.

3.2.2 Community Cloud

The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that

have shared concerns (e.g. mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party, and either hosted internally or externally. The costs are spread over fewer users than a public cloud (but more than a private cloud), so only some of the cost savings potential of cloud computing are realized.

3.2.3 Public Cloud

The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. The deployment of a public cloud computing system is characterized on the one hand by the public availability of the cloud service offering and on the other hand by the public network that is used to communicate with the cloud service. The cloud services and cloud resources are procured from very large resource pools that are shared by all end users.

3.2.4 Hybrid Cloud

A hybrid cloud service deployment model implements the required processes by combining the cloud services of different cloud computing systems, e.g. private and public cloud services. The hybrid model is also suitable for enterprises in which the transition to full outsourcing has already been completed, for instance, to combine community cloud services with public cloud services. Hybrid Clouds are bound together by standardized or proprietary technology that enables data and application portability (e.g. cloud bursting for load balancing between clouds). [2]

4 KEY CHARACTERISTICS OF CLOUD COMPUTING

The following set of bullets identifies the primary characteristics of cloud computing solutions.

There is not, however, a litmus test to determine if a particular service is or is not a cloud computing service.

- Centralization of applications, servers, data and storage resources.
- Extensive virtualization of every component of IT, including servers, desktops, applications, storage, switches, routers and appliances such as WAN optimization controllers, application delivery controllers and firewalls.
- Automation and Orchestration of as many tasks as possible; e.g., provisioning, troubleshooting, change and configuration management.

- The dynamic creation and movement of resources such as virtual machines and the associated storage.
- Heavy reliance on the network.
- Self-service to allow end users to select and modify their use of IT resources without the IT organization being an intermediary.
- Usage sensitive chargeback that is often referred to as pay-as-you-go. An alternative is for IT organizations to show the consumption of IT resources by certain individuals or organizations.
- Simplification of the applications and services provided by IT.
- Standardization of the IT infrastructure.
- Technology convergence such as the convergence of LAN and SAN and of switch and server.
- The development of standards that enable, among other things, the federation of disparate cloud computing infrastructures with one another.
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5 BENEFITS OF CLOUD COMPUTING – AN ARCHITECTURAL PERSPECTIVE

Benefits of cloud vary subjectively depending upon each enterprise's need to incorporate the cloud model into the way the usage of IT resources is being carried out. It also fluctuates due to emerging new verticals and horizontal opportunities as well as newer platforms and ecosystems coming into picture. Cloud benefits continuously evolve with the addition of new services, uncompromising research and innovations that relentlessly push the boundaries of the underlying technology and architecture.

Additional breakthroughs in horizontal and vertical markets as well as the birth of new ecosystems and development platforms provide the construct behind a continuum of opportunity for businesses to benefit from cloud providers' enhancements to technology offerings.

But speaking in a broad sense of way, the benefits of cloud computing can be stated as:

5.1 Cost

The cost of imbibing the cloud model is much less than having an on-premise infrastructural model. The benefits in this area are tangible.

- No hardware or computing resources lingering on balance sheet.
- No depreciation.

- No need for lengthy justification.
- No monthly review of system utilization.
- No need to re-factor computing resources after project completion.

5.2 Scale

Cloud computing provides the flexibility in terms of scale. You can increase or decrease usage as per the demand curve. This ensures that estimated and actual usage as per demand is a flexible curve.

Initially, when IT resources are purchased, they are as per the demand. When the demand increases, more resources are purchased. When the demand goes down, there is no way to reduce these resources. Therefore, there is an observed underutilization of the resources. With cloud, when the demand becomes lean, the services can be scaled down. Conversely, it can also be scaled up as and when required.

5.3 Flexibility

One of the key differentiators for a company relates to its ability to be first to market, such differentiators correlate to speed of execution for which I provide a few examples below:

- Virtual resources adapt more easily to business objectives requirements.
- Rapid expansion of bandwidth speed as needed.
- Access to solid-state drive (SSD) technology on-demand enhances application speed.
- No red tape—cloud effortlessly adapts to technology landscape changes.

5.4 Integration

Within five years, the major cloud providers will create an interconnected Internet super highway on which data will travel, communicate and collaborate interactively in the delivery of services that cannot be fathomed today. Cloud will help to enable this by:

- Providing countless application programming interfaces (APIs) for the consumption of third party services.
- Think of OData, JSON, JSONP, and XML for API data access
- Providing flexible access to traditional SQL or No SQL databases.
- Providing analytic platforms for countless business needs.

5.4 Audit and Compliance

Audit and compliance is probably one of the biggest burdens on any IT organization. Fortunately, cloud can help in the following ways:

Cloud vendors' service level agreements (SLAs) ensure that all audits and compliance activities are logged, monitored and audited to your satisfaction.

Regardless of business security requirements, most cloud vendors abide to industry standards to support Sarbanes & Oxley, ISO2001, ITIL, SAE116, SaaS Type I & II, HIPAA, PCI and more.

- Cloud providers are regularly audited by third party organizations to ensure that security standards are met.

5.5 Business Continuity Planning (BCP)

BCP truly showcases one of the many benefits of cloud and how it can serve as an extension of IT and your business. BCP enables:

- Disaster recovery with cold or hot backup.
- Disaster recovery with high-failover or high-redundancy.
- Data duplication and backup.
- Testing and verification of recovery procedures

6 CLOUD COMPUTING IN INDIA

India is growing at faster pace in information technology sector thereby showing a great potential for the cloud computing services. According to Springboard Research report (Jan 2009) SAAS India i.e. software as a service in India will register a compounded annual growth rate of 76% in the time period of 2007-2011. Cloud computing services has huge opportunity in Indian market due to the large number of Small and Medium businesses (SMBs) which is at around 35 million and they want easy to use, reliable and scalable application that helps them to grow and expand their business. This makes India as the fastest growing SaaS market in Asia Pacific region.

With the statistics showing upward trends, India is a market that is as profitable as promising. It provides a place for coming up with innovations and provides ample scope for pioneering path breaking applications.

As a key player in the IT field, India is poised to be a Billion Dollar market in the next 5 years according to a study by an IT infrastructure firm. The study claims that this growth will be driven by the rapid increase in data such as text and media moving online. Some numbers shared in the study are quite interesting, it is expected that information stored online will reach a staggering 2.3 million petabytes (from 40,000 petabytes.) India's top IT firms, Infosys, TCS, Wipro and Tech Mahindra have cloud projects to their names. The competition is fierce as the market is nascent and big international names like Microsoft, IBM have dedicated resources as well. Support from the government to get basic infrastructure (cheaper and faster Internet) in place will go a long way in ensuring India's IT prominence. [8]

The major applications of Cloud Computing in India are highlighted below:

6.1 Social Impact

It is officially the age of micro blogging and social networking. Twitter, Google, Facebook are testimonies that cloud is penetrating the very fabric of everyday living in India Young Indians are well appraised about usage of these platforms.

These social media sites are now being used as a platform for various social and political activities. In its own way, cloud technology is playing a role in connecting India.

6.2 Education

Educational institutions have been quick to realize the advantages of cloud technology and have been eagerly adopting it for several reasons, including:

- Ability for the students to access data anywhere, anytime, to enroll in online classes and to participate in group activities.
- Ability to collaborate enabling learning round the clock erasing demographical boundaries.

6.3 Development

Cloud technology also offers other benefits to developing countries since they no longer have the burden of investing in costly infrastructures and can tap into data and applications that are readily available in the cloud.

Take as an example the telecom industry, where the developing countries are tapping into the potential of cloud by coming up with economical solutions for telecommunication connections.

6.4 Healthcare

There are many reasons why using cloud technology in the healthcare industry is gaining pace. Some examples include: managing non-soloed patient data and sharing it among different parties such as medical professionals or patients checking their own status and treatment follow-ups; reducing operational costs such as data storage; accessing this data through pervasive devices such as mobile phones and going beyond the traditional intranet; implementing a quick solution in a secure environment that is compliant with the Health Insurance Portability and Accountability Act regulations.

While there may be challenges in integrating old or current tools with new technologies and the corresponding level of services, the benefits will outweigh the inhibition to move to the cloud. According to the industry, healthcare will be a growing market in the coming years, running into the billions. [3]

6.5 Banking and Financial Services

The banking and financial services sector has seen a huge increase in the use of cloud technology. The remote data centers, security, flexibility and immediate scalability options have been the main reasons for the increase. Banks, Insurance companies and Mutual Fund houses are slowly using cloud technology for their fund management, treasury and risk management solutions. Adoption of the architecture has not only helped remote backups, data security and data recovery in case of any unforeseen events.

6.6 Government Agencies

Federal, State and Local, and Defense and Military are widely embracing cloud service as it helps in collecting and managing huge amount of data. The most important thing that these

government agencies require is a cloud that has effective and able developers to easily integrate it with other parts of the infrastructure. Maintaining huge amount of confidential data with regular increase in internet users has caused this slow and steady increase.

Alongside central government projects such as excise, income tax, and post office; other state governments will also undertake initiatives in municipalities, land records and other joint initiatives like digital court rooms and common service centers. [11]

7 FUTURE OF CLOUD COMPUTING IN INDIA

One of the striking features of cloud computing is that it presents benefits to every aspect of Indian economy including but not limited to SMEs, the education system and the Government of India.

Cloud computing is becoming all pervasive and when implemented in conjunction with mobile technology, it sets stage for having power of cloud with the convenience of mobility. This model is already coming into picture with apps. Future of cloud computing lies in making the cloud model goes completely on pay as you go basis not only for enterprise applications but for apps in handheld devices.

Total IT End-User Spending Forecast, India, 2014-2017 (US\$ Millions)

Segment	2014	2015	2016	2017
Devices	23,504	26,644	31,118	34,108
Data Center Systems	2,492	2,668	2,825	2,973
Software	4,109	4,667	5,293	6,014
IT Services	11,235	13,037	15,137	17,608
Telecommunications Services	30,006	30,728	31,545	32,277
Grand Total	71,347	77,744	85,917	92,980

The value of the cloud services market in India is expected to hit a record high of over \$556 million by the end of 2014. Growth for the year is projected at 32.2%, which will see India's cloud sector rise from \$421 million in 2013 to \$556.8 this year, an increase of \$135.8 million. This rapid rate of increase is expected to hold for the next few years, and by 2018, the Indian cloud services market could hit a staggering \$1.7 billion in total worth.

The numbers also indicate that Infrastructure-as-a-Service (IaaS) will experience a large amount of growth in India, growing from \$58 million last year to \$78 million this year (a difference of \$20 million, or 34.5%). As cloud services grow, so will IaaS, according to projections, which will hit around \$317 million by 2018. Related components – such as Business Process-as-a-Service (BPaaS) and Software-as-a-Service (SaaS) – will expand, too.

BPaaS will grow from \$62.3 million to \$75 million this year (\$12.7 million, or 20.4%), and SaaS, which will experience the most growth overall by 2018, will hit \$636 million by the end of that year. BPaaS will grow to \$204 million by the end of 2018, putting it in third place behind SaaS and IaaS. India is adopting cloud-based systems more and more, as they require less physical storage space, are more cost efficient, and reliable. There are concerns about privacy and accessibility, but adoption of the technology continues to remain high.

Other study shows private cloud landscape in India estimated that the total cloud market in India, currently at \$400 million, will reach a market value of \$ 4.5 billion by 2015. Of this private cloud adoption will dominate and account for \$3.5 billion in revenues, growing at over 60%. The study also estimates that the segment will create 1 lakh jobs by 2015 from 10,000 today. With the overall environment of cloud adoption fast evolving in India, cloud computing will account for a significant share in the total IT spends of enterprises. Total clouds spend as a percentage of the total IT spends is expected to rise from 1.4% in 2010 to 8.2% in 2015. IT/ITeS, telecom, BFSI, manufacturing and government sectors will contribute largest to the cloud market in India, with nearly 78% of the total market.

Long with worldwide government bodies, the Indian government has also taken a keen interest in the technology and is expected to grow at a rapid pace of 45.1% annually until 2018 investing a total of \$18 billion. India has seen a number of high-tech firms from the US acquire its smaller IT companies because of their work with cloud-based technologies. Start-ups in Bangalore, Hyderabad, and Pune have been picked up by mid-size companies and large corporations alike over the last year as IT firms continue to push towards increasing their cloud computing capabilities.

The growing number of Internet users and increase in mobile device adoption in India is a key factor for its cloud growth, neither of which shows much sign of slowing down over the next few years. [10]

Apart from the numbers the Cloud technology is continuously evolving in the features and architecture models providing more cost effective solutions and infrastructure flexibility to not only startups, SME's and IT companies but also government bodies and agencies.

The Indian government is also developing a cloud policy, namely the GI cloud (or Meghraj) which will see more clarity in the near future. Wide proliferation of affordable broadband connectivity (and mobile phones alongside) is expected to provide further opportunities in e-Governance and mobility solutions.

The Indian cloud is on the rise but there are certain advancements that are expected and Cloud is evolving more than ever. Let's take a look at the possible future developments.

7.1 Proactive Application Monitoring

Proactive application monitoring technology is currently available, but predictive technology and software will soon make this more robust and accurate. Companies will be able to foresee disaster and avert it, mitigating damage to their systems. This will prevent downtime and make the company safer.

7.2 Technology to Ensure Uptime

With low-power processors, data centers will become more affordable, allowing companies to acquire seven to ten data centers around the world in different time zones and thereby allowing them to guarantee 99.9 percent uptime. This will keep companies from losing money and falling prey to their competitors. Windows Azure already is providing 99.99% SLA by providing data redundancy across various data centers in the world

7.3 Ability to Validate Identities through Trusts

In the future, cloud security systems will be able to validate identities through a "centralized trust." Identity-based security is thought to be more secure than current forms of security. More people will begin to trust cloud computing when this happens.

7.4 Mobile Optimization for Clod Services

Mobile commerce is on the rise. Cloud computing applications require fewer resources and are recommended for mobile devices. Accessibility is increased because fewer resources are required. This is why cloud computing is recommended for business and personal applications.

7.5 Cloud Computing will help businesses optimize their investments

Cloud computing can help companies optimize investments and scale operations. In the future, new low-power processors and other chip technology will help businesses operate to their full IT capacity. With more innovation, greater revenue potential is possible. Companies can re-invest in their products and services with higher profit margins. Scaling investments will also lead to greater operational agility.

7.6 Data Recovery and Remote Access

Cloud computing enables and enhances remote access and faster disaster recovery. When companies have an emergency information security strategy with security penetration tests, companies can maintain their competitive edge within their respective industries.

With cloud computing, some companies that didn't recognize a breach may recover within minutes instead of hours. Losing proprietary data can cripple a company and even cause doors to close. Every company should migrate to cloud computing for this reason.

7.7 Centralized Data

Centralized data is expected in abundance in the future of cloud computing. This allows companies to create huge databases. Patient care can be improved with centralized data in huge databases. Better stock market decisions are also possi-

ble. Centralized data is a way of the future.

7.8 Enhanced Connectivity

Mobile devices that rely on the cloud will become more powerful and thinner because all applications will be web-based. All mobile devices will store data that resides in the cloud, and designers can add more capability and lower costs of the phone. One example of this concept is Apple's iCloud.

7.9 Enhanced Security

Data center physical security is just as important as data encryption. While minimum encryption regulations may be increased from the current 256-bit SSL, physical access to data center facilities may require biometric scans in addition to electronic pass. These facilities will also be protected by advanced alarm systems.

In addition to physical security, firewall and VPN technology will be improved to protect data transfer. New firewall policies, although not fully defined, will limit VPN traffic to specific IP addresses and ports. With upgraded firmware, breaches will be less likely to occur.

CONCLUSION

Cloud Computing is here to stay. The technology has plenty to offer in terms of infrastructure cost saving, it caters to the needs of an audience that needs everything on the go; it provides an uptime through replication and provides impeccable service in terms of processing speed managed through sophisticated load balancing techniques. It sticks close to the demand curve and reduces underutilization tangibly. When these considerations are put in a business scenario, they spell high ROI and low risks. Cloud Computing and its contribution to development and making technology available to all is going to be the highlight of this decade's technology.

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