Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2018, 5(4): 263-273

Research Article ISSN: 2394 - 658X

Future Challenges of Cloud Computing

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ABSTRACT

Almost everything in the digital world is connected to the cloud in some way or another — unless it's specifically kept in local storage for security reasons. As tech giants and start-ups find new ways to organize process and present data cloud computing will become a more and more integral part of our lives. Over the next 10-15 years we can expect cloud computing to quickly evolve, and become so ubiquitous, that the concepts we label as 'cloud' will simply be known as 'computing. Cloud computing leading feature is the availability of all required software on the web. The five cloud attributes and the three service delivery models are highlighted in this paper. The four basic deployment models public cloud, private cloud, hybrid cloud and community cloud are also discussed. The future of cloud computing will most likely represent a combination of cloud based software products and on premises compute to create a hybrid IT solution that balances the scalability and flexibility associated with cloud and the security and control of a private data centre. The real future of cloud will be easy access and consumption of any data and services in the cloud. This paper will address the strengths and weaknesses of cloud computing and addresses its future challenges.

Keywords: SaaS, PaaS, IaaS, Public cloud, Private cloud

INTRODUCTION

In simpler words Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network. It means storing and accessing data and programs over the Internet instead of your computer's hard drive. The cloud is just a metaphor for the Internet.

Cloud Computing – NIST Definition:
'A model for enabling 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' Often described as software as a service (SaaS), users are provided on-line access to application software and databases [1-3]. There are many commercial workloads such as transaction processing, search, database, and data intensive computing that cloud computing is designed to support. As these commercial applications are hosted centrally, updates can be released without users having to reinstall new software. Users typically access cloud-based applications through a web browser while the commercial software and user's data are stored on servers at a remote location.

Table 1 Comparison between Conventional Computing and Cloud Computing

Conventional Computing	Cloud Computing
▪ Manually Provisioned	▪ Self-provisioned
▪ Dedicated Hardware	▪ Shared Hardware
▪ Fixed Capacity	▪ Elastic Capacity
▪ Pay for Capacity	▪ Pay for Use
▪ Capital & Operational Expenses	▪ Operational Expenses
▪ Managed via Sysadmins	▪ Managed via APIs

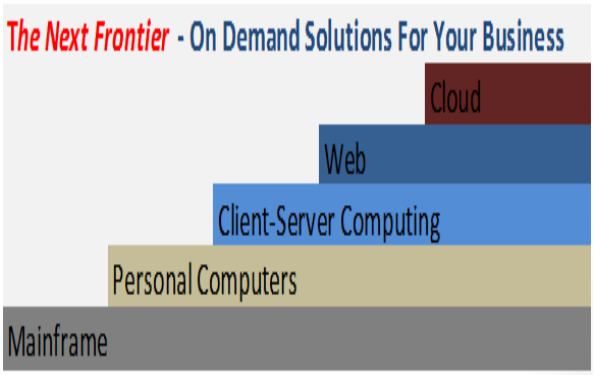

Fig.1 Layered structure of Cloud [2]

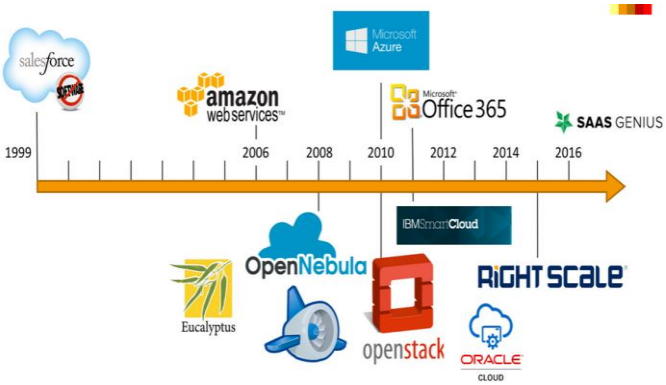

Fig. 2 Timeline of Cloud computing [3]

Cloud Computing is a paradigm that focuses on sharing data and computations over a scalable network of nodes. Computing nodes include end user computers, data centers, and cloud services [4]. The cloud enhances collaboration, agility, scalability, availability, ability to adapt to fluctuations according to demand, accelerate development work, and provides potential for cost reduction through optimized and efficient computing [5- 7]. A comparison between Conventional Computing and Cloud Computing is described in Table -1.

Cloud computing has changed the corporate world dramatically in a few short years and is now about to play a major role in scientific and engineering applications. Cloud computing reflects the latest trends in business to deliver software and services over the Internet. Gartner predicts that the bulk of new IT spending by 2016 will be for cloud computing platforms and applications with nearly half of large enterprises having cloud deployments by the end of 2017. Worldwide spending on public IT cloud services is expected to be more than $107 billion in 2017, according to a forecast from International Data Corporation (IDC) in 2013. Over the 2013-2017 forecast period, public IT cloud services are estimated to have a compound annual growth rate (CAGR) of 23.5%, five times that of the IT industry as a whole.

Timeline of Cloud Computing

Developments in bandwidth, processing and open-source networking over three decades have made cloud a necessity. This timeline illustrates cloud's jumpy history and what that means for its future.

HOW CLOUD COMPUTING WORKS

Cloud computing refers to the concept of sharing software, resources, and information via a network connection such as the Internet. In a cloud structure, the cloud servers save the end-users information, data, and can serve the service application(s) as well reducing the need for storage space on client computers. End-users have the freedom to access information wherever one can obtain an Internet connection.

Cloud computing takes the emphasis away from local computers. It is less about the machine one use at home or on the move and more about what is happening on computers many miles away. Instead of having to store information on your PC, smartphone or tablet, your data can be kept remotely. It will then be made available to any device that is capable of reading it.

Typically, most cloud computing is conducted via a web browser but there are other ways, including specially-made apps for computers, tablets and smartphones. These act as access points for cloud services. They also mean that you don't always need to have dedicated software installed on your machines. The benefit is that one can access the data and that be done from any machine.

It is different from traditional computing because portable storage media is not required. With cloud computing, programs and data are being managed and provided as a service over the internet and it opens up many possibilities.

ESSENTIAL FIVE CLOUD ATTRIBUTES

A number of characteristics define cloud data, applications services and infrastructure. The common characteristics of Cloud computing are use on Massive Scale, Virtualization, Low Cost Software, Resilient Computing, Geographic Distribution, Service Orientation, Advanced Security. Here we will focus on five essential attributes of cloud as per NIST definition which are:

i. **On-Demand Self Service:** A consumer can unilaterally provision computing capabilities, automatically without requiring human interaction with each service's provider. The services are completely automated and Users are ab-

stracted from the implementation. Other features are near real-time delivery (seconds or minutes) and services accessed through a self-serve web interface

ii. **Broad network access/ Ubiquitous:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs). The services are available from anywhere with an internet connection. They have Open standards and APIs and almost always IP, HTTP, and REST.

iii. **Resource Pooling:** In cloud computing Resources are drawn from a common pool. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacentre). Different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Common resources build economies of scale and the common infrastructure runs at high efficiency. Examples of resources include storage, processing, memory, network bandwidth, and virtual machines. No matter which cloud provider and architecture an organization uses, an open cloud will make it easy for them to work with other groups, even if those other groups choose different providers and architectures.

iv. **Measured Service:** All cloud services are metered. The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would use! Cloud systems automatically control and optimize resources used by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). It will provide analysable and predictable computing platform. Users pay only for services used and the services can be cancelled at any time.

v. **Scalable, elastic and Resiliency:** Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time. In cloud resources are dynamically-allocated between users and additional resources dynamically-released when needed. It is fully automated. Cloud providers have mirrored solutions to minimize downtime in the event of a disaster. This type of resiliency can give businesses the sustainability they need during unanticipated events.

Cloud Computing is a general term used to describe a new class of network based computing that takes place over the Internet, basically a step on from Utility Computing, a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform) and using the Internet for communication and transport provides hardware, software and networking services to clients. These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API (Applications Programming Interface). In addition, the platform provides on demand services that are always on anywhere, anytime and anyplace. Its uniqueness is pay for use and as needed, elastic, scale up and down in capacity and functionalities. The hardware and software services are available to general public, enterprises, corporations and businesses markets. Cloud computing is an umbrella term used to refer to Internet based development and services.

Cloud computing is a model for enabling 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. cloud computing customers do not own the physical infrastructure. Cloud computing users avoid capital expenditure (CapEx) on hardware, software, and services when they pay a provider only for what they use. Low shared infrastructure and costs, low management overhead, and immediate access to a broad range of applications are major benefits of cloud.

THREE SERVICE DELIVERY MODELS

Cloud computing evolved from the traditional outsourcing model. In this model the necessary service is provided by an organization that specializes in that field. The contracting organization chooses a specific period for which the service is provided. Many small and medium-sized businesses, instead of outsourcing their Information Systems, contracted with specialists to manage their Information Systems. In either case the Information System was under the control of a third party. The primary attraction with cloud computing for businesses is the ability to have a fully functional computing system within a few hours or a few days depending on the level of complexity in the chosen system. The cloud computing platform makes available all the options such as the type of hardware needed, the service type, applications needed, and amount of storage, etc. for the customers to select and launch their system [8]. The access to the system for the customer is through the internet. Cloud customers who need higher level of protection for their communication with the cloud may choose a Virtual Private Network (VPN) connection which is offered by the Internet Service Provider (ISP). The ISP connection speed determines their communication speed with the cloud service. Speeds such as 10 Mbps and higher are quite affordable for many individuals and businesses and so accessing the cloud computing service via their internet service will not be cost prohibitive.

Today Cloud computing service comes in a variety of service types and deployment models. The most common three categories of service types are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

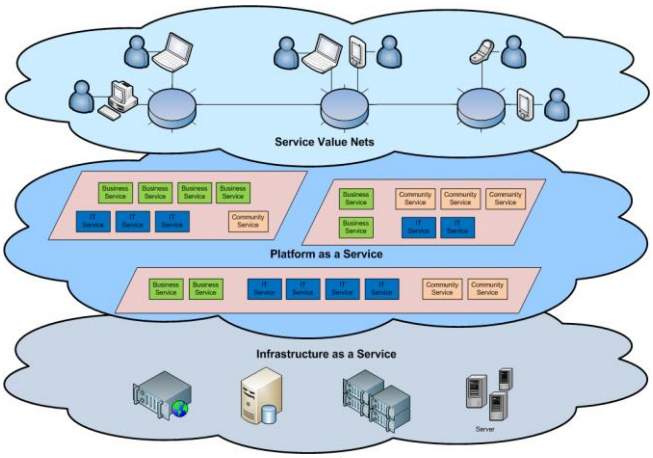

Fig. 3 Architecture of Cloud computing

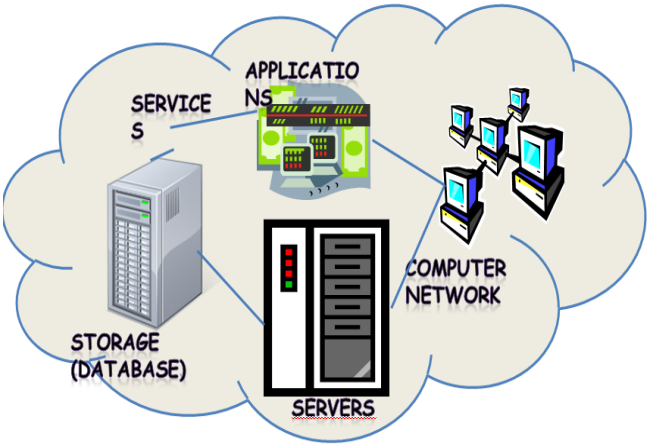

Fig. 4. Model of Cloud

a) **Software as a Service (SaaS):** SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service. Software as a Service (SaaS) is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet**.** In this model, a complete application is offered to the customer, as a service on demand. A single instance of the service runs on the cloud & multiple end users are serviced. On the customers‟ side, there is no need for upfront investment in servers or software licenses, while for the provider, the costs are lowered, since only a single application needs to be hosted & maintained. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage. Today SaaS is offered by companies such as Google, Salesforce, Microsoft, Zoho, for applications as *Google Apps, Salesforce, Nivio, Caspio, Learn.com.*

b) **Platform as a Service (Paas):** In PaaS Consumer can create custom applications using programming tools supported by the provider and deploy them onto the provider's cloud infrastructure. Here, a layer of software or development environment is encapsulated & offered as a service, upon which other higher levels of service can be built. The customer has the freedom to build his own applications, which run on the provider‟s infrastructure. Consumer has control over the deployed applications and possibly application hosting environment configurations. To meet manageability and scalability requirements of the applications, PaaS providers offer a predefined combination of OS and application servers, such as LAMP platform (Linux, Apache, MySql and PHP), restricted J2EE, ***Windows Azure*** Ruby etc. Google‟s App Engine, Force.com, etc are some of the popular PaaS examples.

c) **Infrastructure as a Service (Iaas):** IaaS provides basic storage and computing capabilities as standardized services over the network. Servers, storage systems, networking equipment, data centre space etc. are pooled and made available to handle workloads. The consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls). Some common examples are ***Amazon EC2, GoGrid, iland, Rackspace Cloud Servers, ReliaCloud.***

In the first IaaS layer, physical resources are delivered as a service, usually through machine virtualization. This layer is dominant for running HPC Cloud environment. In the second PaaS layer, a software development platform is delivered as a service to deploy and maintain applications in an integrated environment. In the third SaaS layer, a software application is delivered as a service and instead of purchasing license to be installed on premise; users subscribe to use the service of a specific application.

Cloud are transparent to users and applications, they can be built in multiple ways as branded products, proprietary open source, hardware or software, or just off-the-shelf PCs. In general, they are built on clusters of PC servers and off-the-shelf components plus Open Source software combined with in-house applications and/or system software. As discussed SaaS is a model of software deployment where an application is hosted as a service provided to customers across the Internet. Saas alleviates the burden of software maintenance/support but users relinquish control over software versions and requirements.

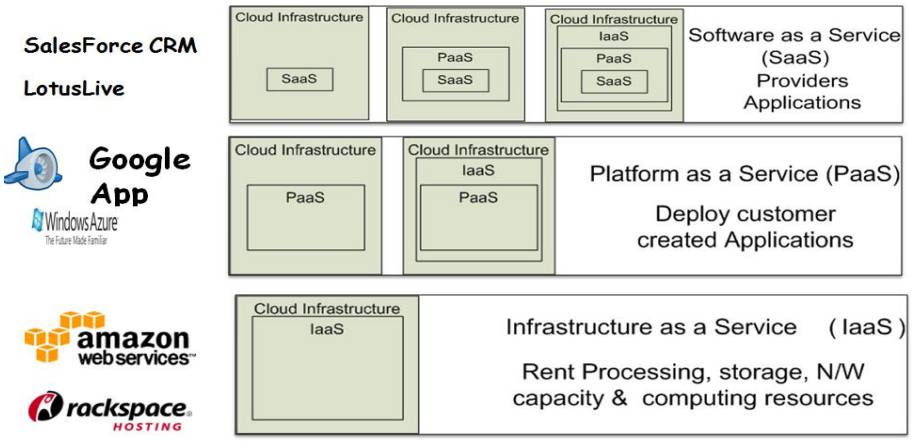

Fig. 5 Service delivery model of cloud [3]

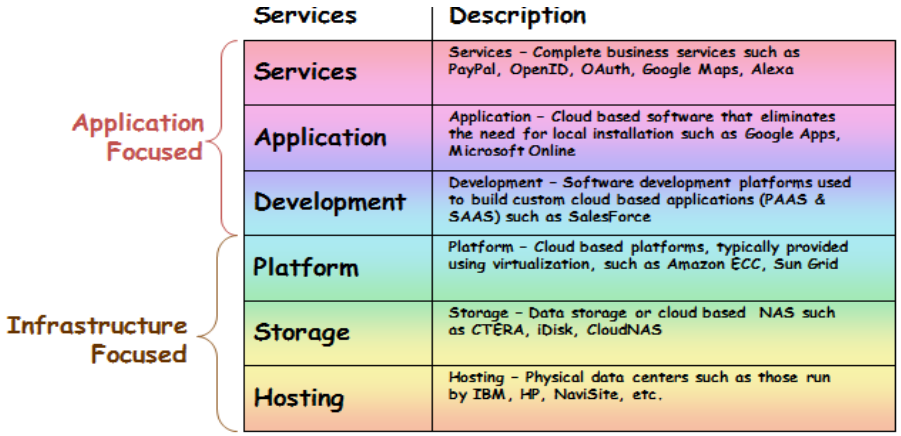

Fig. 6 Cloud Computing Service Layers [4]

CLOUD DEPLOYMENT MODELS

Cloud Computing has been defined as 'a model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. Clouds can be classified into three categories, depending on their accessibility restrictions and the deployment model. Cloud Integrators can play a vital part in determining the right cloud path for each organization. The models are:

a) Public Cloud b) Private Cloud and c) Hybrid Cloud

Public clouds are owned and operated by third parties and is made available in a pay-as-you-go manner to the general public users irrespective of their origin or affiliation. *Public cloud* (off-site and remote) describes cloud computing where resources are dynamically provisioned on an on-demand, self-service basis over the Internet, via web applications/web services, open API, from a third-party provider who bills on a utility computing basis. All customers share the same infrastructure pool with limited configuration, security protections, and availability variances. One of the advantages of a Public cloud is that they may be larger than an enterprises cloud, thus providing the ability to scale seamlessly, on demand.

A private Cloud's usage is restricted to members, employees, and trusted partners of the organization. A *private cloud* environment is often the first step for a corporation prior to adopting a public cloud initiative. Corporations have discovered the benefits of consolidating shared services on virtualized hardware deployed from a primary datacenter to serve local and remote users. There are two variations to a private cloud:

On-premise Private Cloud: On-premise private clouds, also known as internal clouds are hosted within one's own data center. This model provides a more standardized process and protection, but is limited in aspects of size and scalability. IT departments would also need to incur the capital and operational costs for the physical resources. This is best suited for applications which require complete control and configurability of the infrastructure and security.

Externally hosted Private Cloud: This type of private cloud is hosted externally with a cloud provider, where the provider facilitates an exclusive cloud environment with full guarantee of privacy. This is best suited for enterprises that don't prefers a public cloud due to sharing of physical resources.

A ***hybrid cloud*** environment consists of some portion of computing resources on-site (on premise) and off-site (*public cloud) i.e* they combine both public and private cloud models. By integrating public cloud services, users can leverage cloud solutions for specific functions that are too costly to maintain on premise such as virtual server disaster recovery, backups and test/development environments.

A *community cloud* has also been defined which is formed when several organizations with similar requirements share common infrastructure. Costs are spread over fewer users than a *public cloud* but more than a single tenant. A hybrid Cloud enables the use of private and public Cloud in a seamless manner. In a typical public Cloud scenario, a third-party vendor delivers services such as computation, storage, networks, virtualization, and applications to various customers. In a private Cloud environment, internal IT resources are used to serve their internal users and customers. Businesses are adopting public Cloud services to save capital expenditure and operational costs by leveraging Cloud's elastic scalability and market-oriented costing features. Nevertheless, public Cloud computing also raises concerns about data security, management, data transfer, performance, and level of control. Cloud computing applications span many domains, including business, technology, government, health care, smart grids, intelligent transportation networks, life sciences, disaster management, automation, data analytics, and consumer and social networks. Various models for the creation, deployment, and delivery of these applications as Cloud services have emerged.

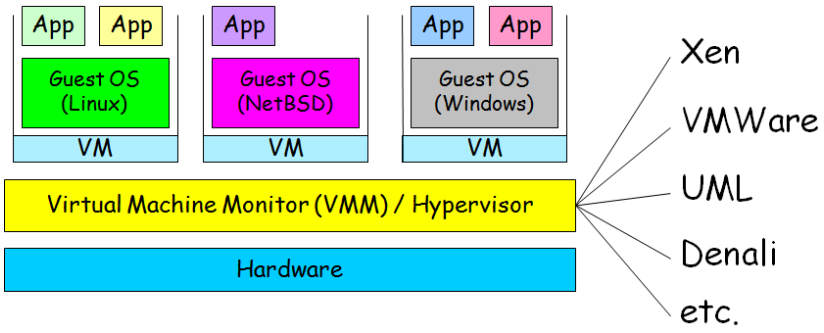

Fig. 7 Schematic of Virtual machine structure [6]

Virtualization in Cloud Computing: Virtualization is the 'creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources. Virtualization provides many benefits which include reduction in costs, efficient utilization of resources, better accessibility and minimization of risk among others. Access to the virtual machine and the host machine or server is facilitated by a software known as Hypervisor. Hypervisor acts as a link between the hardware and the virtual environment and distributes the hardware resources such as CPU usage, memory allotment between the different virtual environments. The hypervisor can emulate **multiple** virtual hardware platforms that are isolated from each other, **allowing virtual machines to run** Linux and Windows Server operating systems on the same underlying **physical** host. **Virtualization** limits costs by reducing the need for **physical** hardware systems. Virtualization allows easily outsource your hardware and eliminate any energy costs associated with its operation. Virtualization is possible through a wide range of Technologies which are available to use and are also Open Source. The best virtualization experience and performance is provided by XEN or KVM or OpenVZ.

- VM technology allows multiple virtual machines to run on a single physical machine

The main advantages of virtual machines are:

a) It can run operating systems where the physical hardware is unavailable,
b) Easier to create new machines, backup machines, etc.,
c) Software testing using 'clean' installs of operating systems and software,
d) Emulate more machines than are physically available,
e) Timeshare lightly loaded systems on one host,
f) Debug problems (suspend and resume the problem machine),
g) Easy migration of virtual machines (shutdown needed or not).
h) Run legacy systems!

Cloud computing enables companies and applications, which are system infrastructure dependent, to be infrastructure-less. By using the Cloud infrastructure on 'pay as used and on demand', all of us can save in capital and operational investment!

Clients can put their data on the platform instead of on their own desktop PCs and/or on their own servers. They can put their applications on the cloud and use the servers within the cloud to do processing and data manipulations etc.

Several large Web companies are now exploiting the fact that they have data storage capacity that can be hired out to others which allows data stored remotely to be temporarily cached on desktop computers, mobile phones or other Internet-linked devices. Amazon's Elastic Compute Cloud (EC2) and Simple Storage Solution (S3) are well known examples, Mechanical Turk and Unlimited Storage.

OPPORTUNITIES AND CHALLENGES OF CLOUD COMPUTING

The use of the cloud provides a number of opportunities. It enables services to be used without any understanding of their infrastructure. Cloud computing works using economies of scale as It potentially lowers the outlay expense for start-up companies, as they would no longer need to buy their own software or servers and cost would be by on-demand pricing. Vendors and Service providers claim costs by establishing an ongoing revenue stream. Data and services are stored remotely but accessible from 'anywhere'.

Although there are many benefits to adopting Cloud Computing, there are also some significant barriers to adoption. One of the most significant is that use of cloud computing means dependence on others and that could possibly limit flexibility and innovation as the others are likely becomes the bigger Internet companies like Google and IBM, who may monopolise the market. Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against. Security could prove to be a big issue as it is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.

ADVANTAGES OF CLOUD COMPUTING

a. **Lower computer costs** Lower capital costs, Lower IT operating costs, Absence of hardware or software installation or maintenance, Optimized IT infrastructure. Since cloud users do not have to invest in information technology infrastructure, purchase hardware, or buy software licenses, the benefits include low up-front costs, rapid return on investment, rapid deployment, customization, flexible use, and solutions that can make use of new innovations. Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software. When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor. In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

b. **Improved performance**: With few large programs hogging your computer's memory, you will see better performance from your PC. Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory…

b) **Reduced software costs:** Instead of purchasing expensive software applications, you can get most of what you need for free. Most cloud computing applications today, such as the Google Docs suite. It is better than paying for similar commercial software and which alone may be justification for switching to cloud applications

c) **Instant software updates**: Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs. When the application is web-based, updates happen automatically available the next time you log into the cloud. When you access a web-based application, you get the latest version without needing to pay for or download an upgrade.

d) Improved document format compatibility. You do not have to worry about the documents you create on your machine being compatible with other users' applications or OSes. There are potentially no format incompatibilities when everyone is sharing documents and applications in the cloud.

e) Unlimited storage capacity: Cloud computing offers virtually limitless storage. Your computer's current 1 T byte hard drive is small compared to the hundreds of Pbytes available in the cloud.

f) Increased data reliability: Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data. if your personal computer crashes, all your data is still out there in the cloud, still accessible. In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform!

g) Universal document access: That is not a problem with cloud computing, because you do not take your documents with you. Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection Documents are instantly available from wherever you are

h) Latest version availability: When you edit a document at home, that edited version is what you see when you access the document at work. The cloud always hosts the latest version of your documents **as** long as you are connected, you are not in danger of having an outdated version

i) Easier group collaboration: Sharing documents leads directly to better collaboration. Many users do this as it is an important advantages of cloud computing and multiple users can collaborate easily on documents and projects

j) Device independence: As the user is not attached to a single computer or network, changes to computers, applications and documents follow him through the cloud. If he moves to a portable device, and his applications and documents will be still available.

DISADVANTAGES OF CLOUD COMPUTING

- **Requires a constant Internet connection:** Cloud computing is impossible if you cannot connect to the Internet. Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents. A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.
- **Does not work well with low-speed connections:** Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible. Web-based applications require a lot of bandwidth to download, as do large documents.
- **Features might be limited:** This situation is bound to change, but today many web-based applications simply are not as full-featured as their desktop-based applications. For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering
- **Can be slow:** Even with a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC. Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud. If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you would not get the instantaneous access you might expect from desktop applications.
- **Stored data might not be secure:** With cloud computing, all your data is stored on the cloud. The questions is How secure is the cloud? Can unauthorized users gain access to your confidential data?
- **Stored data can be lost:** Theoretically, data stored in the cloud is safe, replicated across multiple machines. But on the off chance that your data goes missing, you have no physical or local backup. Put simply, relying on the cloud puts you at risk if the cloud lets you down.
- **HPC Systems:** Not clear that you can run compute-intensive HPC applications that use MPI/OpenMP! Scheduling is important with this type of application **as** you want all the VM to be co-located to minimize communication latency!
- **General Concerns:** Each cloud systems use different protocols and different APIs may not be possible to run applications between cloud based systems. Amazon has created its own DB system (not SQL 92), and workflow system (many popular workflow systems out there) so your normal applications will have to be adapted to execute on these platforms. There are also issues relating to policy and access as if your data is stored abroad whose policy do you adhere to? What happens if the remote server goes down? How will you then access files? There have been cases of users being locked out of accounts and losing access to data.

POPULAR CLOUD COMPUTING SERVICES

When it comes to major cloud providers, there are three top contenders Amazon Web Services, Microsoft, and Google retaining the top three spots in 2017 [9]. These public cloud companies amass pools of computers, storage, and networking that they rent to business customers who don’t want to spend more money running their own data centres.

Amazon Web Services, which is expected to bring in $14 billion in revenue this year, remains the biggest player by far. Amazon Web Services (AWS) market share retains at about 40 percent of the IaaS and PaaS sector — larger than the next three players (Microsoft, Google and IBM) combined.

Microsoft provides most affordable Cloud Service for Small Businesses. Microsoft remains the cloud of choice for many businesses that have run Microsoft software in their own data centres for years. Microsoft Azure revenue is nearly $3 billion in 2017.

The Internet search and ad giant Google has invested heavily in the Google Cloud Platform and improved its sales approach to appeal to business customers in bigger companies as well as start-ups that tend to be cloud-oriented.

As cloud computing turning computing and software into commodity services, everything as a service in other words, it leads to not only a technology revolution but also a business revolution. Insights and impacts of various types of services (infrastructure as a service, platform as a service, software as a service, business process as a service) have to be re-examined.

Most cloud services are set up to provide standardized commodity hardware, open source system software, application software, and databases. Cloud servers are typically clusters with X86 CPUs, and a Gigabit Ethernet interconnect fabric. Since most commercial workloads do not require data movement across the interconnection network fabric, this is a cost effective approach. Some higher end cloud servers are beginning to use a high performance Infiniband interconnection network fabric.

Most commercial Clouds use commodity networking and storage devices which are suitable to effectively host loosely coupled scientific applications which frequently require large amounts of computation with modest data requirements and infrequent communication among tasks. Several studies have shown that Cloud Computing is viable platform for running loosely coupled scientific applications and workflow applications composed of loosely coupled parallel applications consisting of a set of computational tasks linked via data and control dependencies [10-16].

However, practical adoption of cloud technologies may be greatly impeded if security and privacy issues are not adequately addressed. As the cloud is an open platform, it can be subjected to malicious attacks from both insiders and outsiders; the need to protect the security and privacy of the data in the cloud becomes a critical issue. Although recent advances in cryptography, such as fully homomorphic encryption and secure multiparty computation, are promising, more work is still needed to transform theoretical techniques into practical solutions that can be efficiently implemented in the cloud.

The business potential of Cloud computing is recognized by several market research analysts. It is anticipated that the worldwide spending on Cloud services will reach about a trillion dollar by 2020. To achieve this potential, several technological, business, security, and application-oriented challenges need to be addressed.

SECURITY ISSUES IN THE CLOUD

Data Security is a crucial element that warrants scrutiny. Enterprises are reluctant to buy an assurance of business data security from vendors. They fear losing data to competition and the data confidentiality of consumers. Cloud security concept requires total situational awareness of the threats to the network, infrastructure and information. Data in the cloud typically resides in a shared environment, but the data owner should have full control over who has the right to use the data and what they are allowed to do with it once they gain access. Information security is an area of concern in cloud environment [17-20]. Security is the capability of a system to prevent malicious or accidental actions outside of the designed usage, and to prevent disclosure or loss of information. Cloud applications are exposed on the Internet outside trusted on-premises boundaries, are often open to the public, and may serve untrusted users. Applications must be designed and deployed in a way that protects them from malicious attacks, restricts access to only approved users, and protects sensitive data. Figure.4 depicts the challenges which include the issue of vendor lock-in. The vendor lock-in problem is the situation where customers are dependent (i.e. locked-in) on a single cloud provider technology implementation and cannot easily move to a different vendor in future without substantial costs, legal constraints, or technical incompatibilities [21-24]. In the cloud model, service providers are responsible for maintaining data security and enterprises would have to rely on them.

THE FUTURE OF CLOUD

By 2020, the popularity of the ‘cloud’ will have grown significantly. There will be many pleasant changes, and one of them should be the complete freedom from the ‘no-cloud’ policy. Cloud-based analogues are much better and more flexible to use. Experts believe that all ‘no-cloud’ companies will definitely start using cloud services in their work. After all, at the end of 2015, 88% of entrepreneurs transferred their companies to clouds. However, there are concerns that the mainstream adoption of cloud computing could cause many problems for users. Many new open source systems appearing that you can install and run on your local cluster should be able to run a variety of applications on these systems. The software will be separated from the hardware and Modular software will be a priority in future. It is anticipated that Low-power processors will stimulate the decline in prices for services of cloud providers and Data security will continue to be superior.

There will be a large demand of IT & Computer skilled manpower for the progress and maintenance of Cloud computing. With 83% of businesses ranking cloud skills as critical for digital transformation in 2017, it’s great news for anyone with cloud architecting experience, and for those considering a career in cloud computing. The cloud will continue to disrupt traditional IT models as the growing amount of data generated by people, machines, and things will increasingly be handled in the cloud. As the cloud adoption increases, companies are using it to achieve greater scalability, higher performance, and faster time to market. As a result, skills for architecting, deploying, and securing the cloud will continue to be essential. And because companies are embracing multiple cloud models and multiple providers, those working in the cloud will need versatile skills that cover different platforms and services to help companies leverage the cloud for continued benefits and competitive advantage. For functional application development and support proficiency in Oracle, SAP, SQL, linking hardware to software will be required. For leveraging data to make strategic business decisions, Business Intelligence: Applying sales forecasts to inventory and manufacturing decisions expertise will be essential. Mobile apps will require skill in Android, iPhone, Windows Mobile. Optical engineers as Optical fibre communication offers the highest bandwidth with PON, CWDM, DWDM technologies and IP Engineers, Network Security Specialists, Web developers, Social Media developers, Business Intelligence application development and support will be in good demand in future.

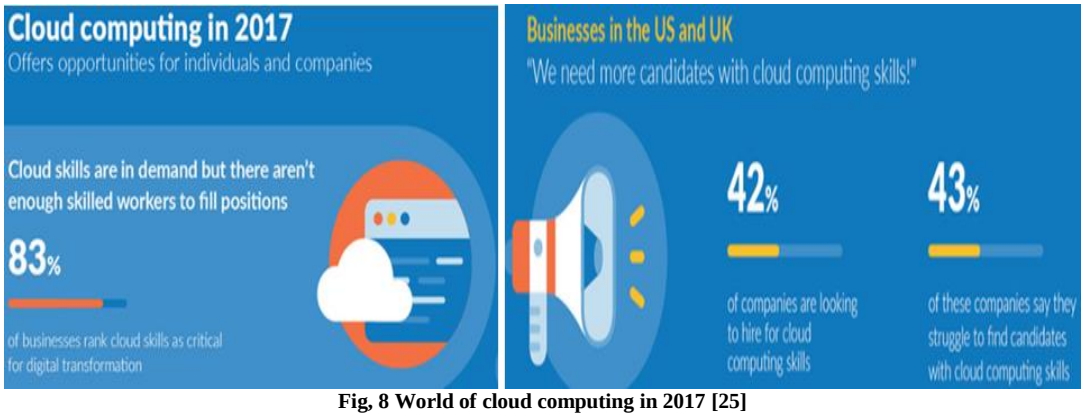

Fig. 8 World of cloud computing in 2017 [25]

Cloud computing introduces many challenges for system and application developers, engineers, system administrators, and service providers. The foremost is to effectively manage the virtual machine (VM) life cycle to deliver quality expectations of consumers and at the same time reduce the cost delivery of services. Second challenge is sensitive to secure the data and computation on the VMs managed by Cloud service providers. It is also equally important to guarantee users' privacy and trust requirements and to meet legal and regulatory compliance requirements about data hosting in Clouds. The model of pricing for services and to manage Service Level Agreements (SLAs) and guarantee quality of service (QoS) satisfaction and prevent or minimize SLA violations are questions to be answered. It is also a challenge to select data centers' locations so that data security, operation costs, and energy consumption meet the terms in the SLA signed with users.

Cloud computing could offer good business models for small computational science and engineering (CSE) research groups because these groups often do not have enough human resources and knowledge to manage the complexity of computational and data infrastructure for their research, while cloud computing aims to eliminate that complexity from the user but the answers to above challenges are to be searched.

CONCLUSION

The emergence of powerful, always-on cloud utilities has transformed how consumers interact with information technology, enabling video streaming, intelligent personal assistants, and the sharing of content. Businesses, too, have benefited from the cloud, outsourcing much of their information technology to cloud services. Science, however, has not fully exploited the advantages of the cloud. Could scientific discovery be accelerated if mundane chores were automated and outsourced to the cloud?

Cloud Computing is outpacing the IT industry and real business value can be realized by customers of all sizes. Cloud solutions are simple to acquire, don't require long term contracts and are easier to scale up and down as needed but proper planning and migration services are needed to ensure a successful implementation. Public and Private Clouds can be deployed together to leverage the best of both. Third party monitoring services ensure customer are getting the most out of their cloud environment. Security Compliance and Monitoring is achievable with careful planning and analysis

The future of cloud computing is a chance for a huge technological breakthrough for the companies using this technology today. Very soon, cloud technologies will allow working faster and more efficiently than it is today. In addition, together with their spread, our life will accelerate.

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