Cloud Security Toolkit

Cloud Computing: Definition and Background

Executive Summary

Cloud computing is gaining in popularity and is utilized by businesses and private users for commercial and non-commercial purposes as well as for public and private use. Server virtualization and consolidation is also becoming commonplace as many enterprises seek to reduce information technology (IT) operating expenses and minimize the data center footprint, while simultaneously improving business agility by decreasing the complexity of data processing.

Cloud computing is one of the key benefactors of virtualization and clustering, and as such has gained prominence in today's IT business model. Increasingly in recent years, more CIOs and IT Managers are looking to the cloud to optimize information technology capital, decrease operating expenses, and deliver unique services and products into a highly dynamic marketplace. Ironically, the concept of cloud computing has been in existence for quite some time, even though it has recently gained increasing amounts of market attention.

This white paper provides background on cloud computing and its evolution into today's IT market. It taps into the history of the cloud, uses of the cloud and possible impacts for the future. This paper also differentiates between various cloud models and environments, depicting the benefits from financial, business continuity, and performance perspectives. Finally, it presents some interesting examples of real-world uses of cloud technology.

Background and History

When reading any current technology magazine article, blog, or website, you are certain to come across various types of cloud offerings or service providers that offer cloud services. Before we discuss today's cloud computing offerings, let's stop and ask the question: How did we get here and how did it all get started?

Cloud computing can be traced back as far as the 1960s when an American computer scientist named John McCarthy stated that computing will become a public utility in the future[1]. The conceptual history of cloud computing can be broken down through its evolution with the start of "cluster computers," which communicated through protocols for balancing computational loads across different machines. Cluster computers then gave way to the "grid," which provided the capability of multiple independent clusters

[1] http://en.wikipedia.org/wiki/Cloud_computing

linking together along with high end storage management. The "cloud" is the term spawned from the grid which technically wraps the concepts of the grid into data center services through the use of Internet for connectivity. The term "cloud computing" originated from the informal use of a "cloud" graphic in technical diagrams/ flow charts to symbolize the internet and is now codified by use in some electronic tools for producing graphical representations of technical architectures, such as Microsoft Office Visio[2] and others. Again, its technical history includes the notion of shared or pooled computing resources.

Time-Sharing and Cloud Computing

Time-sharing[3] is the sharing of a computing resource among many users by means of multiprogramming and multi-tasking. Its introduction in the 1960s, and emergence as the prominent model of computing in the 1970s, represents a major technological shift in the history of computing[4].

The time-sharing model materialized through General Electric[5], which had a Central Processing Unit (CPU) named the GE 225, and a control or switching unit named the Datanet 30. Each unit had 16K core memory. When strapped together, up to 40 simultaneous users could use the system. GE opened information processing centers across the country, offering hundreds of library programs and sub-routines (built using FORTRAN, ALGOL, and Basic programming languages). This networked data center, based on simultaneous usage, resulted in pricing per usage.

In 1968, GE introduced the CRU (Computer Resource Unit). In adding CRU charges for the use of scarce resources, FORTRAN, storage, input/output, and library programs were priced at a premium. This allowed adjusting of the dials to more fairly regulated charges associated with system usage. Competitors joined in with CUU's (Computer Utilization Units) and other pricing schemes to ensure users paid their fair share. This mechanism is synonymous to cloud computing services of today which charges a fee for utilization of their data center resources. Most cloud computing vendors offer services on a month-to-month basis with monthly payment for as-needed usage. In essence cloud computing is much like computer time-sharing but with some distinctions. This comparison is as follows[6]:

Similarities of Cloud Computing vs. Computer Time-Sharing:

- Rent computation time
- Simple, static screen

Differences of Cloud Computing vs. Computer Time-Sharing:

- For $20 a month, anyone can own a Virtual Computer, of any operating system flavor
- For a small fee, you can create your own server farm or data center
- Graphical User Interfaces (GUI)
- Pointing Devices (Mouses)
- Full color virtual screens

[2] Microsoft Visio, http://visiotoolbox.com/2010/
[3] http://en.wikipedia.org/wiki/Time-sharing
[4] http://en.wikipedia.org/wiki/Time-sharing
[5] http://gcn.com/articles/2011/03/21/column-ray-kane.aspx
[6] http://blogs.citrix.com/2010/09/27/cloud-computing-vs-timesharing/

- Client-Server technology
- Web Servers
- Applications & Databases
- Networking & Internet
- Virtual Machines
- Virtual Desktops
- Virtual Applications

The evolution of computing services has led to cloud computing as we know it today. Cloud computing offers ease of access, versatile services, and a cost-effective means of obtaining computing services, which has made it highly prevalent in contemporary times especially with the rapid advancements in computer technology.

The Challenges of Time-Sharing before Cloud Computing

In the past, massive computing was undertaken by supercomputers and mainframes. Supercomputers and mainframes were not bought solely as one package; rather, they were created by connecting several hundred to thousands of central processing units (CPU) so that they could divide computing tasks among them to obtain faster results. Industries specializing in or using information technology were the ones who were in high need of supercomputers to run and manage all of their computing needs.

Challenges associated with this architecture arose from the cost needed to create a supercomputer or mainframe as well as the cost of maintaining it in optimal condition. To make a supercomputer or mainframe work, it was not enough to have CPUs available. The CPUs must also be interconnected using specific technologies, such as a network, so that they can communicate with each other and work as a system. Purchasing the devices and creating the tools contributed to a large share of the cost of a supercomputer. In addition, maintenance had to be performed on a supercomputer to ensure that it was performing optimally across time. This also guaranteed the integrity of the data it outputs after massive computation.

The cost of past computing methods was substantial. The amount of time and variety of resources (hardware, software and personnel) required to implement (configure, test, etc.) and maintain the entire system made business related applications complicated and expensive to implement. This complex and costly effort compelled the industry to develop more economical business models, such as cloud computing, much of which are used today.

What is Cloud Computing?

The term “cloud” is used to describe any web related or internet-based technology; while “computing” is described as the use of computer technology. “Cloud computing” is a technology model that provides a scalable platform for on-demand and real-time computing services accessed by users over a public network (the Internet) or a private network.

As discussed in the Background section, the term “cloud computing” has its roots in the evolution of computing and various architectural approaches to gaining additional resources. Today, there are currently so many vendor offerings in this space, as well as legitimate benefits to users, that technical standards bodies are now conducting work to define and clarify both the term and the technology. For example, the National Institutes of Standards and Technology (NIST) Computer Security Division (CSD) published a draft document in January 2011 entitled, "Special Publication 800-145 (Draft), The NIST Definition of Cloud Computing." This document has recently been updated. In this document, they posit the following formal definition:

> *"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."*

Virtualization and the Cloud

Cloud computing often leverages the use of "virtualization" to establish a unified pool of resources (hardware, software, and network) for the delivery of IT and application functionality. Cloud computing provides end users with flexibility in regards to service consumption, pricing, self-service provisioning and management.

"Virtualization"[7] means to create a virtual (as opposed to real; that is, a simulation) version of a device or resource, such as a server, storage device, network or even an operating system where the framework divides the resource into one or more execution environments. Even a simple procedure such as partitioning a hard drive is considered virtualization because one hard drive needs to be partitioned to create two separate hard drives.

"Server virtualization" provides the means of partitioning a physical server into smaller virtual servers (See Figure 1). This is a form of abstraction in the use of resources (by applications, services, etc.) from the underlying physical resources. This abstraction improves agility and flexibility, reduces costs and thus enhances business value of the resources. The physical resources from specific applications allow virtualized computing environments to be dynamically created, expanded, shrunk or moved as demand varies. Virtualization is therefore considered by many to be a cornerstone of a dynamic cloud infrastructure (See Figure 1), because it provides important advantages in sharing, manageability and isolation (that is, multiple users and applications can share physical resources without affecting one another).

A virtual server is basically the same as a physical server based on outward appearances. Virtual servers perform the same functions as physical servers. In fact, it is nearly impossible to distinguish a physical server from a virtual server when logged on to the server console. The key difference between physical servers and virtual servers is that virtual servers are not installed on the physical hardware (they are hardware agnostic). Virtual servers are installed on something called a hypervisor[8]. This hypervisor allows you to run many virtual servers on a single piece of physical hardware.

[7] http://www.webopedia.com/TERM/V/virtualization.html
[8] http://searchservervirtualization.techtarget.com/definition/hypervisor

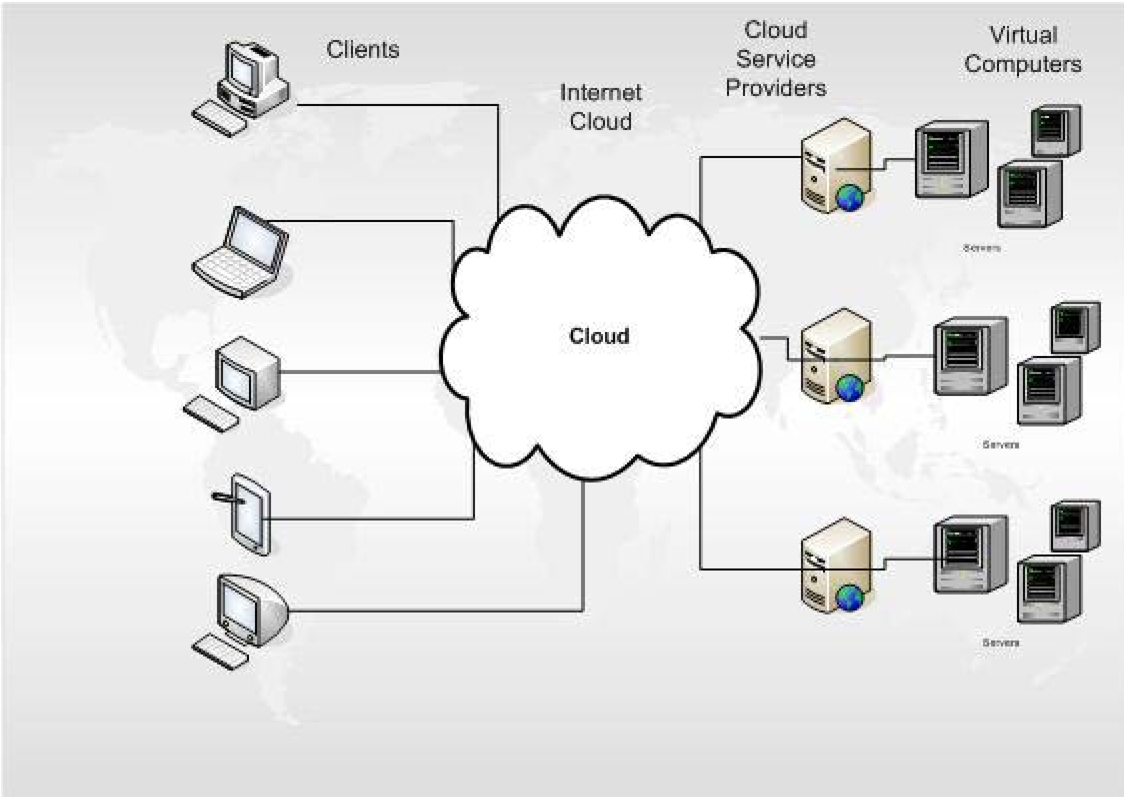

Figure 1 [9]

The cloud computing concept takes virtualization a step further by enabling users of IT resources to avoid investing in dedicated IT infrastructure (e.g., buying computer hardware). IT costs become a variable operational expense for business users because capacity is shared versus the capital expense of purchasing, owning, maintaining and depreciating computer hardware.

Adopting this mode allows capacity to scale up and down dynamically and immediately in a manner that advances how virtualization is used today. The cloud model is designed to let companies use IT resources as a service, taking advantage of shared applications, processing and storage managed within the cloud either inside a private cloud at an internal data center, or in an external cloud at a service provider.

To be clear, cloud computing doesn't necessarily require virtualization. However, in order for cloud computing to be a practical service offering, the economies of scale and automation capabilities of virtualization are often leveraged. Otherwise, the cloud service provider would need to manually provision services per client with dedicated hardware.

Service Models

Cloud Computing is built on layers with each providing a distinct level of functionality. These cloud-based layers or service models deliver business and technology benefits across a range of IT domains. These service models include: Software as a Service (SaaS) for business applications, Platform as a Service (PaaS) for programming development platforms and Infrastructure as a Service (IaaS) which targets

[9] http://www.matthewb.id.au/index.php?option=com_content&view=article&id=31:cloudcomputingpossibilities&catid=1:information-technology&Itemid=2

networking and infrastructure platforms. The diagram (*see* Figure 2) below depicts the arrangements of a typical cloud-based service model.

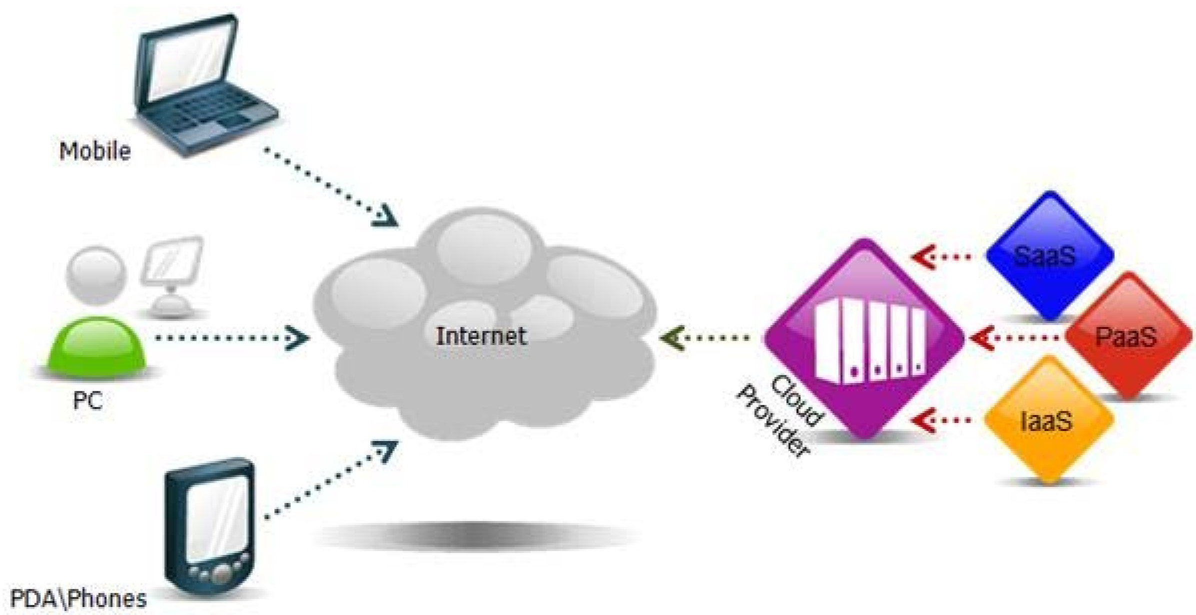

Figure 2 [10]

These service models are typically offered in a subscription model with various means of pricing.

- Software as a Service (SaaS)[11]. This provides the capability to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email) to provide some type of business application functionality.

- Platform as a Service (PaaS)[12]. This provides the capability to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider.

- Infrastructure as a Service (IaaS)[13]. This provides the capability to provision processing, storage, networks and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

Figure 3 below depicts a more detailed service model of the cloud computing infrastructure.

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[10] http://www.govloop.com/group/SaaSGov
[11] National Institute of Standards and Technology – The NIST Definition of Cloud Computing. http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf
[12] Ibid
[13] Ibid

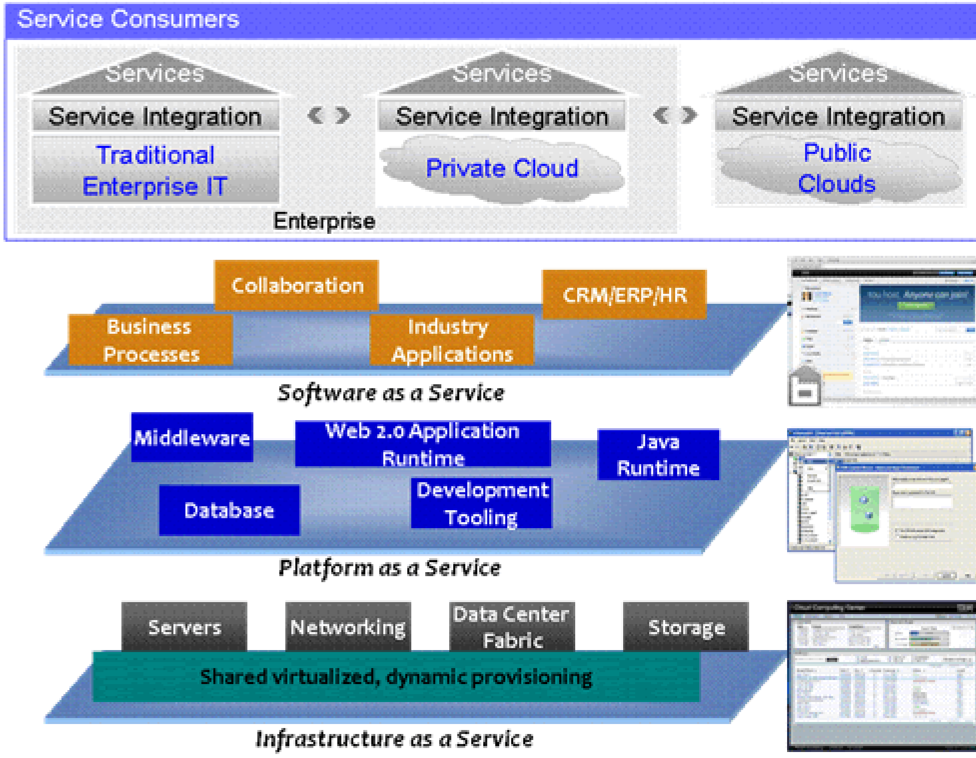

Figure 3 [14]

Deployment Models

There are four types of cloud deployment models (see Figure 4):

- Private cloud. This cloud model is operated solely for an organization. It may be managed by the third party and may exist on-site or off-site.
- Public cloud. This cloud model is made available to the general public or a large industry group and is owned by an organization selling cloud services.
- Community cloud. In this cloud model, the underlying information technology infrastructure is provided by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy and compliance considerations). It may be managed by the organizations or a third party and may exist on-site or off-site.
- Hybrid cloud. This cloud model is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

[14] http://www.jot.fm/issues/issue_2009_05/column3/index.html

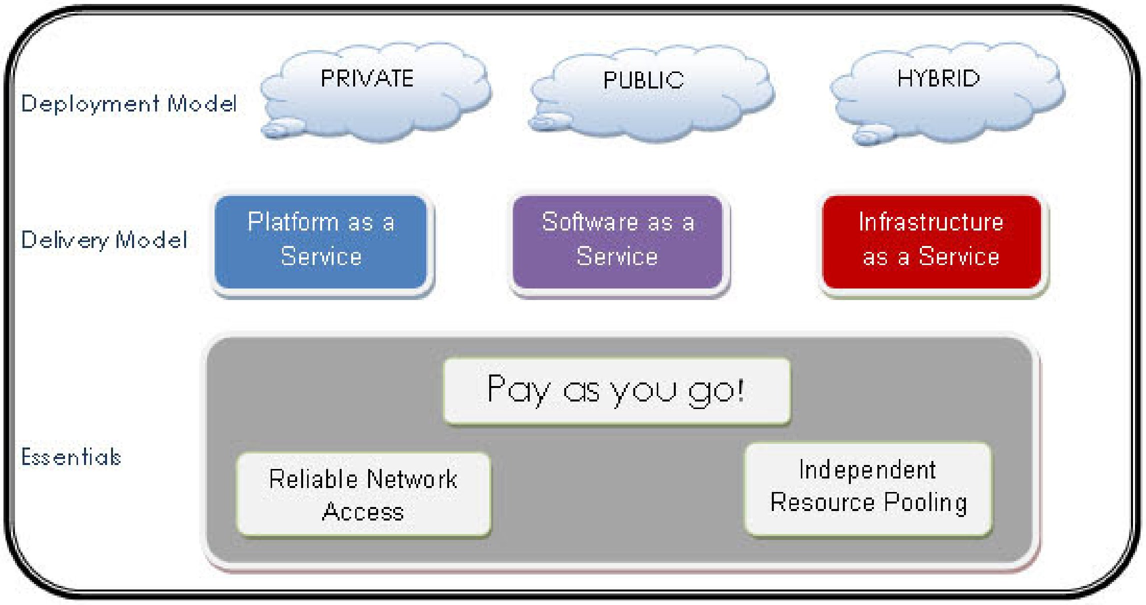

Figure 4 [15]

Advantages of Cloud Computing

Cloud computing provides a solution to the limitations and challenges described in the previous section. Cloud computing enables businesses to consolidate resources - servers, software, databases, etc. -through methods such as a vendor hosting an application on its own private server farm and deploying it to a cloud infrastructure. The trade-off is that businesses can take advantage of such service models to reduce the IT costs associated with traditional on-premise applications like hardware, patch management, upgrades, etc.

Ideally, cloud computing offers two very important benefits - speed and cost. There are also other benefits such as:

Efficiency – Cloud computing offers high efficiency and high utilization due to the sharing of pooled resources, enabling better workload balancing across multiple applications.

Availability – The cloud architecture makes use of efficient redundancy with its numerous servers and storage capabilities. The result is efficient failover[16] protection.

Agility – There is increased business agility as there is no longer a need for internally developed or customized third-party software. In addition, cloud applications are essentially web-based, allowing businesses to quickly and easily extend new functionality to customers through their business web site(s).

Flexibility – There is resilience with business continuity and disaster recovery. Managing business continuity and recovery internally requires a dedicated focus so companies typically concentrate only on the most critical applications. Utilizing cloud environments allows organizations to safeguard their full IT infrastructure because the cloud's inherent scalability integrates disaster recovery capabilities.

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[15] http://www.sterkis.com/cloud_computing.php

[16] In computing, failover is automatic switching to a redundant or standby computer server, system, or network upon the failure or abnormal termination of the previously active application,[1] server, system, or network. See http://en.wikipedia.org/wiki/Failover.

Challenges

Although the above are compelling benefits of cloud computing, there remain key areas of concern such as trust, security and privacy related to the storage and use of sensitive data in the cloud (see Cloud Security 101 in the HIMSS Cloud Security Toolkit). Purchasers of cloud services must have some visibility into the security controls employed and must obtain certain contractual service level agreements and security assurances.

Cloud service models also need to be periodically assessed for conformance to regulatory and industry standards. The SAS 70 standard includes operating procedures for physical and perimeter security of data centers and service providers. Access, storage, and processing of sensitive data needs to be carefully controlled and is governed under regulations such as ISO-27001, Sarbanes-Oxley Act [SOX], Gramm-Leach-Bliley Act [GLBA], Health Insurance Portability and Accountability Act [HIPAA] and industry standards like Payment Card Industry Data Security Standard [PCI-DSS].

Uses of the Cloud Today

Today, Cloud computing has been adopted in many industries and is being used in a variety of ways. Some organizations have fully embraced cloud computing, while others have only adopted cloud computing for a portion of their business.

Some organizations adopt both public and private cloud computing for distinct portions of their business; that is, these organizations are running some applications in public clouds and others in private clouds. Cloud computing is utilized throughout many instances of commerce and industries today; evidenced by companies such as IBM taking the helm of supporting such evolution. A wide range of implementation examples can be mentioned about cloud usage. One such example is:

- IBM's Research Division uses cloud computing technologies for its Research Compute Cloud (RC2). This cloud allows researchers to obtain cloud computing infrastructure and application resources on demand for their projects. The resources are allocated and provisioned with software in a matter of minutes. Automated service management has dramatically reduced provisioning time and has improved overall monitoring and management of the project.

- IBM's cloud-building services helped a major U.S. university build an infrastructure cloud computing service to share computing resources across as many as 10 campuses, allowing it to optimize computing power, storage, service and data center labor across the university system, and deliver services across its constituency.

Uses in Healthcare

According to the CDW 2011 Cloud Computing Tracking Poll[17], 30 percent of health care organizations are now either implementing or operating cloud-based solutions and have realized an annual average savings of 20 percent for those applications. Health care is widely adopting cloud-based services to exchange medical and financial data across Healthcare Information Exchange networks (HIEs), as well as to store and manage large amounts of data.

[17] http://webobjects.cdw.com/webobjects/media/pdf/Newsroom/CDW-Cloud-Tracking-Poll-Report-0511.pdf

Below are some example uses in healthcare:

- Cloud services including pharmaceutical, radiology, billing and other areas of specialty that had already been traditionally outsourced by health care organizations.

- Cloud computing can provide authorized access to records from anywhere on any device, allowing health care personnel to respond to life-threatening emergencies, a patient in crisis or law enforcement. The cloud provides near real time, accurate exchange of information to support a variety of health care scenarios—which is the objective of the Health Information Technology for Economic and Clinical Health Act (HITECH Act), enacted as part of the American Recovery and Reinvestment Act (ARRA) in 2009.

- The Centers for Medicare and Medicaid Services (CMS) issued new standards and conditions[18] directing states to "pursue a service-based and cloud-first strategy for system development" as a condition for federal (CMS) funding.

- Cloud Vendors are now offering applications like EHRs. This allows healthcare providers to deploy these types of applications faster than if they purchase and implement in their own environment.

- Allows sharing of data between different healthcare entities (e.g. providers, payers, specialists, labs, etc) that may have disparate systems allowing collaboration. A "Picture Archiving and Communication System" or "PACS-on demand" system is an example of this. This model uses cloud services for storing and sharing of medical images.

- Management of "Big Data[19]" such as digital imaging data that must be stored and exchanged electronically and is predicted to grow rapidly.

- Cloud technology is accelerating the ability to create and store a "longitudinal," "lifetime," or "hybrid" patient medical record can enable better decision support or information-enabled care.

- On the business systems side of healthcare, outsourcing processes like Revenue Cycle Management, Claims Processing and Patient Enrollment enhances the ability to search and process medical and claims data.

The Future of Cloud Computing

There is little question that cloud computing, including server virtualization, is the single biggest game-changing trend in today's technology and it is not hard to see why. Driving down costs and increasing technology agility are powerful reasons for utilizing the cloud. Virtualization helps enterprise organizations further leverage hardware investments, reduce data center space required, and help to drive down associated power consumption requirements. Fully virtualized data centers will become the norm and so will cloud computing.

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[18] Enhanced Funding Requirements: Seven Conditions and Standards Medicaid IT Supplement (MITS-11-01-v1.0) April 2011, http://www.oregon.gov/OHA/OHPR/HITOC/MITA/Docs/Enhanced-Funding-Requirement-Seven-Conditions-and-Standards.pdf?ga=t

[19] "Big data" is a term often used for massive amounts of patient-related data now being created by the many clinical and diagnostic imaging IT applications now deployed in healthcare.

In the near future, it is said that the demand for IT in business organizations will increase dramatically[20]. Over the next 5 - 10 years, spending on IT cloud services is expected to grow threefold, reaching $42 billion by the end of 2012 and accounting for 9% of revenues in five key market segments[21]. Cloud computing will become more mainstream as the technology landscape evolves.

Large organizations will start hosting important applications using the cloud. There will be an increase in service providers offering both public and private cloud commodities and other consumer-focused cloud services. There will also be increased revenue generated by these service provider companies, especially for those that address data-center-to-cloud latency capabilities

As the convergence of data and resources become more prevalent, the market will see the emergence of cloud security standards to help further regulate cloud compliance. Cloud providers will be driven to agree on security standards which offer stronger and more consistent protections than those used within current in-house and cloud-based information technology infrastructure.

Conclusion

Cloud Computing was once thought of as another fad or marketing gimmick, even though the concept has been around for quite some time. Cloud computing is driving a fundamental shift in the way organizations build, deploy and use applications, and it's raising awareness on how quickly and cost-effectively new IT functionality can be made available to meet business needs.

In years ahead, computers, particularly those used in business, may function in a completely different fashion from the way they function today, and the impact is likely to be felt throughout the industry. Cloud computing will almost be the 'way of life' for most business enterprises and private individuals. The real question is - will you be onboard?

[20] http://is002.sbpauog.us/The%20Website/background.html
[21] http://blogs.idc.com/ie/?p=224