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Introduction to Cloud Computing:
Cloud Computing; the Future of Information Technology?

Introduction

What is Cloud Computing?

Cloud Computing has seen an explosion in the recent years with the turn to mobile technology, that has the same capabilities of modern computers. With this new need for data while on the go, Cloud computing evolved. While many people have misconceptions of what Cloud Computing is, most of them have been using services built for the Cloud. For example email using a web interface is a Cloud application, accessing files on a web server or a backup server is a Cloud application. However, cloud applications go well beyond a simple data site with a web interface. Newer items like Windows Azure, Amazon Elastic Compute Cloud, and many others owned by For-Profit businesses are emerging to allow small businesses and developers to release application in the Cloud, on remote platforms. All of the items aforementioned meet the general definition of what Cloud Computing is; since the Electrical Engineering and Computer Sciences department at the University of California at Berkeley lists Cloud Computing as applications or programs delivered over the Internet, they further go on to explain that the hardware and software provided on the servers is actually the Cloud and the software, whether it be a web mail interface or an advance application running on the .NET framework, is the Software as a Service. As we can see from the examples and definitions above, the Cloud is essentially anything that is accessed over the Internet, where computations or data is accessed and processed on the Cloud server at the remote location that the End User is accessing over the Internet using a web browser or an Internet connected application (Armbrust).

A Brief History of the Evolution of Cloud Computing

Cloud computing, like many aspects of Information Technology has been evolving ever since the concept was derived in 1960, where one of the main developers of ARPANET, J.C.R Licklider, envisioned an idea where a global network offered the power of a computer to the public using the network, which can now be thought of as the Internet. The term Cloud Computing was first used in 1997 by Ramnath Chellappa, an Information Systems professor, from this point the notion of having computational power available to many over the Internet began to become a favor of businesses. Businesses started switching from maintaining high maintenance and expensive hardware and servers to Cloud services, since they could reduce costs of hardware and personal in the Information Technology department of their business, and to mainstream their business, by making their business more efficient and cost friendly. Many industry leaders feel that the driving factor for the exponential growth in Cloud infrastructures is the growth in data and the need to efficiently access it (Cantu).

Like many things in the Information Technology field, Cloud Computing will evolve as people find need for data and computational power over the Internet. Since Cloud Computing is over the Internet, the evolution of Cloud Computing will be parallel with the development of Network Technologies and Internet Protocol development, because as the speed of Networking and Internet access increases the use of Cloud Computing items will increase, allowing for more advance computations to be achieved, due to the higher bandwidth and network speed available to the service being developed.

The Capabilities of Cloud Computing

Architecture of the Cloud

From the Client side the architecture of cloud computing is relatively simple. The End User connects their computer, either through a web browser or application, to a cloud service, and then accesses the cloud. Luckily for the Client the majority of the architecture for connecting to the Servers that hosts the Cloud Application is simple TCP/IP and other Networking protocols. Because of this fact Cloud Computing is easy to allow clients access

to the cloud applications, since the End User does not require new hardware or networking equipment to access the Cloud. Therefore, from the Client point of view the networking infrastructure is the main architecture, since from the client side the IP based networks are what make Cloud Computing a possibility for allowing all clients access to the Cloud Application being hosted. (Winkler).

However, the architecture hosting the Cloud application is a bit more complex. For example, for an enterprise creating a cloud application to be hosted they need to get the Servers that will host the application, these servers need to be powerful enough to handle the highest traffic that may be expected and be secure. For the architecture of the system they will need the Service Management Platform, which is what the Client will interact with upon connecting to the Cloud from their workstation to allow for management of account or other items or to provide a form of service. Depending on what type of Cloud system is being implemented, Platform as a Service or Infrastructure as a Service, will dictate what is in the next level. If Platform as a Service is being used it will just need to host Database, Reports, Web, or business services to provide to the Client. However, if Infrastructure as a Service is used it will require three underlying layers, the Application Layer which will handle load balancing of application resources, quality of the service being provided, and recovery from system failures and virtual machine hosting. The next layer, going toward hardware, will be the virtual layer, which will provide the network, storage, and computational power; these items are usually virtualized for the specific cloud application being hosted. The Virtual Layer communicates with the Hardware Layer to give the cloud applications to the firmware, storage, networking, processing power, and computational power. Regardless of the Service being used, the Cloud service needs to provide a form of security to prevent intrusion and ensure that data is secure, as well as a way for network and Information Technology administrators to manage the system, by specifying events and resource allocation for workload and services. Finally the last piece that makes up the Cloud Application's server hosting is a database system to give the client access to data as needed and automation to ensure that the system will not fail if hardware failure happens to a specific server, this is accomplished by duplicating and backing up the service. The architecture of the cloud is advance, but by following this roadmap, the application should be safe and able to run with minimal downtime (Chahal).

The Different Uses of the Cloud

One of the best ways to learn about new technology is to see it in action. A great way to do this is to find companies that use the new technology for their website. After exploring the case studies of different companies that have found amazing uses for the Windows Azure platform, the most interesting and creative uses were found. These creative uses came from such places as the National Aeronautics and Space Administration, T-Mobile USA, and Boeing. There are many companies that have found great benefits by moving their servers to the Cloud; however, these three companies have found great ways to use the Cloud and other great Microsoft software to create interactive and secure systems to interact with their customers and provide a great business experience and reputation on the Internet.

The National Aeronautics and Space Administration, NASA, is the leader of space and planetary exploration in the United States and the majority of the world. Recently NASA has frequently spent most of their efforts on exploring Mars. NASA has sent numerous probes and cameras to Mars to gather information, however, NASA soon realized the information gathered was great and they needed help to analyze the large quantity of data. To remedy this problem they turned to the Cloud. They hoped to use the power of the Web to get the entire world to study the images and upload their findings to a community based platform that would allow the world to study and release its findings to the community and help NASA. To do this NASA launched a web site called BeAMartian, which allowed visitors to study high-resolution pictures and data and provide a community platform to discuss and release findings from the data. The site was a success, providing users an interactive and secure platform to study NASA raw data and allow the world to participate and the future of space exploration and the future of what Mars can offer. To achieve this NASA used the Windows Azure platform to host the site and the Microsoft Silverlight platform to create a rich and interactive end user experience, which gave users a secure and open environment to discuss and list findings that they find from the images and data that NASA provides on the site ("NASA").

T-Mobile USA is one of the main wireless telecommunication providers in the United States of America. T-Mobile hoped to create an application that families could use to synchronize activities and share information on the go. T-Mobile also wanted to ensure that they could release the product in a very small timeframe and that once they released it they could spend most of their development time on the Application and not maintaining servers and infrastructures that are hosting the applications. T-Mobile wanted to partner this release with their new phone option, Windows Phone 7. Luckily for T-Mobile, by choosing Microsoft based platforms, they were able to quickly develop all the applications with Visual Studio 2010, since it can develop for Windows Phone 7, Windows Azure, and the Windows Communication Foundation. T-Mobile also benefited from the security that is offered and built into Windows Azure and with Windows Communication Foundation, since they can support HTTPS and Transport Layer Security. With all the benefits of the Microsoft platforms, and the familiarity of Visual Studio 2010 the team was able to deliver its application in just six weeks, and create engaging and interactive applications that worked in harmony across the Windows Phone 7, Windows Azure platform for Push Notification, and SQL Azure for registering and storing users. T-Mobile was able to benefit from Cloud Computing by accelerating development time and offering its customers a great experience with T-Mobile's new Windows Phone 7 smartphone, the HTC HD7 ("T-Mobile USA").

Boeing, the world leader of aviation, was hoping to provide customers a more interactive look at its best selling airplane, the Boeing 737, in the hopes of gaining more customers with an interactive presentation of the Boeing 737. They wanted an application that can be viewed on a wide range of Windows based devices, like smartphones to large screens, with the ability of showing realistic and 3D-like details of the airplane. They were able to use Windows Azure to host and manage the application. Boeing also benefited from other solutions offered by Microsoft, like Windows Touch to allow for multi gestures, Microsoft Kinect for hand gestures, and Silverlight Deep Zoom for high level zoom and interactive navigation. Boeing was able to use the Cloud to provide users with an in-depth look at the Boeing 737 airplane and provide support for numerous Windows based devices with the Windows Azure platform they could offer a reliable platform with minimal cost to the company ("Boeing").

Cloud Computing Providers

There are numerous providers of Cloud Computing, however, like most industries there are a specific few that usually dominate the market. The different companies offer different levels of Cloud Computing. Some offer the developer or customer an infrastructure as a service, where the server hardware, usually virtualized, is used for outsourcing the application. The developer has full control of the software aspect, from Operating System to software loaded on the virtual hardware. IaaS provides the user a more controlled Cloud platform, and is the idea behind some of the main Cloud providers like: Amazon EC2 and IBM Cloud Computing. The other main option is Platform as a Service. This is usually the preferred choice of small businesses since it allows for a simple deployment process, on an already loaded Server with an Operating System. The main contender in this section is Windows Azure from Microsoft. Windows Azure provides users a cloud experience that is extremely simple and includes the power and familiarity of a Windows Server 2008 R2 based Operating System. In a PaaS the developer only needs to provide the application that supports Windows Server 2008 R2, and Microsoft handles the rest. One of the other options that are more controlled by the company and has little control by the end user is Software as a Service. Google Apps is an example of a Software as a Service, since users sign up for Google Apps and then use the already created application to complete the business or organization's tasks. For example, Google Apps includes access to Google's Email System; Gmail, Google's Office Suite; Google Docs, and many other Google services. All of these systems are applications that are accessed over the Internet and are hosted on Google Servers where the computations of their binaries are handled ("Google Apps helps businesses work smarter").

Windows Azure is the Platform as a Service offering from Microsoft. It is one of the simplest Cloud Platforms, since Microsoft handles everything from hardware to Operating System. The main benefit of Windows Azure is the Operating System, since Windows Azure uses a Windows based Operating System, based off of Windows Server 2008 R2, developers can usually run any program that runs on a local server on the Windows Azure platform. When you sign up for Windows Azure you select how much space, bandwidth, and computational power you need and that is what your monthly price is based off of. If

you find you have too much or too little you can always change it and raise or lower your monthly rate. Since your application will be running on a Windows based Operating System you can use familiar development tools like Visual Studio 2010 and numerous languages including the .NET family, JavaScript, Java, PHP, and nearly any language that supports Windows. Once you develop your application, all that is needed is for the application to be uploaded to the Azure platform and then your site will be live shortly after. The End User does not have to handle or deal with server settings, firmware updates, Operating System patches, maintenance, backup creation, or hardware failure events. Since you pay for what you need, you can start off small and grow with the business with little money. For example, if you were to sign up for Windows Azure at the time of this writing, a simple server with a 1.6 GHz CPU, 1.75 GB of RAM, and 225 GB of Storage, 10 GB of SQL Azure Database capacity, and 100 GB of Bandwidth would cost you around 201.99 USD a month. Microsoft also offers plans to lower your price by paying in advance for a specific time frame. Windows Azure is an easy to use platform, allowing for startups and small businesses to offer their clients the power of enterprise computing at affordable prices, and with little technical knowledge for setting up a Cloud Server to host their application, Windows Azure is as easy as uploading your application (Brunetti)!

A popular choice of a Cloud Platform is Infrastructure as a Service, since the developer or company has more control over the Cloud platform. For example, in Windows Azure and any Platform as a Service you have no choice over what type of Operating System can be used, however in Infrastructure as a Service you can choose Operating System and nearly every aspect of software that runs on the Cloud Platform. There are numerous very popular choices of Infrastructure as a Service provider; for example, Amazon's Elastic Compute Cloud or EC2, which provides a pay for what you use system and completely customize and use your Cloud Platform. Amazon provides complete control over the server, including Root and Administrative access. You are able to load your preferred Operating System including many distributions of LINUX, UNIX and Windows Server. Then once you have the server set up with the Operating System of your choice you can then load your application and web interface and get IP addresses from Amazon to link to your Domain or access system ("Amazon Elastic Compute Cloud").

Problems for the Future of Cloud Computing

There are many problems faced with Cloud Computing from legal issues to security issues. Like anything new, the law has not yet made rulings on what can and cannot be done on a Cloud Server, as well as who is responsible for the data on the Cloud servers. Currently there are many problems with the law and new technology, especially Cloud Computing. For example which laws apply and to who, and what about when multiple jurisdictions are involved? In Europe many legislations define who is in control of the data, verse the company processing the data. For example a company uploading an application to a cloud service is the controller of the data and the company hosing the cloud service is the processor. Because many jurisdictions can hold the service provider responsible for illegal content on the servers, many providers look for countries that have less strict rules, for example the United States. To help eliminate the problem of holding the provider responsible many Directives have introduced protection for hosting providers, for example eCommerce Directive 2000/31/EC provides no liability for storage of illegal content assuming that the provider had knowledge of the content. However, there are many problems in the law and too many jurisdictions involved to eradicate this problem (Van Eecke).

The other main concern over cloud computing is security. Since Cloud Computing takes sensitive and confidential information and places it on an Internet connected server which could potentially be hacked, and with Cloud Computing making information available over the internet we run into issues of possible intrusion into the server, Man in the Middle attacks, and identity theft to gain access as another individual. While there are many ways to handle security problems, there is no full proof way to protect the data (Winkler). For every patch or protection implemented someone is finding a way around it. Because of this, high-level encryption is a must, therefore allowing data to be intercepted, but hopefully, not compromised. However, having plans set up to handle data compromises and intrusions is essential to quickly find out what has been compromised and initiate plans to change or protect the data that has been compromised. However, as mentioned, there is no full proof way to protect data and being prepared for the worse is the best defense.

Conclusion

Saving Money in the Cloud

The main principle of Cloud Computing is the benefit of saving money to the client. Cloud Computing saves money to small businesses and startup businesses by giving them a pay as you use plan and no maintenance or upgrading fees or designated Information Technology department to manage equipment or software. When a business decides to release a Web application or move to the Cloud they normally have to purchase a server with enough power to handle the highest level of customers at any time, then they need to purchase licenses for Operating Systems, if required, and any other commercial software. They need to have an individual or department to ensure that equipment is up and running at all times and that data is backed up in case of hardware failure, and then as technology or their business evolves they need to update the software and upgrade the hardware to keep up to date. This could cost in the hundreds of thousands of USD in just a year, depending on the amount of people hired to maintain the server. On the other hand if the business went with a Cloud Computing provider, like Windows Azure, they could be running for a year for only around four thousand USD. No matter how you do the math Cloud Computing is a cheaper option over a dedicated server. Also, since Cloud Computing is scalable, if your business grows or shrinks you can raise or lower your computation power and save money when your business decreases or upgrade for little cost when your business grows ("No upfront costs. Pay only for what you use.")!

Final Thoughts

As we have seen from the information above, the Cloud is an amazing shift in technology. The Cloud allows for businesses to start up for little cost, and for small businesses to grow and offer services in comparison to those offered by large enterprises. The Cloud also fuels the shift to mobile computing allowing for our data to synchronize over Web servers and access our data at any location in the world with Internet. Because the Cloud uses the Networking Protocols already in use today, the Cloud can grow rapidly on current technology and little costs to end users to gain support for accessing the Cloud.

We have already seen a shift in Internet based services in how we access our email, documents, and even TV and Movies. The Future of Cloud Computing is truly unlimited and will allow everyone to have access to their documents and media on the go, and even allow powerful computational power to be present in places that could not afford expensive servers, thus making the future a truly connected and better place in which data always available to the masses.

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