Cloud Nine, Are we there yet?

Introduction

In 1961 at the MIT Centennial, John McCarthy opined "if computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility…. the computer utility could become the basis of a new and important industry" [1]. In 2006, Amazon Web Services was launched providing computing on a utility basis. Since that time the notion of cloud computing has been emerging and evolving.

Cloud computing is a paradigm that makes the notion of utility computing a reality. Instead of Information Technology (IT) organizations investing in all of the hardware, software and infrastructure necessary to meet their business needs, cloud computing makes access to hardware, software and infrastructure available through the internet, generally utilizing a pay for use model. Basically cloud computing allows an organization to adopt a different economic model for meeting IT needs by reducing capital investments and increasing operational investments, a model which is likely to offer cost savings to many organizations.

There is still a great deal of hype around cloud computing, as many vendors have their marketing engines further into the clouds then their technology supports. Despite this Gartner predicts that by 2012 one in five businesses will not own its own IT assets. [2]. In late 2010 the Office of Management and Budget (OMB) under direction from the White House told federal agencies that starting in 2012 they are expected to consider cloud first "whenever a secure, reliable, cost-effective cloud option exists." [3]

There are certainly many reasons why an organization would consider moving at least some of their IT functions into the cloud. In addition to potential cost savings the cloud offers the possibility of increased availability, easier collaboration, lower capital costs, scalability and virtualization. There are of course concerns as well. The technology is still relatively immature with no definitive set of standards for interface or compliance with regulations. Businesses lose hands on control of their IT resources with little recourse if their IT vendor shuts down or goes out of business. Additionally, there are security and data privacy concerns. There is also the fact that not all ventures into the cloud will be cost effective for the business.

This paper introduces the concept of cloud computing and discusses the potential benefits for a business as well as those things which could be barriers to adoption. It examines the types of applications where cloud computing is an efficient cost effective solution and the types of applications where its use could be problematic or costly. Several examples of successful cloud implementations are presented and discussed.

Cloud Computing

"Cloud computing embraces cyber-infrastructure and builds upon decades of research in virtualization, distributed computing, grid computing, and more recently networking, web and software services." [4] In other words, although the term cloud computing is relatively new, the concepts and technologies behind cloud computing have been emerging and evolving for some time. Consumers of cloud computing access hardware, software and networking capabilities from third party providers.

So what is "the cloud" anyway? The cloud refers to the resources and applications that are available on the Internet or other network via any device that connects to the internet or other network. The term cloud originates from the diagrams that are often used to portray the reaches and capabilities of the Internet. According to the National Institute of Standards and Technology (NIST), cloud computing delivers five key features; on-demand self-service, ubiquitous network access, location independent resource pooling, rapid elasticity and measured service [8].

Cloud computing providers offer Internet connected servers which house applications and can store data. They also provide needed capabilities such as virtualization, grid management, database, and communications infrastructure. Usage monitoring and billing mechanisms are also required. Through virtualization, multiple customers can access the same piece of physical hardware through separate server instances – allowing them to share hardware resources while isolating their operations and data from one another. The process for scaling and provisioning to meet changing customer demand is usually fully automated through software designed for that purpose. Application Program Interfaces (APIs) or web services provide control and access for the cloud.

There are four types of clouds discussed in the literature. Some consider only public clouds to be cloud computing but there are many instances where cloud computing technology is being applied to other types of clouds as well

- **Public cloud –** Available to any user of the Internet willing to meet the terms and conditions of the cloud service providers. The public cloud is owned by the organizations selling cloud services
- **Private cloud –** Cloud computing infrastructure and technologies are maintained and operated for a specific organization, department or agency. The private cloud is owned by the organization, department or agency that utilizes it. It may be run by them or a 3rd party organization. A private cloud makes sense to bring some cloud computing benefits to an organization that for security or legal reasons cannot have their data in "the cloud"
- **Community cloud –** Cloud infrastructure that is established and maintained where several organizations, departments or agencies have similar concerns, security requirements, or compliance requirements.
- **Hybrid cloud –** There are multiple interpretations for what specifically constitutes a hybrid cloud but it clearly denotes the combined use of multiple types of clouds linked together through unique interfaces to allow organizations to optimize their use of the cloud without exposing themselves to potential risks of a public or community cloud.

In addition to there being various types of clouds, there are also several types of cloud computing offerings described in the literature:

- **Software as a Service** (SaaS) Applications that are accessed via the cloud. End users access commercially available software applications remotely through the internet. Typical examples of SaaS include collaboration, project management, document management, social networking, customer relationship management (CRM) and Human Resource (HR) applications.
- **Infrastructure as a Service** (IaaS) – Computer Infrastructure is accessed via the cloud. Rather than purchasing, provisioning and maintaining servers, data center and network equipment, end users utilize computer infrastructure, generally through a platform virtualization environment, through the Internet. IaaS is usually purchased on a utility computing basis where the user only pays for the resources that they utilize such as processing by the hour or storage by the day. Typical examples of IaaS include backup and recovery, storage, content delivery networks, service management and computation.
- **Platform as a Service** (PaaS) – Development platform is accessed via the cloud. End user has access to the hardware, software and infrastructure necessary to develop or test applications. Typical examples of PaaS include database, development and testing, and business intelligence environments

Benefits

One could easily see the value cloud computing might bring to organizations – particularly small to medium enterprises (SMEs) that may not have the capital to invest in the IT infrastructure that might take their business to the next level. Some benefits will be also be attractive to larger organizations although there may be additional barriers to their adoption.

One oft cited benefit of cloud computing is the cost savings that can be offered to organizations that chose to take advantage of cloud services. Potential cost savings come from several sources. Certainly an organization can expect to save money on both hardware and software. As less hardware is being used, maintenance costs on existing hardware will reduce and less new hardware will be acquired. Software license and maintenance fees will be eliminated. These benefits are particularly important in organizations where needs for hardware and/or software peak and ebb over time. Instead of resourcing to peak needs, they have the opportunity of only paying for what they actually use. This will not only offer savings for hardware and software but also has the potential to reduce an organizations need for space, power consumption and IT staff. According to James Staten of Forrester, "Most enterprise data centers are using less than 50 percent of the total capacity of their resources."[5]

Because cloud technology provides for automatic or near automatic scaling and provisioning, the cloud can add agility to an organization as their needs for IT change. Reliability and availability may be significantly improved because large, well established cloud providers have equipment and redundancy built into their offerings. Dynamic provisioning makes it possible for cloud providers to offer Infrastructure on Demand (IOD). Portability is increased because IT resources are no longer tied to a location, data and applications are available wherever the Internet is available

Cloud providers and consumers benefit from the fact that software is located in one central location. Updates and repairs are accomplished easily and can be delivered to all clients as soon as they are available with no installation dramas on the end user's side.

Finally, if all of the worlds computing can be done with fewer servers running at any given time, the world benefits through a reduced carbon footprint. A study recently conducted by Microsoft, Accenture and WSP Environment and Energy found that for large deployments (10,000 users) energy use and carbon emissions could be reduced by more than 30% while for small deployments (100 users) the improvement could be as much as 90%.[6]

Risks and Challenges

Clearly there are many reasons an organization might consider transcending to the clouds. There are of course also reasons that the cloud may not be the right option for every organization or for every type of application,

Security is a key concern of many potential cloud customers. Certain organizations and agencies may never be comfortable with housing specific categories of data outside of their own walls. Additional, organizations, agencies and/or governments may have regulations as to physical locations where certain types of data are allowed to be stored. Data stored in the cloud could be anywhere. The good news is that security concerns in the cloud are being proactively addressed by the federal government in anticipation of the cloud first initiative mentioned earlier. In 2009 the GSA's cloud office established working groups on both security and standards and in 2010 they launched a government wide security certification and accreditation process for solutions in the cloud. Lockheed Martin conducted a survey in 2010 where they found that the more people know about the cloud, the less concerned they are with security in the cloud. [7]

Some have cited reliability as a concern. This may seem contradictory to the availability benefit noted earlier, but surely not all cloud providers have the same level of redundancy built into their systems. Additionally, cloud providers tend to co-locate their servers in one or few locations – taking advantage of favorable real estate and power costs- so a major power outage could have a significant effect on service availability.

There are instances where cloud computing may not be a cost effective solution, especially for organizations with large amounts of data and intensive data processing requirements. Potential cost savings could be overshadowed by the cost associated with the high bandwidth required to process all that data.

Another risk to consider when evaluating cloud based solutions has to do with the loss of control that occurs when you opt for the cloud. There are several aspects of this loss of control to think about. IT staff lose a level of control because they are no longer free to design platforms for specific business needs and they can't change technology on a whim. Another concern relates to the portability of cloud based solutions. Because of the relative immaturity of the technology, standards have yet to be established and cloud APIs are proprietary. If a cloud provider were to go out of business, or if the

service they deliver deteriorates, there may be no quick exit strategy for customers who need to switch to another cloud provider.

Cost Drivers

As previously mentioned, one potential benefit of cloud computing is cost savings. And there is compelling evidence that migration to the cloud is definitely worth it for many computing needs of many organizations and agencies. When evaluating cloud solutions it is important to look at the cost of migration as well as the costs of operation once transition to the cloud is complete. What follows are some factors to consider when evaluating potential migrations to the cloud.

Clearly, the complexity of the migration is a significant factor in its overall cost. Complex migrations take more time and effort than simple ones. The nature of the capabilities being migrated as well as the volume of data involved in the migration will significantly impact the cost of transition to the cloud

Cost benefit is realized when equipment can be eliminated. Cloud solutions that result in an organizations elimination of servers and other equipment will realize more cost benefit. The more capacity that is moved to the cloud, the more an organization can lower their maintenance, acquisition and IT staff costs – increasing the cost benefit of cloud migration.

Another factor is the efficiency of the organization's current operation. If an organization has already achieved high utilization of their resources through optimization, load balancing or constant high volume operations, they may find less benefit than an organization that resources for peak but normally operates way below peak.

The type of cloud involved may drive cost as well. The potential for cost savings is greatest with the public cloud because there are many customers using the same resources allowing providers to pass savings along to their customers. Community and private clouds have more limited audiences, making them likely to be more expensive per user. Clearly the extent of a private or community cloud can influence the amount of cost savings they can offer to end users.

Requirements for security can also drive costs of cloud migration and on-going operation. Storage and transmission of secure data requires both digital and physical safe guards which naturally come with a price.

Additionally, there are organizational and cultural considerations when migrating to the cloud. Marketing, training and education are important when introducing any new tool or process to an organization in order to combat cultural resistance. New policies, standards and software license agreements (SLAs) may need to be developed, deployed and implemented.

Examples and Findings

While there are many reasons for organizations to consider the cloud, there are also many factors to evaluate before making the leap. It seems that the cloud offers huge potential benefits for smaller

organization while larger organizations and government agencies are likely to find that some hybrid solution combining public and private cloud concepts will be their best option.

In light of the cloud first directive, several agencies of the US Federal government have already begun to deploy solutions in the clouds with some relatively impressive successes. By targeting capabilities that are currently expensive or inefficient and well suited to the cloud is a good strategy for cloud migration. A few examples follow:

Los Alamos National Laboratories wanted to roll out an infrastructure on demand architecture to facilitate quick rollout of new projects and eliminate other delays. Because of the nature of their work, security was a significant concern so they decided to go with a private cloud. They created a cloud using Microsoft© SharePoint for cloud workflows and integration point, VMware vCloud Director to manage and operate the cloud, and VMware vShield to provide security. With this architecture they have been able to provision a server, an activity that used to take 30 days, in under 30 minutes. As they are now using virtualization, they have been able to eliminate physical hardware reducing maintenance costs, power and electronic waste. According to Anil Karemel, IT Manager at Los Alamos, they expect their eventual savings to be $1.3 million annually. No data was available on the cost of the migration. [9]

The Defense Information Systems Agency, recognized that implementation of new software and systems at the DoD was expensive, time consuming and was being conducted in an environment less than conducive to cross collaborate and ubiquitous delivery. To address this, DISA created Forge.mil which provides tools and services for rapid development, testing and deployment of software to the entire DoD. Cloud provider CollabNet provides a software development platform that facilitates reuse and collaboration for Forge.mil's 5000 users. DISA estimates that Forge.mil saves between $200,000 and $500,000 per project.

The US Federal Government's website, USA.gov provides users with information about benefits, grants, jobs, taxes, health, voting, technology, and other information useful to the citizenry. Naturally access to USA.gov varies dramatically as conditions in the country and the world change with spikes in traffic around natural disasters, national elections, etc. The General Services Administration decided to move USA.gov to the Terremark's Enterprise Cloud service. In doing this they found that site upgrade time went from nine months to one day and monthly down time moved from two hours to near zero. The cost to operate the legacy USA.gov operations was $2.35 million annually plus personnel costs of $350,000. The move to the cloud resulted in a total annual cost of $650,000 resulting in a 72% cost savings

More examples of federal migrations to the cloud can be found in [10].

Conclusions

The cloud computing paradigm offers organizations and federal agencies an alternative to meeting all their IT needs with in-house resources. Cloud computing consumers use the Internet (or other network) to run applications and store data on servers that could be anywhere in the world. The ability to access

computing power on a utility basis offers the consumer the opportunity to save costs since costs are shared among all of provider's users. It also allows them to reduce or remove internally acquired and maintained software and hardware – reducing costs for acquisition, maintenance and potentially IT staff. Cloud servers are generally utilized at a much higher utilization than in house computers because they are shared by so many users, increasing the productivity of the cloud providers and eliminating waste on the users side. Cloud computing providers offer virtualization and provisioning capabilities that may increase significantly the efficiencies with which solutions are available to the end user.

While there are many benefits to cloud computing, there are concerns as well. Security continues to be an issue, driving some organizations to less cost effective private clouds. There are also risks associated with the fact that the technology is still immature and the APIs being used are proprietary, making portability between providers problematic. End users must be able to deal with some loss of control of their IT environment.

The US Federal government agencies have been challenged by the OMB and President Obama to start thinking "cloud first" whenever and wherever it makes sense. And many federal agencies have already started to address that challenge with noticeable improvements in cost and productivity. While there is still immaturity and imperfections in the cloud solutions that are available, there is definitely reason to believe that cloud computing can help both industry and the government do more with less.

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