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Successful Introduction of Cloud Computing into your Organization: A Six-Step Conceptual Model

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ABSTRACT

Cloud computing is the fastest area of application within the information systems field. The adoption of cloud computing by businesses, government agencies, and academic institutions is on the rise. Cloud computing platforms could reduce cost, offer scale, and increase information systems responsiveness for those companies that are adopting it properly. However, still many decision makers do not really know what exactly cloud computing is, its unique capabilities, and how it may increase the efficiency and effectiveness of IT services. Also cloud computing may mean different things to different people. This paper first examines different applications within the cloud computing domain and then explores the existing applications, trends, opportunities, and challenges in cloud computing environment and presents a series of guidelines summarized under a six step conceptual model. Managers and IT personnel should benefit from following these steps by being able to choose the right application for their organizations and be able to minimize the security and privacy concerns associated with the introduction of this fast growing technology.

LITERATURE SURVEY: THE LANDSCAPE OF CLOUD COMPUTING

A recent survey on the status, applications, versatilities, popularities, and opportunities gained by using cloud computing platforms reveals interesting facts as follows:

Many banks including ING are testing cloud computing for integrating it into their operations. In a survey of 186 banking technology professionals interested in cloud computing 73 percent of the participants indicated that cloud computing will enable them to meet user demands quickly and achieve scale (Crosman, 2010). Morgan Stanley is another major bank that is planning to integrate cloud computing into its operations. However, security and privacy in cloud computing are among the major concerns (Cohen, 2008).

Department of Defense (DoD) is exploring the use of cloud computing in one of the following four categories (Anonymous, 2010):

- Use commercially provided cloud services
- Deploy cloud computing within DoD networks
- Develop a multi-agency cloud computing network for data processing and storage
- Develop a combined DoD/commercial provider system

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Key decision makers believe cloud computing will provide greater agility and flexibility for the DoD, today and in the future. Cloud computing will also increase efficiencies and incur marked cost savings during their life-cycles to alleviate some of the pressure of budget reductions. Once again, security and privacy are major concerns for this deployment (Forbes, 2011, Anonymous, 2011). In addition, experts believe that, the department of defense could run more effectively using cloud technologies. DoD could become a model and show other large organizations how cloud computing applications could be used (Linthicum, 2010d).

According to experts it makes no sense for smaller enterprises to operate their own data centers. Cloud computing will be both cost effective and also environmentally safer and cleaner for such organizations (Krill, 2010). Cloud computing platforms clearly support the growing phenomenal of green computing and could help organization to achieve their "green" goals.

An executive at global consultancy CSC predicts that half of all IT workloads will become cloud services by 2016 (Knorr, 2011).

Despite millisecond delays cross-ocean cloud applications are gaining in popularity because of major cost saving and other advantages (Thibodeau, 2011c).

President Barack Obama relies heavily on cloud computing and data center consolidation to keep IT costs under control (Thibodeau, 2011b). The Obama administration aims to cut costs by embracing the cloud in place of in-house, proprietary technology (Samson, 2010).

A report published in Techland.time.com in February 2011 indicates that YouTube uses cloud computing infrastructure to split video processing between "hundreds of thousands of machines," allowing them to process video seven times faster than in 2008 (and even four times faster than just six months ago) (McMillan, 2011).

Tata Communications will offer cloud computing that includes services for computing, data transfer, and storage (Ribeiro, 2010).

Joining Microsoft, Oracle, Google and others, IBM plans to offer a cloud-based office suite (Jackson, 2011). IBM also puts Notes and collaboration in the cloud (Knorr, 2010).

China is building a city-sized cloud computing and office complex that will include a mega data center. Cloud computing is among the projects supporting that country's double-digit growth in IT spending (Thibodeau, 2011a).

BACKGROUND

As reviewed in the previous section, cloud computing is one of the fastest area of application within the information systems field. Most computer and networking companies are trying to either enter into this area or increase their existing market share. Even during the economic down turn, cloud computing related jobs have been in high demand (Linthicum, 2010b). Some experts believe that cloud computing could save the economy. In a survey conducted by CRN, 68 percent of the respondents indicated that cloud computing will help their businesses recover from the recession. More than 600 IT and business decision

makers in the United States, the United Kingdom, and Singapore participated in the survey (Linthicum, 2010c).

The adoption of cloud computing by businesses and academic institutions is on the rise. Cloud computing platforms could reduce cost and increase the information systems responsiveness for those companies that are properly adopting it. Table 1 summarizes the advantages of cloud computing (Brodkin, 2010).

Table 1: Advantages of Cloud Computing.

Reduced cost	Cloud computing cost is paid incrementally, saving organizations money. Also because the software development cost is divided among many participants, it is generally cheaper than traditional computing methods.
Increased storage	Organizations can store more data than on private computer systems and storage can grow as the organization grows.
Highly automated	No longer do IT personnel need to worry about keeping software up to date. The "what version of the software do I need" syndrome is eliminated.
Flexibility	Cloud computing offers much more flexibility than traditional computing methods. It can offer vertical as well as horizontal flexibility.
More mobility	Employees can access information wherever they are, rather than having to remain at their desks. It offers a true portability for both data and application.
Allows IT to shift focus	No longer having to worry about constant server updates and other computing issues, the adopting organization will be free to concentrate on innovation and growing the business. Mission critical applications become the main focus.

The ROI, total cost of ownership, and payback period for cloud computing have been explored by several studies and experts (Skilton, 2010a, Skilton, 2010b, Hinchcliffe, 2009). Some experts believe that cloud computing may not be initially cost justified (Linthicum, 2011b). However most studies have concluded that cloud computing is cost justified and if it is property implemented it offers a very high ROI. One such study was conducted by IBM Research. According to this study the many benefits of cloud computing amply and quickly justify that investment. IBM has identified cost saving in the following five categories: hardware, software, productivity improvements, automated provisioning, and system administration (IBM Research, 2009)

The following two case studies set the stage for our presentation:

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Case 1: Cloud Computing in Action.

Jeff Bezos, the founder of Amazon.com, says, "You don't generate your own electricity. Why generate your own computing?" (Mcfedries, 2008). Amazon.com has established a computing platform that companies can use, regardless of their location. This platform provides storage and processing power on demand, and companies pay only for the resources they use. By using this service, companies don't have to invest in technology that might become obsolete quickly (Dignan, 2008). With decreasing prices and better offerings, Amazon.com has become a major cloud infrastructure provider (Linthicum, 2011a). Google Apps, a cloud platform, introduced in February 2007, is competing with Microsoft's Office suite, and many companies use it now, including universities such as Arizona State University and Northwestern University (Brodkin, 2009).

Case 2: Cloud Computing in Action.

Queensland University of Technology in Australia implemented cloud computing to provide enterprise software to more than 140 universities in the Asia Pacific. According to Glenn Stewart, Professor of Information Systems, a cloud computing platform not only has reduced cost it has also provided greater reliability and scalability. Professor Stewart is in charge of the SAP University Competence Centre (UCC), which provides the SAP suite of business software to over 800 academics and 42,000 students from 140 universities in the Asia Pacific and Japan. If a university chooses to run this suite of software without the help of UCC it has to invest in hardware, software, backup facilities, and so forth. The upfront investment would be over $300,000, which is a major undertaking for any university. By migrating the services into a private cloud, each university pays $6,760 for that same package, which is more than a 74% reduction in cost (Ng, 2010).

However, many organizations do not follow a systematic approach before adopting this technology, and to be able to better understand the many opportunities and challenges that this fast growing platform offers. This paper presents a series of guidelines summarized under a six step conceptual model that if followed should increase the chances of success when introducing cloud computing into your organization (see Figure 1). These steps provide managerial literacy as well as checklists that organizations could use before introducing this technology into their organizations. The steps include: (1) understanding grid computing, (2) understanding application service providers, (3) understanding utility (on-demand) computing, (4) understanding the components of a cloud platform, (5) understanding the security issues in cloud computing, and (6) preparing a cloud computing plan for implementation.

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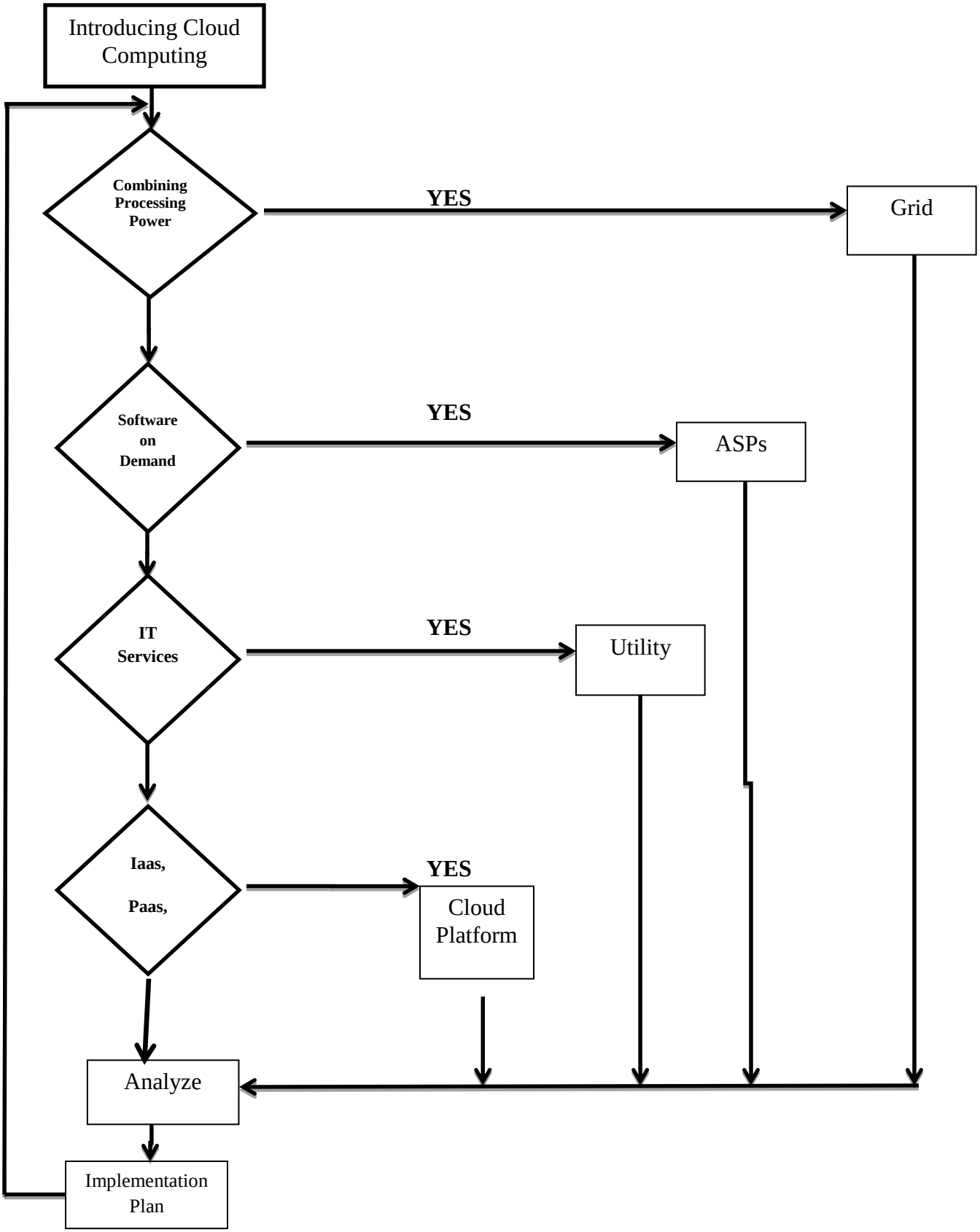
Figure 1: A Six-Step Conceptual Model.



Step-1: Understanding Grid Computing

Grid computing involves connecting all the different computers combining their processing power to solve a particular problem. With this configuration, users can make use of other computers' resources to solve problems involving large-scale, complex calculations, such as circuit analysis or mechanical design, that a single computer is not capable of solving. Each participant in a grid is referred to as a "node." Cost savings is a major advantage of grid computing because companies don't have to purchase additional equipment. In addition, processing on overused nodes can be switched to idle servers and even desktop systems. Grid computing has already been used in bioinformatics, oil and gas drilling, and financial applications. Other advantages of grid computing include the following:

- Improved reliability—If one node in the grid fails, another node can take over.
- Parallel processing nature—Complex tasks can be performed in parallel, which improves performance. In other words, a large complex task can be split into smaller tasks that run simultaneously on several nodes.
- Scalability—If needed, more nodes can be added for additional computing power without affecting the network's operation. Upgrades can also be managed by segmenting the grid and performing the upgrade in stages without any major effect on the grid's performance

.

Grid computing does have some drawbacks, however. Some applications cannot be spread among nodes, so they are not suitable for grid computing, and applications requiring extensive memory that a single node cannot provide cannot be used on a grid. In addition, licensing agreements can be challenging, synchronizing operations in several different network domains can be difficult, and require sophisticated network management tools. Finally, some organizations are resistant to sharing resources, even if doing so benefits them.

After examining the pros, cons, and capabilities of grid computing, an organization should decide if this platform is suitable for its needs. If the answer is "yes", then the decision maker should go to steps 5 and 6 as shown in Figure 1. If the answer is "no" then step 2 should be examined.

Step-2: Understanding Application Service Providers

Internet service providers (ISPs) provide access to the Internet for a fee. A more recent business model called application service providers (ASPs) provide access to software or services for a fee. Software as a service (SaaS), or on-demand software, is a model for ASPs to deliver software to users for a fee; the software might be for temporary or long-term use. With this delivery model, users do not need to be concerned with new software versions and compatibility problems because the ASP offers the most recent version of the software. Users can also save all application data on the ASP's server so that the software and data are portable. This flexibility is convenient for those who travel or work in different locations, but it can also create privacy and security issues. Saving data on the ASPs' servers instead of users' own workstations might leave this data more exposed to theft or corruption by attackers (Bidgoli, 2010).

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Here is a simple example of how SaaS might work: say you want to edit a document, TEST.doc, and you need word-processing software for this task. With SaaS, you do not need the software installed on your computer. You simply access it from the SaaS provider site. You can then run the software from the provider's server (and not take up your computing resources) or on your computer. The location of the TEST.doc file does not matter. You make use of the provider's SaaS service to edit the document, which stays on your hard drive (or wherever you had it stored—a flash drive, for example). The word-processing application is not stored on your computer, so the next time you access the word-processing software from the provider's SaaS site you might get a newer version of the word-processing software. SaaS deals only with software, not with data and document storage or with hardware resources, such as processing power and memory. The SaaS model can take several forms, such as the following:

- Software services for general use, such as office suite packages
- Offering a specific service, such as credit card processing
- Offering a service in a vertical market, such as software solutions for doctors, accountants, and attorneys

Generally, the advantages of outsourcing, such as being less expensive and delivering information more quickly, apply to the ASP model, too. However, ASPs have some specific advantages, including the following:

- The customer does not need to be concerned about whether software is current.
- IS personnel time is freed up to focus on applications, such as customer relationship management and financial information systems, which are more important strategically to the organization.
- Software development costs are spread over several customers, so vendors can absorb some expenses of software development and develop more improved software.
- Software is kept up to date, based on users' request.
- The ASP contract guarantees a certain level of technical support.
- An organization's software costs can be reduced to a predictable monthly fee.

Some disadvantages of ASPs are as follows:

- Generally, users must accept applications as provided by ASPs; they are not customized for users' needs.
- Because the organization has less control over how applications are developed, there is the risk that applications might not fully meet the organization's needs.

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- Integration with the customer's other applications and systems might be challenging.

Google, NetSuite, Inc., and Salesforce.com are three companies that offer software as a service. Google Apps (*www.google.com/apps*) is a service from Google with several Google products. It features several Web applications with similar functionality to traditional office suites, including: Gmail, Google Calendar, Talk, Docs, and Sites. The standard edition is free. In addition, Basecamp (*basecamphq.com*) and Mint.com (*www.mint.com*) also offer SaaS. Basecamp is a web-based project collaboration tool that allows users to share files, meet deadlines, assign tasks, and receive feedback. Mint.com is a free web-based personal financial management service. SaaS is also common for human resources applications and has been used in ERP systems with vendors such as Workday (*www.workday.com*).

After examining the pros, cons, and capabilities of ASPs, an organization should decide if this platform is suitable for its needs. If the answer is "yes", then the decision maker should go to steps 5 and 6 as shown in Figure 1. If the answer is "no" then step 3 should be examined.

Step-3: Understanding Utility (On-Demand) Computing

Utility (on-demand) computing is similar to the SaaS model and provides IT services on demand. Users pay for computing or storage resources on an as-needed basis, similar to paying for utilities. Convenience and cost savings are two main advantages of utility computing, but this service does have drawbacks in the areas of privacy and security. Because the service is outside the company's location, theft or corruption of data is a concern.

Utility computing can work with the SaaS discussed earlier. Returning to the example of editing a Word document, suppose the TEST.doc file is very large because it contains a lot of images. You notice that your computer is running slowly because it has an older CPU and does not have enough RAM to handle the file size adequately. With utility computing, you can request computing power and memory from the provider. It is like leasing a more powerful computer just for the period you need it. So to compare utility computing with SaaS, utility computing handles hardware resources, such as CPU processing and memory, not software.

Utility computing has been available at universities and research centers that need to run complex programs and do not have the necessary resources. For example, NASA has offered to lease its supercomputer for a fee, which ensures the supercomputer is being used and adds income for NASA. Other organizations, such as Sun Microsystems (a part of Oracle now) and IBM, offer this service in the form of storage and virtual servers. Some companies offer virtual data centers with services that enable users to combine memory, storage, and computing capabilities. Liquid Computing's LiquidIQ is one example (*www.liquidcomputing.com*). Enki (*www.enkiconsulting.net*), Joyent (*www.joyent.com*), and Layered Technologies (*www.layeredtech.com*) are other vendors.

After examining the pros, cons, and capabilities of utility computing, an organization should decide if this platform is suitable for its needs. If the answer is "yes", then the decision maker should go to steps 5 and 6 as shown in Figure 1. If the answer is "no" then step 4 should be examined.

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Step-4: Understanding the Components of a Cloud Platform

Cloud computing is a platform incorporating many recent technologies under one platform, including the SaaS model, Web 2.0, grid computing, and utility computing, so that a variety of resources can be provided to users over the Internet. Business applications are accessed via a Web browser, and data is stored on the providers' servers (Knorr & Gruman, 2008). In addition, cloud providers, such as Amazon, set up an environment that enables the user to subscribe to SaaS, utility, grid, and other services the user needs and coordinates all these services for the user.

Nearly all tech vendors are involved in cloud computing. BTC Logic, an IT consulting firm, has classified seven areas within cloud computing and has identified some of the top players in each category. The summary is provided in Table 2 (Brodkin, 2010).

Table 2: Major Categories and Players in Cloud Computing.

Cloud Categories	**Cloud Players**
Foundations (tools and software that make it possible to build cloud infrastructure)	VMware, Microsoft, Red Hat
Infrastructure	Amazon
Network Services (the communication components that combine with cloud foundation and infrastructure to form cloud architecture)	Amazon, Level 3 Computing Services ,Cisco, Citrix
Platforms	Amazon, IBM
Applications	Google, Salesforce.com, Oracle, DROPBOX
Security	EMC/RSA , Symantec, IBM
Management	Amazon, IBM

Going back to the example of editing the TEST.doc file, say you are using your iPhone instead of your computer. Clearly, your iPhone doesn't have the storage space to save such a large file, and it does not have the necessary computing power or Word installed. With cloud computing, you can subscribe to Word at the provider's SaaS site, store the document on an external storage unit provided by the vendor, and run Word on a multiprocessor system the vendor provides. You might even get extra RAM from another computer available in the cloud, and the cloud provider coordinates all these tasks for you. Your iPhone is simply the device for viewing the document while you are editing it, and because it is a mobile device, you can do your work anywhere. In other words, the document, the software, and the computing resources are like a cloud that

surrounds you wherever you go and is available whenever you need it. Generally, cloud computing includes components in the form of infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS).

Cloud computing offers many of the advantages and disadvantages of distributed computing. With this platform, users can request services, applications, and storage. For small and medium businesses, it means they do not have to invest in expensive equipment to compete effectively with large companies and can concentrate on the services and products they provide. Cloud computing services typically require a fee, although some are free. Google Apps, which includes Gmail, Google Talk, and Google Docs, provides commonly used applications accessed via a Web browser; software and data are stored on Google's servers, not on the user's computer. The standard edition for personal use is free (Knorr & Gruman, 2008).

Step-5: Understanding the Security Issues in Cloud Computing

Security, privacy, spam, and mobile computing issues, acceptance, and vulnerabilities of all network-based systems have been addressed by several studies (Bidgoli, 2003; Lu et al., 2005; Marchewka et al., 2003; Ryker et al., 2005).

Most experts believe that security and privacy could be particularly a concern when using a cloud computing platform and users play an important role in its success. In any case some degree of trust must exists between the user and the provider for a successful implementation of cloud computing. The organization that uses cloud computing should provide end-user education, force software updates, and work with the cloud computing provider in order to spot unusual activities (Knorr & Gruman, 2008).

In a cloud computing environment there are two types of security issues: The client side (the user) and the server side (the provider). The organization that uses the cloud services basically does not have much control over the security issues of the server side. The provider of the cloud services is responsible for that. However, the client side security is the responsibility of the organization that uses cloud services. Table 3 lists common client-side threats. Table 4 lists important client-side security measures.

Table 3: Common client-side threats.

Viruses
Worms
Trojan programs
Logic bombs
Backdoors
Blended threats (e.g., worm launched by Trojan)
Rootkits
Denial-of-service attacks
Social engineering

Table 4: Important client-side security measures.

Biometric security measures
Nonbiometric security measures (firewalls and intrusion detection systems)
Physical security measures
Access controls
Virtual private networks
Data encryption
E-commerce transaction security measures

The mobile users in particular play an important role in improving the security of cloud computing environment. Mobile users increasingly use smart phones and tablet computers such as iPad/ iPad 2 to access various applications from the servers of the cloud providers. One popular application is Chatter from Saleforece.com. Chatter is a social networking and collaborative application that works with Sales Cloud. All users of Salesforce can access Chatter for no additional cost. Similar to Facebook Pages, Chatter enables groups to collaborate on projects, share information and documents, and control the privacy so that information is only shown to appropriate team members.

Generally speaking mobile devices pose additional threats to the network security because anyone walking or driving within the range of an AP (even outside of homes and offices) could connect and use the network (Bidgoli, 2011). An AP (access point) is a part of a wireless LAN (WLAN) that connects the WLAN to other networks. Finding WLANs is an easy task. A user can walk or drive around different office buildings or homes with a WLAN-equipped computer and see if it can pick up a signal. There are free software tools available on the Internet that can teach you more about the network that was just broken into. Wireless signals can also be intercepted and they are susceptible to DoS attacks similar to wired networks.

There are several techniques that could improve the security of wireless networks and mobile devices in a cloud environment as follows:

Using SSID (Service Set Identifier) - This technique requires all client computers that try to access the AP to include a SSID in all of their packets, a packet without a SSID will not be processed by the AP. The major weakness of using SSID is that it can be picked up by other devices in the range with the right software.

1. Using WEP (Wired Equivalent Privacy) - This technique uses a key that must be manually entered into AP and the client computer. This key encrypts the message before transmission. Because of the manual process this technique is not suitable for large networks as the key management becomes a complex and time consuming task.

2. Using EAP (Extensible Authentication Protocol) - This technique dynamically generates the WEP keys based on the user's ID and password. When the user logs out of the system the key is discarded. A new key will be generated when the user logs back into the network.

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3. Using WPA (Wi-Fi Protected Access) - This technique combines the strong features of WEP and EAP. Keys can be fixed such as in WEP or dynamically changed as is in EAP. However, the WPA key is longer than the WEP key; therefore it is more difficult to break. Additionally, the key is changed for every frame (a distinct and identifiable data set) before transmission.

4. Using WPA2 or 802.11i - This technique uses EAP to obtain a master key. With this master key a user's computer and the AP negotiates for a key that will be used for a session. After the session termination the key is discarded. This technique uses Advanced Encryption Standard, which is more complex than WPA and much harder to break.

Step-6: Preparing a Cloud Computing Plan for Implementation

Now that various options within the clod computing domain have been analyzed and security issues and measures have been addressed, then the organization is ready to prepare an implementation plan. An organization's employees are an essential part of the success of any cloud computing initiatives, so training and education on strengths and weaknesses of this platform and security awareness and security measures are important. Some organizations use a classroom setting for training, and others conduct it over the organization's intranet. Tests and certificates should be given to participants at the end of training sessions. In addition, making sure management supports the training program is important to help promote the adoption of this new technology throughout the organization. The following steps should be considered when developing a cloud computing implementation plan (Bidgoli, 2008):

1. Set up a cloud computing committee with representatives from all departments as well as upper management. The committee's responsibilities include the following:

    - Developing a clear, detailed cloud computing acquisition and use plan
    - Providing cloud computing awareness for key decision makers and users
    - Conducting a basic cost/benefit analysis and calculating an ROI for the cloud computing acquisition
    - Overseeing enforcement of the cloud computing policy

2. Define the organization's needs. A clear definition of needs will assist the organization to decide on the following:

    - Does the organization need grid computing?
    - Does the organization need SaaS?
    - Does the organization need utility (on-demand) computing?

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- Does the organization need a full featured cloud platform?

3. Force software updates and work with the cloud computing provider (s) in order to spot unusual activities.

4. Examine the providers of cloud platforms (see Table 2) and match their offerings against your needs, not all vendors are equal. Choose the provider (s) whose offerings are the closest to your needs.

5. Post the security policy in a visible place, or post copies next to all workstations.

6. Raise employees' awareness of security problems in a cloud environment.

7. Revoke terminated employees' passwords immediately to prevent attempts for retaliation.

8. Exit programs and systems promptly and never leave logged-on workstations unattended.

9. Limit computer access to authorized personnel only.

10. Examine security threats outlined in Table 3 and offer countermeasures outlined in Table 4.

11. Examine wireless security threats and implement measures outlined in the paper.

CONCLUSION

This paper first provided a comprehensive literature review in order to highlight the potential opportunities and challenges in cloud computing environment. Secondly, it examined different applications within the cloud computing domain in order to provide a general understanding of different cloud options. Thirdly, the paper presented a series of guidelines summarized under a six step conceptual model for cloud computing acquisition and implementation. The guidelines and steps presented should offer the following benefits to key decision makers interested in cloud computing deployment in their organizations:

1. Should assist an organization to decide on the type of cloud that would be the most beneficial to a particular situation. For example, should the organization choose grid computing, ASPs, utility computing, or a full featured cloud platform?

2. The organization will know the justification for ROI that will come from hardware, software, productivity improvements, automated provisioning, and system administration.

3. The organization will know the security and privacy issues in the cloud environment and will know how to guard against these issues.

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4. The organization will be able to follow the implementation plan presented in the paper as a guide and checklist.

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