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Advantages and challenges of adopting cloud computing from an enterprise perspective

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Abstract

With the rapid development of processing and storage technologies and the success of the Internet, computing resources have become cheaper, more powerful and more available than ever before. This technological trend has enabled the realization of a new computing model called cloud computing, in which resources are provided as general utilities that can be leased and released by users through the Internet in an on-demand fashion. The organizations are gaining more experience in the cloud and they start to shift more core business functions onto cloud platforms. Because of this fact, we are seeing that cloud adoption is significantly more complex than we imagined initially, particularly in terms of data management, system integration and the management of multiple cloud providers. Cloud computing is of growing interest to companies around the globe, but many are finding greater costs and greater obstacles to the adoption of cloud computing than they anticipated. In this case, is cloud computing still able to deliver all the promises?

In this paper we will analyze from a company's point of view the factors that need to be considered by an enterprise when making the decision of using cloud computing. Some of the companies are moving towards cloud computing just because it is the latest trend in information technology. On the other hand, other companies cannot even take into consideration the idea of having their sensitive data outside their premises. Both of these cases represent companies that are just not very well informed. We are not sustaining that cloud computing is a perfect solution for everybody, but adopting it or not should be result of a very well informed analysis. We will analyze the positive and negative aspects of each of the following factors: integration with existing IT infrastructure and existing software, costs, return on investment, performances, security. Also, we will correlate all these factors with the company size and business area in order to identify if or what type of cloud computing solution is suitable for their needs.

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1. Introduction

Cloud computing has recently emerged as a new paradigm for hosting and delivering services over the Internet. Cloud computing is attractive to business owners as it eliminates the requirement for users to plan ahead for provisioning, and allows enterprises to start from the small and increase resources only when there is a rise in service demand. However, despite the fact that cloud computing offers huge opportunities to the IT industry, the development of cloud computing technology is currently at its infancy, with many issues still to be addressed.

The emergence of the phenomenon commonly known as cloud computing represents a fundamental change in the way information technology (IT) services are invented, developed, deployed, scaled, updated, maintained and paid for. Computing as we know today reflects a paradox — on one hand, computers continue to become exponentially more powerful [1] and the per-unit cost of computing continues to fall rapidly, so much so that computing power per se is nowadays considered to be largely a commodity[2]. On the other hand, as computing becomes more pervasive within the organization, the increasing complexity of managing the whole infrastructure of disparate information architectures and distributed data and software has made computing more expensive than ever before to an organization [3].

The promise of cloud computing is to deliver all the functionality of existing information technology services even as it dramatically reduces the upfront costs of computing that deter many organizations from deploying many cutting-edge IT services [4]. All such promise has led to lofty expectations — Gartner Research expects cloud computing to be a $150 billion business by 2014, and according to AMI partners, small and medium businesses are expected to spend over $100 billion on cloud computing by 2014.

The impetus for change right now is seen predominantly from a costs perspective (even though, as we discuss later in the document, the promises from a technological functionality perspective are equally attractive), as organizations increasingly discover that their substantial capital investments in information technology are often grossly underutilized [5].

2. What is cloud computing?

Cloud computing represents a convergence of two major trends in information technology — (a) IT efficiency, whereby the power of modern computers is utilized more efficiently through highly scalable hardware and software resources and (b) business agility, whereby IT can be used as a competitive tool through rapid deployment, parallel batch processing, use of compute-intensive business analytics and mobile interactive applications that respond in real time to user requirements [6].

Many practitioners in the commercial and academic spheres have attempted to define exactly what "cloud computing" is and what unique characteristics it presents. Buyya has defined it as follows: "Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements (SLA) established through negotiation between the service provider and consumers" [7].

Vaquero has stated "clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized Service Level Agreements"[8]. A recent McKinsey and Co. report claims that "Clouds are hardware based services offering compute, network, and storage capacity where: Hardware management is highly abstracted from the buyer, buyers incur infrastructure costs as variable OPEX, and infrastructure capacity is highly elastic" [9].

A report from the University of California Berkeley summarized the key characteristics of cloud computing as: "(1) the illusion of infinite computing resources; (2) the elimination of an up-front commitment by cloud users; and (3) the ability to pay for use . . . as needed . . ."[10]. The National Institute of Standards and Technology (NIST) characterizes cloud computing as ". . . a pay-per-use model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." [11]

While there are countless other definitions, there seems to be common characteristics between the most notable ones listed above, which a cloud should have: (i) pay-per-use (no on-going commitment, utility prices); (ii) elastic capacity and the illusion of infinite resources; (iii) self-service interface; and (iv) resources that are abstracted or virtualized. In addition to raw computing and storage, cloud computing providers usually offer a broad range of software services. They also include APIs and development tools that allow developers to build seamlessly scalable applications upon their services. The ultimate goal is allowing customers to run their everyday IT infrastructure "in the cloud".

Cloud computing isn't so much a technology as it is the combination of many pre-existing technologies. These technologies have matured at different rates and in different contexts, and were not designed as a coherent whole; however, they have come together to create a technical ecosystem for cloud computing. New advances in processors, virtualization technology, disk storage, broadband Internet connection, and fast, inexpensive servers have combined to make the cloud a more compelling solution.

3. Advantages of cloud computing

Specifically, cloud computing offers the following key advantages:

- It dramatically lowers the cost of entry for smaller firms trying to benefit from compute-intensive business analytics that were hither to available only to the largest of corporations. These computational exercises typically involve large amounts of computing power for relatively short amounts of time, and cloud computing makes such dynamic provisioning of resources possible. Cloud computing also represents a huge opportunity to many third-world countries that have been so far left behind in the IT revolution — as we discuss later, some cloud computing providers are using the advantages of a cloud platform to enable IT services in countries that would have traditionally lacked the resources for widespread deployment of IT services.
- It can provide an almost immediate access to hardware resources, with no upfront capital investments for users, leading to a faster time to market in many businesses. Treating IT as an operational expense (in industry-speak, employing an 'Op-ex' as opposed to a 'Cap-ex' model) also helps in dramatically reducing the upfront costs in corporate computing. For example, many of the promising new Internet startups like 37 Signals, Jungle Disk, Gigavox, SmugMug and others were realized with investments in information technology that are orders of magnitude lesser than that required just a few years ago. The cloud becomes an adaptive infrastructure that can be shared by different end users, each of whom might use it in very different ways. The users are completely separated from each other, and the flexibility of the infrastructure allows for computing loads to be balanced on the fly as more users join the system (the process of setting up the infrastructure has become so standardized that adding computing capacity has become almost as simple as adding building blocks to an existing grid). The beauty of the arrangement is that as the number of users goes up, the demand load on the system gets more balanced in a stochastic sense, even as its economies of scale expand.
- Cloud computing can lower IT barriers to innovation, as can be witnessed from the many promising startups, from the ubiquitous online applications such as Facebook and Youtube to the more focused applications like TripIt (for managing one's travel) or Mint (for managing one's personal finances).
- Cloud computing makes it easier for enterprises to scale their services – which are increasingly reliant on accurate information – according to client demand. Since the computing resources are managed through software, they can be deployed very fast as new requirements arise. In fact, the goal of cloud computing is to scale resources up or down dynamically through software APIs depending on client load with minimal service provider interaction. [12]
- Cloud computing also makes possible new classes of applications and delivers services that were not possible before. Examples include (a) mobile interactive applications that are location-, environment- and context-aware

and that respond in real time to information provided by human users, nonhuman sensors (e.g. humidity and stress sensors within a shipping container) or even from independent information services (e.g. worldwide weather data); (b) parallel batch processing, that allows users to take advantage of huge amounts of processing power to analyze terabytes of data for relatively small periods of time, while programming abstractions like Google's MapReduce or its open source counterpart Hadoop makes the complex process of parallel execution of an application over hundreds of servers transparent to programmers; (c) business analytics that can use the vast amount of computer resources to understand customers, buying habits, supply chains and so on from voluminous amounts of data; and (d) extensions of compute-intensive desktop applications that can offload the data crunching to the cloud leaving only the rendering of the processed data at the front-end, with the availability of network bandwidth reducing the latency involved. [13]

4. Barriers to Cloud Computing Adoption in the Enterprise

Although there are many benefits to adopting cloud computing, there are also some significant barriers to adoption.

4.1. Security and Privacy

Because cloud computing represents a new computing model, there is a great deal of uncertainty about how security at all levels (e.g., network, host, application, and data levels) can be achieved. That uncertainty has consistently led information executives to state that security is their number one concern with cloud computing. The ability of cloud computing to adequately address privacy regulations has been called into question. [14] Organizations today face numerous different requirements attempting to protect the privacy of individuals' information, and it is not clear (i.e., not yet established) whether the cloud computing model provides adequate protection of such information, or whether organizations will be found in violation of regulations because of this new model.

4.2. Connectivity and Open Access

The full potential of cloud computing depends on the availability of high-speed access to all. Such connectivity, rather like electricity availability, globally opens the possibility for industry and a new range of consumer products. Connectivity and open access to computing power and information availability through the cloud promotes another era of industrialization and the need for more sophisticated consumer products.

4.3. Reliability

Enterprise applications are now so critical that they must be reliable and available to support 24/7 operations. In the event of failure or outages, contingency plans must take effect smoothly, and for disastrous or catastrophic failure, recovery plans must begin with minimum disruption. (See the Cloud Computing Incidents Database at http://wiki.cloudcommunity.org/wiki/CloudComputing:Incidents_Database.) Each aspect of reliability should be carefully considered when engaging with a CSP, negotiated as part of the SLA, and tested in failover drills. Additional costs may be associated with the required levels of reliability; however, the business can do only so much to mitigate risks and the cost of a failure. Establishing a track record of reliability will be a prerequisite for widespread adoption.

4.4. Interoperability

The interoperability and portability of information between private clouds and public clouds are critical enablers for broad adoption of cloud computing by the enterprise. Many companies have made considerable progress toward standardizing their processes, data, and systems through implementation of ERPs. This process has been enabled by scalable infrastructures to create single instances, or highly integrated connections between instances, to manage the

consistency of master and transaction data and produce reliable consolidated information. Even with these improved platforms, the speed at which businesses change may still outpace the ability of IT organizations to respond to these changes. SaaS applications delivered through the cloud provide a low-capital, fast-deployment option. Depending on the application, it is critical to integrate with traditional applications that may be resident in a separate cloud or on traditional technology. The standard for interoperability is either an enabler or a barrier to interoperability, and permits maintenance of the integrity and consistency of a company's information and processes.

4.5. Economic Value

The growth of cloud computing is predicated on the return on investment that accrues. It seems intuitive that by sharing resources to smooth out peaks, paying only for what is used, and cutting upfront capital investment in deploying IT solutions, the economic value will be there. There will be a need to carefully balance all costs and benefits associated with cloud computing—in both the short and long terms. Hidden costs could include support, disaster recovery, application modification, and data loss insurance. There will be threshold values whereby consolidating investments or combining cloud services makes sense; for example, it might not be efficient or cost-effective to utilize multiple autonomous SaaS applications. Each may contract for disaster recovery program services. There is a point where economies of scale mean these functions should be combined in a similar service. Application usage may begin with a low volume of transactions that can be supported with semi-automated master data management [15]. As usage expands and interoperability requirements for the business process become more onerous, a new approach is needed. This evolution may be the most cost-effective approach; however, there is a risk that the business transition costs from one solution to another may change the cost and benefit equation, and hence the solution that should be employed.

4.6. Changes in the IT Organization

The IT organization will be affected by cloud computing, as has been the case with other technology shifts. There are two dimensions to shifts in technology. The first is acquiring the new skill sets to deploy the technology in the context of solving a business problem, and the second is how the technology changes the IT role. During the COBOL era, users rarely programmed, the expectations of the user interface varied, and the adaptability of the solution was low. Training was delivered in separate manuals and the user used the computer to solve problems only down predefined paths. With the advent of fourth-generation languages, roles within IT, such as system analyst and programmer, became merged into analyst/programmer, users started to write their own reports, and new applications, including operational data stores, data entry, and query programs, could be rapidly deployed in weeks. IT's role will change once again: the speed of change will impact the adoption of cloud technologies and the ability to decompose mature solutions from hype to deliver real value from cloud technology; and the need to maintain the controls to manage IT risk in the business will increase.

4.7. Political Issues Due to Global Boundaries

In the cloud computing world, there is variability in terms of where the physical data resides, where processing takes place, and from where the data is accessed. Given this variability, different privacy rules and regulations may apply. Because of these varying rules and regulations, by definition politics becomes an element in the adoption of cloud computing, which is effectively multijurisdictional. For cloud computing to continually evolve into a borderless and global tool, it needs to be separated from politics. Currently, some major global technological and political powers are making laws that can have a negative impact on the development of the global cloud. For example, as a result of the USA Patriot Act, Canada has recently asked that its government not use computers in the global network that are operating within U.S. borders, fearing for the confidentiality and privacy of the Canadian data stored on those computers[16]. Providers have been unable to guarantee the location of a company's information on specified set of servers in a specified location. However, cloud computing service providers are rapidly adopting measures to handle this issue. For example, Amazon Web Services recently announced the Amazon Virtual Private Cloud that allows a business to connect its existing infrastructure to a set of isolated AWS compute resources via a

VPN connection. To satisfy the European Union data regulations, AWS now allows for companies to deploy its SimpleDB structured storage physically within the EU region. Cloud computing depends largely on global politics to survive. Imagine if the telecommunications companies in the United States get their way and do away with the current Internet standard of network neutrality completely. Having data throttled and information filtered goes against the basic concept of cloud computing and global knowledge. You can't have a working cloud of information and services to draw from and build on if someone or something is constantly manipulating the data held within it, or worse, if something is blocking it from your view to achieve a hidden agenda. Politics are affecting the scalability of the Internet, the availability of Internet access, the free flow of information, and the cloud-based global economy on a daily basis [17].

5. Conclusion

With all of the hype around cloud computing, and multiple definitions of cloud computing, it is difficult to discern exactly what constitutes "cloud computing." This problem is made more difficult as vendors rush to claim that they are now cloud computing companies, or at least "cloud-friendly." Suddenly, the entire technology sector has become "cloudy"—similar to the dot-com stampede of the late 1990s.

Adopting one or another technology should start by evaluating the economical processes of the organization. IT is, or it is supposed to be, an integrated part of a business. We need technology to support or improve the economical processes. Before rushing into the cloud, the company should study their processes and evaluate the risks and advantages brought to their business. Since the small and mid-size companies have less complex processes, they should be the first category of businesses to use cloud computing services.

One of the most important advantages offered by cloud computing is the reduced cost. Related to the IT governance principles we should study first the value brought by cloud services to our organization. This value is defined by two characteristics: utility and guarantee. Any organization has customers and the main scope is satisfying their needs. In my opinion, the organization should first define their economic objectives related to the 4 elements of the balanced scorecard: financial, customer, internal and learning-development and then we should identify the way cloud services can sustain these objectives.

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