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Cloud Computing: Introduction and Enabling Technologies

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Abstract

Cloud computing is a relatively recent technology, builds on decades of research in distributed computing, virtualization, utility computing, networking, web and software services. Cloud Computing implies a service oriented architecture, it reduce information technology overhead for the end-user and provide great flexibility. There are more offerings, more in-house development in Cloud Computing and more experience in how best to use the technology. In this paper the enabling technologies in Cloud Computing and advantages are described.

Keywords: *Workflows, Virtualization, Cloud Computing, Service Oriented Architecture.*

1. Introduction

Cloud computing is simply defined as Internet computing, generally the internet is seen as collection of clouds or nodes; thus the word cloud computing can be defined as utilizing the internet or existing network to provide technology enabled services to the customers and organizations. Cloud Computing allows consumers to access the resources online through the internet, from any location at any time without worrying about technical or physical management and maintenance issues of the original resources[7]. Resources of Cloud Computing are dynamic and scalable.

Cloud Computing is a Pay-per-Use and On-Demand mode that can conveniently access the shared IT resources through the Internet[4]. Where the IT resources include network, server, storage, application, service and so on and they can be deployed with much quick and easy manner and least management and also interactions with service providers. Cloud computing can much improve the availability of IT resources and owns many advantages over other computing techniques. Users can use the IT infrastructure with Pay-per-Use-On-Demand mode; this would benefit and save the cost to buy the physical resources that may be vacant[16]. Cloud computing is independent computing it is totally different from grid and utility computing. Google Apps is an example of Cloud Computing, it enables to access services of Cloud Computing via the browser and deployed on millions of machines over the Internet[8]. Resources are accessible from the cloud at any time and from any location across the world using the internet.

Cloud Computing concepts promise a cost-effective realization of the utility computing principle. Cloud Computing allow users and providers to easy access the resources in a self-service, pay-per-use fashion, thus results in decreasing cost for system administration and improving resource utilization and accounting. Over the last few years, the Cloud Computing has generated a major impact on the global IT ecosystem, giving rise to new markets and new customer communities[3]. The concept of Cloud Computing is not a novel in itself – in fact, the principles arose from a direct industrial need to improve resource utilization without affecting on consumer requirements, i.e. using the available resources more efficiently[1]. Initial data center server farms employed load balancing mechanisms not unlike the base Cloud principles, to ensure great availability of resources according to current usage. Cloud Computing involves the researchers and engineers from various fields backgrounds, e.g., Software engineering, Grid computing, and database. They work on Cloud computing from different viewpoints[14]. Enabling Technologies of Cloud computing are still evolving and progressing, for example, Web

2.0 and Service Oriented Computing, Virtualization etc.

2. Enabling Technologies

Cloud computing is enabled by number of technologies, several state-of-the-art techniques are identified here:

2.1 Programming Model

Users drive into the Cloud Computing with data and applications. Cloud Computing programming models should be designed for users to use the Cloud infrastructure. For the simple and easy access of Cloud services or Cloud Computing resources, the Cloud Computing programming model should not be too complex for users[17]. The MapReduce 4, 5) is a programming model and an associated implementation for processing and generating large data sets across the Google worldwide infrastructures. The MapReduce model firstly involves applying a "map" operation to some data records – a set of key/value pairs, and then processes a "reduce" operation to all the values that shared the same key[8].

2.2 Virtualization

Virtualization is another very important and useful concept. It allows abstraction and isolation of lower level functionalities and underlying hardware infrastructure. Virtualization enables portability of higher level functions and sharing and/or aggregation of the physical resources used in Cloud Computing[3]. The virtualization concept has been around since 1960s. Since then, the concept has matured considerably and it has been applied to all aspects of computing – memory virtualization, storage, processors virtualization, software, networks, as well as services that IT offers. It is the combination of the growing needs and the recent advances in the IT architectures. Virtualization, through its economy of scale, and its ability to offer very advanced services and complex IT services at a reasonable cost, is poised to become, along with wireless and highly distributed and pervasive computing devices, such as sensors and personal cell-based access devices, the driving technology behind the next waive in IT growth [17].

2.3 Workflows

A Workflow is a simple flow graph. An integrated view of service-based activities is provided by the concept of a workflow[8]. An Information technology assisted workflow represents a series of structured activities and computations that arise in information-assisted problem solving[10]. Workflows have been drawing enormous attention in the database and information systems research and development communities [9]. Similarly, the scientific community has developed a number of problem solving environments, most of them as integrated solutions. Scientific workflows merge advances in these two areas to automate support for sophisticated scientific problem solving [17]. A workflow can be represented by a directed graph of data flows that connect loosely and tightly coupled processing modules. In the context of "cloud computing", the key questions should be whether the underlying infrastructure is supportive of the workflow oriented view of the world. This includes on demand and advance reservation based access to users and aggregated computational and other resources, autonomics, ability to group resources from different "clouds" to deliver workflow results, best level of security and privacy, etc[8].

2.4 Service Oriented Architecture (SOA)

The services organization and services inside Clouds aree managed in a Service Oriented Architecture (SOA). Services of Computing Cloud are normally exposed as Web services, which follow the industry standards such as WSDL 33), SOAP 28) and UDDI 25)[17]. A set of Cloud Computing services furthermore could be used in a SOA application environment, thus making them available on various distributed platforms and could be further accessed across the Internet by end users[6].

2.5 Distributed Storage System

A distributed data storage system provides data sources access in a semantic way. Users could locate data sources in a large distributed environment by the logical name or key instead of physical locations. Virtual Data System (VDS) 32) is good reference[8]. A network storage system, which is handled by distributed storage providers (e.g., data centers), offers storage capacity for end users to lease[7]. The data storage could be , merged, migrated, and managed

transparently to end users for any data formats. Examples are Google File System 9) and Amazon S3 14). A Mashup 11) is a Web application system that combines data from more than one source into a single integrated storage system. The SmugMug 29) is an example of Mashup, which is a digital photo sharing Web site, allowing the upload of an unlimited number of photos for all account types and for any format, providing a published API which allows programmers to create new functionality, and supporting XML-based RSS.

3. Advantages of Cloud Computing

Advantages of cloud computing Specifically, cloud computing offers the following key advantages:

(i) 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[12]. 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[2]. 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 [7].

(ii) 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[11]. 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[9]. 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 [2].

(iii) 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. [2]

(iv) 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[2]; (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. [14]

4. Disadvantages of Cloud Computing

Although there are many benefits to adopting cloud computing, there are also some significant barriers to adoption [2].

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. [15] 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 [15,13].

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 [2].

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 [2,13].

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[16]. 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 [3]. 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 [5]. 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[17]. 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[13]. 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[2]. Providers have been unable to guarantee the location of a company's information on specified set of servers in a specified location. 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 [13].

5. Conclusion

Cloud Computing builds from decades of research in distributed computing, utility computing, virtualization, and, more recently, networking, web and software services. It implies a service-oriented architecture, reduced information technology overhead for the end-user, great flexibility, reduced total cost of ownership, on demand services and many other things. This paper discusses the concept of Cloud Computing, and various enabling techniques of Cloud Computing. The perspective study aims to contribute the evolution of the paradigm of Cloud Computing.

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