ISSN No. 0976-5697

Volume 2, No. 5, Sept-Oct 2011

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

Cloud Computing: Virtualization of Resources

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Abstract: In the past few years, Information Technology (IT) has entered on a new standard — cloud computing. Although cloud computing is only a different way to deliver computer resources, rather than a new technology, it has started a revolution in the way organizations provide information and service. Cloud computing is creating a fundamental change in computer architecture, software and tools development, and the way we store, distribute and consume information. The intent of this paper is to aid you in assimilating the reality of the revolution, so you can use it for your own profit and well being.

Keywords: **Clouds, Information, Server, Date, Speed, Services, Logic.**

I. INTRODUCTION

Cloud Computing is the term given to the use of multiple server computers via a digital network as if they were one computer. The 'Cloud' itself is a virtualization of resources: networks, servers, applications, data storage and services, which the end user has on-demand access to. These resources can be provided with minimal management or service provider interaction.

Cloud computing offers the end user resources without the requirement of having knowledge of the systems that deliver it. Additionally, the cloud can provide the user with a far greater range of applications and services. Therefore the cloud enables users and business scalable and tailored services.

Cloud computing was coined for what happens when applications and services are moved into the internet "cloud." Cloud computing is not something that suddenly appeared overnight; in some form it may trace back to a time when computer systems remotely time-shared computing resources and applications. More currently though, cloud computing refers to the many different types of services and applications being delivered in the internet cloud, and the fact that, in many cases, the devices used to access these services and applications do not require any special applications.[1]

Many companies are delivering services from the cloud. Some notable examples as of 2010 include the following:

A. Google: Has a private cloud that it uses for delivering many different services to its users, including email access, document applications, text translations, maps, web analytics, and much more.[2]

B. Microsoft: Has Microsoft Sharepoint online service that allows for content and business intelligence tools to be moved into the cloud, and Microsoft currently makes its office applications available in a cloud.

C. Salesforce.com: Runs its application set for its customers in a cloud, and its Force.com and Vmforce.com products provide developers with platforms to build customized cloud services.

II. WORKING OF CLOUD COMPUTING

A cloud computing system is divide it into two sections: the **front end** and the **back end**. They connect to each other through a network, usually the Internet. The front end is the side the computer user, or client, sees. The back end is the "cloud" section of the system.

The front end includes the client's computer (or computer network) and the application required to access the cloud computing system. Not all cloud computing systems have the same user interface. Services like Web-based e-mail programs leverage existing Web browsers like Internet Explorer or Firefox. Other systems have unique applications that provide network access to clients.

On the back end of the system are the various computers, servers and data storage systems that create the "cloud" of computing services. In theory, a cloud computing system could include practically any computer program you can imagine, from data processing to video games. Usually, each application will have its own dedicated server. [4]

A central server administers the system, monitoring traffic and client demands to ensure everything runs smoothly. It follows a set of rules called protocols and uses a special kind of software called middleware. Middleware allows networked computers to communicate with each other.

If a cloud computing company has a lot of clients, there's likely to be a high demand for a lot of storage space. Some companies require hundreds of digital storage devices. Cloud computing systems need at least twice the number of storage devices it requires to keep all its clients' information stored. That's because these devices, like all computers, occasionally break down. A cloud computing system must make a copy of all its clients' information and store it on other devices. The copies enable the central server to access backup machines to retrieve data that otherwise would be unreachable. Making copies of data as a backup is called redundancy.

III. CLOUD DEPLOYMENT TYPES

A. Private Clouds:

Private Clouds are typically owned by the respective enterprise and / or leased. Functionalities are not directly exposed to the customer, though in some cases services with cloud enhanced features may be offered – this is similar to (Cloud) Software as a Service from the customer point of view. Example: eBay.

B. Public Clouds:

The Public Clouds. Enterprises may use cloud functionality from others, respectively offer their own services to users outside of the company. Providing the user with the actual capability to exploit the cloud features for his / her own purposes also allows other enterprises to outsource their services to such cloud providers, thus reducing costs and effort to build up their own infrastructure. As noted in the context of cloud types, the scope of functionalities thereby may differ. Example: Amazon, Google Apps, Windows Azure.

C. Hybrid Clouds:

Though public clouds allow enterprises to outsource parts of their infrastructure to cloud providers, they at the same time would lose control over the resources and the distribution / management of code and data. In some cases, this is not desired by the respective enterprise. Hybrid clouds consist of a mixed employment of private and public cloud infrastructures so as to achieve a maximum of cost reduction through outsourcing whilst maintaining the desired degree of control over e.g. sensitive data by employing local private clouds. There are not many hybrid clouds actually in use today, though initial initiatives such as the one by IBM and Juniper already introduce base technologies for their realization.

D. Community Clouds:

Typically cloud systems are restricted to the local infrastructure, i.e. providers of public clouds offer their own infrastructure to customers. Though the provider could actually resell the infrastructure of another provider, clouds do not aggregate infrastructures to build up larger, cross-boundary structures. In particular smaller SMEs could profit from community clouds to which different entities contribute with their respective (smaller) infrastructure. Community clouds can either aggregate public clouds or dedicated resource infrastructures. We may thereby distinguish between private and public community clouds. For example smaller organizations may come together only to pool their resources for building a private community cloud. As opposed to this, resellers such as Zimory may pool cloud resources from different providers and resell them. Community Clouds as such are still just a vision, though there are already indicators for such development.

E. Special Purpose Clouds:

In particular IaaS clouds originating from data centers have a "general purpose" appeal to them, as their according capabilities can be equally used for a wide scope of use cases and customer types. As opposed to this, PaaS clouds tend to provide functionalities more specialized to specific use cases, which should not be confused with "proprietariness" of the platform: specialization implies providing additional, use case specific methods, whilst proprietary data implies that structure of data and interface are specific to the provider. Specialized functionalities are provided e.g. by the Google App Engine which provides specific capabilities dedicated to distributed document management. Similar to general service provisioning (web based or not), it can be expected that future systems will provide even more specialized capabilities to attract individual user areas, due to competition, customer demand and available expertise. Special Purpose Clouds are just extensions of "normal" cloud systems to provide additional, dedicated capabilities. The basis of such development is already visible.[8]

IV. CHARACTERISTICS / CAPABILITIES OF CLOUDS

Since "clouds" do not refer to a specific technology, but to a general provisioning paradigm with enhanced capabilities, it is mandatory to elaborate on these aspects. There is currently a strong tendency to regard clouds as "just a new name for an old idea", which is mostly due to a confusion between the cloud concepts and the strongly related SaaS paradigms, but also due to the fact that similar aspects have already been addressed without the dedicated term" cloud" associated with it. We can thereby distinguish non-functional, economic and technological capabilities addressed, respectively to be addressed by cloud systems.

A. Non-Functional Aspects:

Non-functional aspects represent qualities or properties of a system, rather than specific technological requirements. Implicitly, they can be realized in multiple fashions and interpreted in different ways which typically leads to strong compatibility and interoperability issues between individual providers as they pursue their own approaches to realize their respective requirements, which strongly differ between providers. Non-functional aspects are one of the key reasons why "clouds" differ so strongly in their interpretation.
The most important non-functional aspects are:

a. ***Elasticity*** is an essential core feature of cloud systems and circumscribes the capability of the underlying infrastructure to adapt to changing, potentially non-functional requirements, for example amount and size of data supported by an application, number of concurrent users etc. One can distinguish between horizontal and vertical scalability, whereby horizontal scalability refers to the amount of instances to satisfy e.g. changing amount of requests, and vertical scalability refers to the size of the instances themselves and thus implicit to the amount of resources required to maintain the size. Cloud scalability involves both (rapid) up- and down-scaling. Elasticity goes one step further, tough, and does also allow the dynamic integration and extraction of physical resources to the infrastructure. Whilst from the application perspective, this is identical to scaling, from the middleware management perspective this poses additional requirements, in particular regarding reliability. In general, it is assumed that changes in the resource infrastructure are announced first to the middleware manager, but with large scale systems it is vital that such changes can be maintained automatically.
b. ***Reliability*** is essential for all cloud systems – in order to support today's data centre-type applications in a cloud, reliability is considered one of the main features to exploit cloud capabilities. Reliability denotes the capability to ensure constant operation of the system without disruption, i.e. no loss of data, no code reset during execution etc. Reliability is typically achieved through redundant resource utilization. Interestingly, many of the reliability

aspects move from hardware to a software-based solution. (Redundancy in the file systems vs. RAID controllers, stateless front end servers vs. UPS, etc.). Notably, there is a strong relationship between availability and reliability – however, reliability focuses in particular on prevention of loss (of data or execution progress).

c. ***Quality of Service support*** is a relevant capability that is essential in many use cases where specific requirements have to be met by the outsourced services and / or resources. In business cases, basic QoS metrics like response time, throughput etc. must be guaranteed at least, so as to ensure that the quality guarantees of the cloud user are met. Reliability is a particular QoS aspect which forms a specific quality requirement.

d. ***Agility and adaptability*** are essential features of cloud systems that strongly relate to the elastic capabilities. It includes on-time reaction to changes in the amount of requests and size of resources, but also adaptation to changes in the environmental conditions that e.g. require different types of resources, different quality or different routes, etc. Implicitly, agility and adaptability require resources (or at least their management) to be autonomic and have to enable them to provide self capabilities.

e. ***Availability of services and data*** is an essential capability of cloud systems and was actually one of the core aspects to give rise to clouds in the first instance. It lies in the ability to introduce redundancy for services and data so failures can be masked transparently. Fault tolerance also requires the ability to introduce new redundancy (e.g. previously failed or fresh nodes) in an online manner non-intrusively (without a significant performance penalty). With increasing concurrent access, availability is particularly achieved through replication of data / services and distributing them across different resources to achieve load-balancing. This can be regarded as the original essence of scalability in cloud systems.

B. Economic considerations:

Economic considerations are one of the key reasons to introduce cloud systems in a business environment in the first instance. The particular interest typically lies in the reduction of cost and effort through outsourcing and / or automation of essential resource management. As has been noted in the first section, relevant aspects thereby to consider relate to the cut-off between loss of control and reduction of effort. With respect to hosting private clouds, the gain through cost reduction has to be carefully balanced with the increased effort to build and run such a system.[15]

a. ***Cost reduction*** is one of the first concerns to build up a cloud system that can adapt to changing consumer behavior and reduce cost for infrastructure maintenance and acquisition. Scalability and Pay per Use are essential aspects of this issue. Notably, setting up a cloud system typically entails additional costs – be it by adapting the business logic to the cloud host specific interfaces or by enhancing the local infrastructure to be "cloud-ready". See also return of investment below.

b. ***Pay per use.*** The capability to build up cost according to the actual consumption of resources is a relevant feature of cloud systems. Pay per use strongly relates to quality of service support, where specific requirements to be met by the system and hence to be paid for can be specified. One of the key economic drivers for the current level of interest in cloud computing is the structural change in this domain. By moving from the usual capital upfront investment model to an operational expense, cloud computing promises to enable especially SME's and entrepreneurs to accelerate the development and adoption of innovative solutions.

c. ***Improved time to market*** is essential in particular for small to medium enterprises that want to sell their services quickly and easily with little delays caused by acquiring and setting up the infrastructure, in particular in a scope compatible and competitive with larger industries. Larger enterprises need to be able to publish new capabilities with little overhead to remain competitive. Clouds can support this by providing infrastructures, potentially dedicated to specific use cases that take over essential capabilities to support easy provisioning and thus reduce time to market.

d. ***Return of investment (ROI)*** is essential for all investors and cannot always be guaranteed – in fact some cloud systems currently fail this aspect. Employing a cloud system must ensure that the cost and effort vested into it is outweighed by its benefits to be commercially viable – this may entail direct (e.g. more customers) and indirect (e.g. benefits from advertisements) ROI. Outsourcing resources versus increasing the local infrastructure and employing (private) cloud technologies need therefore to be outweighed and critical cut-off points identified.

e. ***Turning CAPEX into OPEX*** is an implicit, and much argued characteristic of cloud systems, as the actual cost benefit is not always clear [9]. Capital expenditure (CAPEX) is required to build up a local infrastructure, but with outsourcing computational resources to cloud systems on demand and scalable, a company will actually spend operational expenditure (OPEX) for provisioning of its capabilities, as it will acquire and use the resources according to operational need.

f. ***"Going Green"*** is relevant not only to reduce additional costs of energy consumption, but also to reduce the carbon footprint. Whilst carbon emission by individual machines can be quite well estimated, this information is actually taken little into consideration when scaling systems up. Clouds principally allow reducing the consumption of unused resources (down-scaling). In addition, up-scaling should be carefully balanced not only with cost, but also carbon emission issues. Note that beyond software stack aspects, plenty of Green IT issues are subject to development on the hardware level.

C. Technological Aspects:

The main technological challenges that can be identified and that are commonly associated with cloud systems are:

a. ***Virtualization*** is an essential technological characteristic of clouds which hides the technological complexity from the user and enables enhanced Flexibility (through aggregation, routing and translation). More concretely, virtualization supports the following features:

a) Ease of use: through hiding the complexity of the infrastructure (including management, configuration etc.) virtualization can make it easier for the user to develop new applications, as well as reduces the overhead for controlling the system.

b) Infrastructure independency: in principle, virtualization allows for higher interoperability by making the code platform independent.

c) Flexibility and Adaptability: by exposing a virtual execution environment, the underlying infrastructure can change more flexible according to different conditions and requirements (assigning more resources, etc.).

d) Location independence: services can be accessed independent of the physical location of the user and the resource.[9]

b. **Multi-tenancy** is a highly essential issue in cloud systems, where the location of code and / or data is principally unknown and the same resource may be assigned to multiple users (potentially at the same time). This affects infrastructure resources as well as data / applications / services that are hosted on shared resources but need to be made available in multiple isolated instances. Classically, all information is maintained in separate databases or tables, yet in more complicated cases information may be concurrently altered, even though maintained for isolated tenants. Multitenancy implies a lot of potential issues, ranging from data protection to legislator issues [13].

c. **Security,** Privacy and Compliance is obviously essential in all systems dealing with potentially sensitive data and code.

d. **Data Management** is an essential aspect in particular for storage clouds, where data is flexibly distributed across multiple resources. Implicitly, data consistency needs to be maintained over a wide distribution of replicated data sources. At the same time, the system always needs to be aware of the data location (when replicating across data centers) taking latencies and particularly workload into consideration. As size of data may change at any time, data management addresses both horizontal and vertical aspects of scalability. Another crucial aspect of data management is the provided consistency guarantees (eventual vs. strong consistency, transactional isolation vs. no isolation, atomic operations over individual data items vs. multiple data times etc.).

e. **APIs and / or Programming** Enhancements are essential to exploit the cloud features: common programming models require that the developer takes care of the scalability and autonomic capabilities him- / herself, whilst a cloud environment provides the features in a fashion that allows the user to leave such management to the system.[10]

f. **Metering** of any kind of resource and service consumption is essential in order to offer elastic pricing, charging and billing. It is therefore a pre-condition for the elasticity of clouds.

g. **Tools** are generally necessary to support development, adaptation and usage of cloud services.

V. CONCLUSION

Cloud Computing holds a lot of promise and we believe that it is likely to be a major influence on hosting and application development. Smarter Tools is preparing all of our products for potential Cloud compatibility in the future because we have confidence that the incumbent issues will be satisfactorily resolved as this new technology matures.

Without a doubt, cloud computing is truly a revolutionary concept for many business organizations.

Because of the technology's ease of adoption, significantly lower maintenance costs, and greater workflow efficiency, there is no doubt that cloud computing will gain widespread popularity going forward. For managers dealing with the growing demand for IT in their respective organizations, cloud computing presents itself as an all-in-one solution, being able to satisfy the growing IT needs while at the same time reduces energy usage all at an affordable price.

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