

Clouds on IT Horizon

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Summary

The aim of this paper is to present and elaborate a new IT trend – Cloud Computing. Cloud computing is rapidly evolving and is becoming increasingly popular. Cloud computing represents the move from desktop applications toward Web applications and services. The actual computing is moved into the cloud so the users are using third-party services and paying for them on pay-per-use model. The cloud (data and services) can be accessed from any device connected to the Internet. There are currently three distinct cloud service layers and three cloud computing types in existence. Main characteristics of cloud computing are presented and potential benefits are explained. Some concerns and things that need to be corrected are being discussed. Major cloud computing service providers and some of their services are mentioned, as well as some predictions for the future.

Key words: cloud computing, computing, web applications, Internet

Introduction

Computers are increasingly becoming an irreplaceable component of our everyday life. Information technology (IT) is evolving rapidly and new trends are persistently emerging. From its beginning up until today, the Internet gradually developed and received many new features. Subsequently this has changed the way we use computers, especially with the appearance of broadband connections and increased number of Internet users. Today, we spend more time in the Web browser than in the other (desktop) applications. A new trend in the IT field that is evolving rapidly, and is widely discussed approximately in the last two years is cloud computing.

The term cloud computing has become quite popular these days and many companies want to be part of it. But, what is cloud computing actually? Are we already using some form of cloud computing without even being aware of it? If you use a web-based e-mail account (e.g. Gmail) or a social networking web site (e.g. Facebook), then you have already experienced cloud computing. To use these services you don't have to install any software or save data on your computer – the software and storage for your account are in “the cloud”.

Cloud computing uses the Internet as a platform to run applications and store data on servers. Data and services can be accessed from any connected device over the Internet thru Web browsers or specialized applications. The infrastructure behind the cloud is invisible to users which don't need to know how the cloud actually works. With this type of computing the users don't have to worry any more about the infrastructure. This means that organizations don't have to buy new and expensive computers or applications and invest in their expensive maintenance. Besides many benefits, cloud computing enables new forms of group collaboration at a distance.

What are advantages and disadvantages of cloud computing? What types of services exist? Can all desktop applications be moved to the cloud? Is cloud computing suitable for everyone? Is the data in the cloud safe? Some of these questions will be discussed in this paper.

What is Cloud Computing?

Cloud computing is an emerging paradigm in IT industry which represents a major change in how we store data and run applications. It represents a move from desktop applications toward Web applications and services – computing is moved to a cloud of computers. The term first appeared in 2007.

To better understand the concept of cloud computing, the terms "cloud" and "computing" needs to be explained first.

The cloud is a metaphor for the Internet, which came from the cloud symbol that's often used in the networks diagrams.

Computing is the activity of using and developing computer technology. It includes different information operations performed on a computer.

When we join these two words together into one term, cloud computing, and try to define it, we encounter to a problem. Some providers present their services as cloud computing services but they aren't. Everybody seems to be talking about cloud computing but there's no unique definition and common agreement about what it really is so there are many different explanations. The question is which definition is the best? Therefore, a few definitions are mentioned.

Very simplified, cloud computing is using the Internet for computing needs.

Sam Johnston defines cloud computing as "the realisation of Internet ('Cloud') based development and use of computer technology ('Computing') delivered by an ecosystem of providers" (Johnston, 2008).

According to Kent Langley, cloud computing is "commercial extension of utility computing that enables scalable, elastic, highly available deployment of software applications while minimizing the level of detailed interaction with the underlying technology stack itself"(Langley, 2008).

Gartner (the world's leading information technology research and advisory company) defines cloud computing as "a style of computing where massively scalable IT-related capabilities are provided "as a service" using Internet technologies to multiple external customers" (Gartner Research, 2008).

National Institute of Standards and Technology (NIST) defines: “Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability...” (NIST, 2009).

As already mentioned, there is no strict definition of cloud computing so sometimes it’s difficult to tell whether a service is truly a cloud computing service or simply a pre-existing offering that is labelled as one of them. Cloud computing is not something completely new because it uses some already established concepts.

Terms with which cloud computing can be confused are: Grid Computing, Utility Computing, Computing on demand, Software as a Service, Service-oriented architecture (SOA), outsourcing, etc. Cloud computing is closely related to most of these concepts (may include attributes previously associated with them) and often relies on virtualization, Web 2.0 and broadband networks. But, cloud computing goes beyond these concepts – it’s a much more generalized, “umbrella” term.

Traditional computing Vs. Cloud computing

With faster broadband speeds and increased internet access, some tasks (e.g. word-processing) can be done in web browser quickly as on a desktop. While traditional computing is desktop-centric and PC-centric, cloud computing is document-centric and has universal access, 24/7 reliability, and ubiquitous collaboration (Miller, 2009).

With traditional desktop computing, user runs copies of software programs on each computer he owns. Created documents are stored on the computer on which they were created and can’t be accessed by computers outside the network.

With cloud computing, the applications that the user uses aren’t being run from his computer. Computing resources, applications and data that is needed exist on a collection of servers in the cloud, somewhere at the Internet, and can be accessed from any computer connected over the Internet thru Web browsers or specialized applications. Users connect to them and use them as and when needed, and pay only for what they use.

Anyone with permission can access the documents and edit or collaborate on them in real time. If one user’s computer crashes, or one of servers in the cloud, applications and created documents are still available for others to use.

Main characteristics

Main cloud computing characteristics for end-users are scalable and elastic, on-demand, self-service, based on pay-per-use model, location independence and broad network access.

Scalability represents "the ability of a computing system to grow relatively easily in response to increased demand" (Langley, 2008). Computing system can dynamically get or release computing resources (elasticity) via on-demand self-service, which reduces administrative intervention on the end-user side.

Some cloud computing services are billed on a pay-per-use utility model, while others on a subscription basis with little or no upfront cost. Utility computing is the combination of computing resources as a metered service similar to a traditional public utility such as gas or electricity. Consumers pay only for what they use.

Cloud computing is location independent. This characteristic refers to two things: computing resources location and users access. Computing resources are shared on multi-tenant model (serves a large pool of users) so the user doesn't know and doesn't need to know the location of the provided resources (e.g. storage). The other meaning of location independence is the users' ability to access their applications and data in the cloud from anywhere (not just from the office), at any time, and from any device (laptop, mobile phone...) connected to the Internet. Users are not confined to one computer or organisation's internal network.

The main benefits of cloud computing

Besides the advantages which derive from afore mentioned characteristics, there are many benefits for those who use cloud computing: reduced cost of ownership (infrastructure – hardware, software) and of maintenance; increased computing power; new forms of group collaboration; no need for physical space to store servers and databases (companies can store their data on someone else's hardware); virtually limitless storage capacity; independence of operating systems; better document format compatibility (all documents created by application in the cloud can be open by other users who have access to the same application), etc.

It is not necessary to have a high-powered computer (large hard drive, powerful processing power) in order to be able to use cloud computing. Lower priced model with smaller hard disks is adequate, which improves the performance of a computer because applications are not stored and run from it. Increasingly popular netbooks, designed for web browsing, often don't have a CD/DVD drive. They are ideal for the usage of cloud computing services.

By using cloud computing, users also have lower software costs. Organisations don't have to buy separate software packages and software licenses for each computer and they don't have to worry about software updates because updates are applied automatically, and each time the user access the cloud, he gets the latest version of the application. Also, many providers (e.g. Google) are offering their services for free.

As mentioned earlier, cloud computing users pay a provider only for what they use. On the providers' side (back-end), the cost is also reduced because providers can store infrastructure in locations with lower costs.

In the cloud, users can perform more complex calculations and tasks, and significantly speed up their completion, as opposed to what they can do on a single personal computer. They have the processing power of the entire cloud at their disposal.

One of the most important advantages of cloud computing is easier collaboration on the same documents and projects between users who are at distant locations, in real time.

As one of the advantages of cloud computing, increased data safety is often mentioned. If a computer, on which applications and data are stored, crashes, user can't access the data. If a computer in the cloud crashes, all the data is still in the cloud. Data stored within the cloud is safer than data on home computers or laptops (Preston, 2008) because data is not stored in just one place, it's duplicated, and providers invest more in security than any individual company would.

The major drawbacks of cloud computing

Cloud computing also involves some risks and has some disadvantages that need to be further improved.

Data safety is questionable, so it is often mentioned as one of the disadvantages because the data can be anywhere and users don't know how secure or insecure their data truly is.

The only real limitation is the Internet access – cloud computing requires a constant Internet connection because users access their applications and data via the Internet. If they don't have an Internet connection, they can't access anything. Also, low-speed connections impair the usage of cloud services.

Among the biggest concerns about cloud computing are the security and privacy of the data, lack of control, reliability, lock-in to cloud service vendor (an application built for one cloud service should be portable), regulatory compliance... "Some of these risks still don't have a industry-wide solution" (Spinola, 2009).

Once a company puts its data into the cloud, it loses control over that data because the data is outside the company's firewall and therefore might not be secure. The data security and control depends on third-party. For example, if computing service provider is experiencing problems, user may not be able to access his data at all. Regarding the possibility that user can access the cloud from any location, it's possible that the user's privacy could be compromised and sensitive data can fall into the wrong hands.

As one of the disadvantages, it can be mentioned that today's web-based applications might be limited (have less features) and can be slower than similar desktop applications.

Cloud computing layers

Cloud computing service providers offer services on various layers. They provide Everything as a Service (XaaS), from raw hardware to end-user applications. These services can be grouped into three distinct architectural services layers (or service models or sub-areas) of cloud computing (Langley, 2008; Sun Microsystems, 2009; NIST, 2009; Spinola, 2009):

- Software as a Service (SaaS) – e.g. Salesforce.com, Gmail, Facebook applications
- Platform as a Service (PaaS) – e.g. Google App Engine, Microsoft Azure Platform, Facebook
- Infrastructure as a Service (IaaS) – e.g. Amazon Web Services, Joyent.

Figure 1 shows cloud computing service layers from system to the end-user. On the front-end, client side, is client's computer and application (web browser, like Internet Explorer and Firefox, or specialized application) with which accesses to the cloud. On the other side, back-end, there are servers that create the cloud.

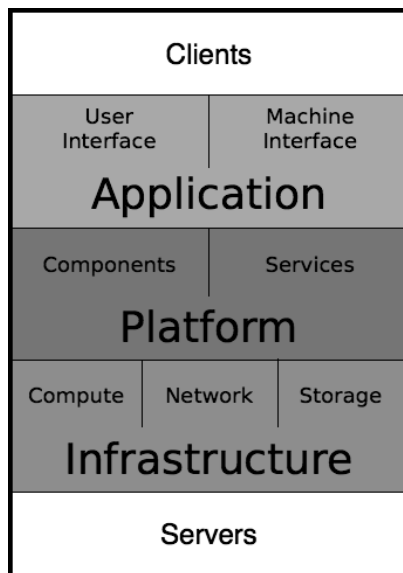


Figure 1: Sam Johnston's cloud computing architecture in stack with layers
 Source: Johnston, Sam. The Cloud and Cloud Computing consensus definition?. 20.04.2009.
<http://samj.net/2009/04/introducing-cloud-computing-stack-2009.html>

Software as a Service (SaaS) is the highest layer which features a complete application offered as a service, on-demand on multi-tenant principle, accessible over the network from various client devices (through a Web browser).

Platform as a Service (PaaS) is the middle layer which delivers development environments as a service. Consumers create their own applications using programming languages and tools supported by the provider on which's infrastructure are being run.

Infrastructure as a Service (IaaS) is the lowest layer which provides basic storage and compute capabilities as standardized services over the network, where the consumers are able to deploy and run arbitrary software (operating systems, applications).

At all layers, consumers do not manage or control the underlying cloud infrastructure. IaaS clouds are the underlying infrastructure of PaaS and SaaS clouds. Sometimes is hard to put some cloud service in one of these layers (e.g. PaaS itself can be cloud application and sometimes runs on the same IaaS that it manages).

Cloud computing types

An organization may choose to use a service provider's cloud (public cloud), build its own cloud (private cloud) or use a hybrid cloud. These are cloud computing types (deployment models).

Private Cloud or Internal Cloud is a cloud of a single organization limited for their internal use. They own or lease infrastructure (e.g. server, network and disk) and control who can use it. This type of cloud allows greater control and customization, security and reliability.

Public Cloud or External Cloud is a cloud computing environment available to the public (individuals, organisations), offered by a third-party vendor. Many different customers use the same infrastructure within the cloud and each of them doesn't know who else is using the same servers as they do. Public clouds are more exposed to security threats and their services can be less flexible than in private clouds.

Private clouds usually cost more than public clouds but they are still cost-efficient. If either of these two types doesn't satisfy an organisation's needs completely, they can choose a hybrid cloud. Hybrid Cloud or Mixed Cloud combines two or more clouds (private and public). It is a cloud computing environment in which an organization possesses and manages some resources in-house and has others provided by third-party.

Service providers and users

Moving to the cloud may or may not be the best choice for individual user or company. What types of users benefit the most from what cloud computing has to offer? Cloud computing is generally great for small and medium sized companies. However, it is not good for everyone, for now. There are discussions about the potential users of cloud computing, who appear to be good and bad "candidates" for cloud computing (Miller, 2009; Spinola, 2009).

Some cloud computing services are mentioned in this paper, but unfortunately due to limited space the matter is not investigated further.

The major cloud computing service providers (vendors) and some of their services are:

- Amazon: Amazon Web Services – several services including Amazon Elastic Compute Cloud (EC2) and Amazon Simple Storage System (S3)
- Google: Google App Engine, Google Apps (some of them are Gmail, Google Calendar, Google Docs, Google Sites)
- IBM
- Microsoft: Windows Azure Platform including Windows Azure, Live Mesh
- Yahoo
- Dell
- Vmware
- Sun Microsystems
- Rackspace
- Salesforce.com
- Ubuntu

Amazon is the pioneer in this field. Besides the mentioned vendors, there are many more, and their number grows every day, as also do the services that they provide.

Two interesting cloud computing services are announced to be released at the end of 2009: Google Wave (a new tool for communication and collaboration on the web) and Windows Azure (a cloud services operating system).

There are several cloud computing (online) operating systems which can be tested (although some of them are still beta versions): Cloudo (<http://beta.cloudo.com/>), eyeOS (<http://www.eyeos.info/>) and iCUBE Operating System (<http://www.oos.cc/>). This operating system is run in the web browser where a desktop is displayed. User can customize desktop, upload and store files, work with provided applications and services, etc. like on a regular desktop on a computer. The main difference is that user and desktop are not confined solely to one computer, but user can access his desktop from any computer that is connected to the internet.

Future outlook

Cloud computing is not the future – it is already happening. Many cloud services are already available. We're currently in the early days of the cloud computing evolution and it is difficult to predict its future. Although it is uncertain how the IT market will evolve in next few years, predictions exist which are the result of the conducted research.

"The projected shift to cloud computing will result in dramatic growth in IT products in some areas and in significant reductions in other areas" (Gartner

Research, 2008). From 4% of all IT spend on cloud services in 2008, in 2015 the proportion of IT spend for cloud services will be 17%, and a half of all IT spend by 2020 (Coda Research, 2009). “Over half (55%) of organisations plan to use cloud services extensively by 2015. The most popular services employed will be collaborative applications, followed by IT management applications, personal applications, business applications, storage, server capacity, and finally, application development” (Coda Research, 2009). These predictions seem to be very significant. If a software or hardware company wants to grab a piece of the IT market in upcoming years and to have a profit, it needs to think about cloud computing and develop (some) services toward that direction. On the other hand, potential cloud computing users (organisations) have to gradually change their businesses in order to benefit from the new business possibilities and advantages that come with cloud computing.

In July 2008, Yahoo, Hewlett Packard and Intel launched open cloud computing research test bed called Open Cirrus. It is created to “promote open collaboration among industry, academia and governments by removing the financial and logistical barriers to research in data-intensive, Internet-scale computing” (Yahoo! Research, 2009). There are more than 50 research projects currently in progress.

Conclusion

The clouds are already over the IT horizon and future forecast of IT is cloudy. Trend of cloud computing will rapidly mature and transform the IT industry, but it is still unclear to which extent, because the development is still in the early stages. Research shows that more and more money is being invested in this field. The web is replacing the desktop and more and more desktop applications will turn into cloud services or at least become hybrid online/offline applications. With cloud computing, the ways the software is being used and the ways of programming are changing.

New opportunities and benefits of cloud computing are becoming interesting for all types of users – organizations and individuals, however (currently) cloud computing is not the best solution for some computing needs. More and more providers and services are emerging. Users can use only what they want, when they want and pay only for what they use. Some providers are even willing to provide their services free of charge, which is good. The most interesting novelties that cloud computing brings (compared to traditional computing) are the emergence of new types of business and new forms of collaboration.

It is of utmost importance that cloud computing enables fast, cost-efficient and secure services. The important prerequisite for cloud computing is high-speed Internet access. If it is not available, the potential users are deprived from cloud computing services. It is important to enable constant high speed Internet access, which will increase the need for cloud computing services.

In order to completely develop cloud computing and to spread its usage, many things need working on. Primarily, a clear and uniform definition of cloud computing is needed. Cloud computing providers need to find ways to increase protection of user privacy, improve the level of security, to work on portability of applications from one cloud service to another, etc.

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