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## Cloud-Computing

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### Abstract

One of the hottest topics today in the information technology (IT) domain is cloud computing, even though it is not very clearly defined what this term means (Pal, 2016). Over the last 10 years, more and more businesses and companies began to use cloud services in order to maximize their number of users at a lower price and minimum resources. Cloud computing offers to their clients a various number of services like databases, network, analytics tools, ETL (Extract Transform Load) tools, servers and more online applications (Cloud). This paper will show the history of Cloud Computing, the evolution, the models, the main researchers and developers, and the main clients.

**Keywords:** cloud computing

## **Introduction**

Like e-commerce, the concept of cloud computing is still not clearly defined and understood by people and businesses. One of the reasons, and maybe the most important one, is that this new concept and technology can be applied in all the IT fields (infrastructure, hardware, software). Because of these various IT fields in which can be used, cloud computing technology can be useful and integrated into almost all the businesses in the world.

The main idea of cloud computing is to give the opportunity and resources of running any application on the internet. Also, this technology will make businesses work easier because the resources will be provided and maintained by third party companies.

The paper presents the history of Cloud Computing and how it changed the whole IT domain over the last years. Also, another main purpose of this paper is to show the evolution of this technology, the delivery models which created new business models, the main researchers, and developers, and the main clients.

## **History of cloud computing**

The first time that Cloud technology was mentioned was in the middle of 1970. This idea was created in the context of virtual machines that should replicate the real computers machines with a functional operating system.

In 1997 years, a new definition of this phenomenon, Cloud Computing, was written by Professor Ramnath Chellappa of Emory University and it was “computing paradigm, where the boundaries of computing will be determined by economic rationale, rather than technical limits alone“ (Foote, 2017) .

The first company which used Cloud similar to what it is today was Salesforce, in 1999. Salesforce was enlightened with the idea to deliver applications to the end-users using Internet services. The applications could be used and could be easily accessed and used by anyone with an internet connection.

## Evolution

After Salesforce had a major success using Cloud services, in 2002 Amazon released on the market its own web-based retail services. Amazon used the Cloud Computing Infrastructure Model in a way to use the computer's capacity with much more efficiency. As said in paper Cloud computing, Amazon demonstrated that this new architecture based on cloud had big results in the context of efficiency and time-response with small improvements (WEB MIT, n.d.). After that, other big businesses and companies followed their example.

The next big impact in the Cloud services subject was again Amazon, in 2006, who released on market the Amazon Web Services package. This package offers other websites online services, or to clients. One of the most important Amazon Web Services sites as Amazon Mechanical Turk which contained a variety of Cloud-based services like computation and storage. Another Amazon Web Services site which had a big impact in the market was Elastic Compute Cloud (EC2) which allowed users to rent virtual machines and run their own applications on it.

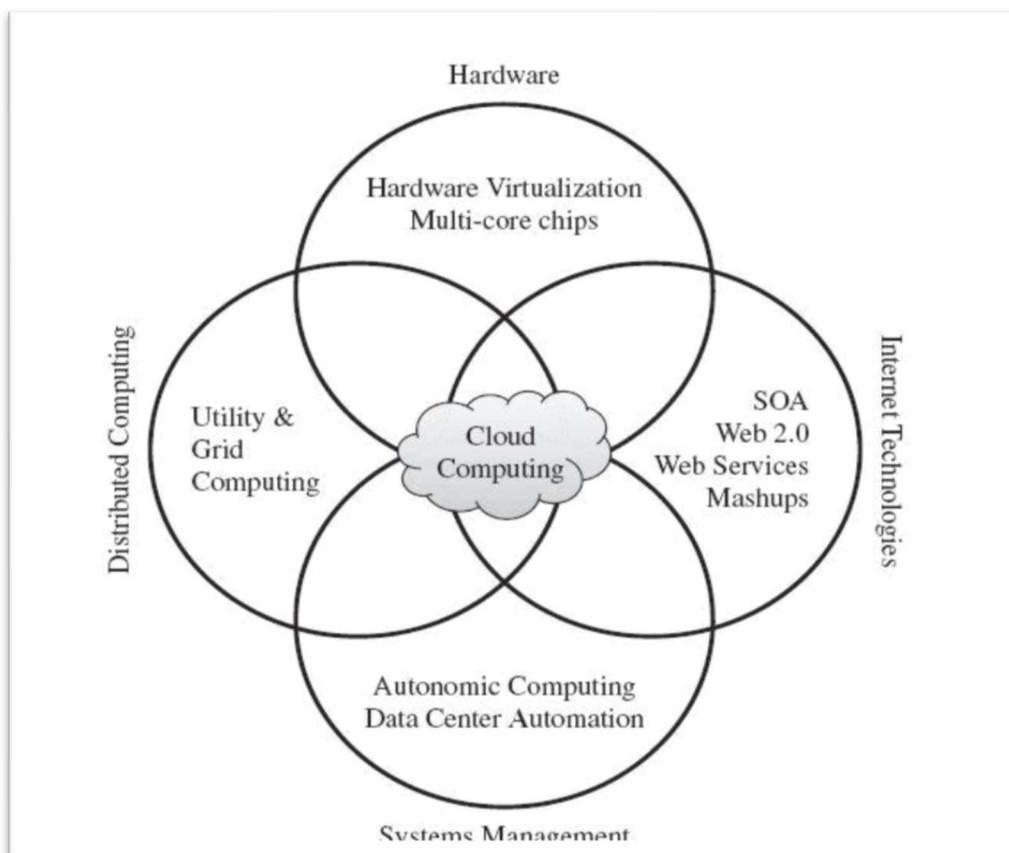
In 2006, Google released Google Docs services. Initially, Google Docs was composed of two products, Google Spreadsheets, and Writely. A little after this release, Google bought Writely. Writely allowed users to create, edit, save documents in the storage on the internet (the documents can be opened with Microsoft Word too). Google Spreadsheets allowed users to create, edit, update, develop and save (also in HTML format) spreadsheets (the documents can be opened with Microsoft Excel too).

In 2007, two pillars of the IT market, IBM and Google, joined forces with several universities to develop a new and unique server for projects that needed fast processors and huge data sets processed in parallel. The first university that used the resources provided by IBM and Google was the University of Washington. Other universities followed their example. Soon, the arrangement became official: IBM and Google provide resources for universities that focus on research that they had interest in.

In 2007 again, the first company that released a streaming video service using the Cloud was Netflix. In 2008, a new concept of Cloud was released by Eucalyptus, i.e. private Clouds which used AWS API (Amazon Web Services Application Programming Interface) compatible platform.

The same year, 2008, NASA was entering on the market with the first open-source software for installing Private and Hybrid Clouds, OpenNebula. The main purpose of the software was to help the needs of big businesses.

Another remarkable year regarding Cloud evolution was 2011. During this year, IBM provided the IBM SmartCloud. This IBM tool included infrastructure, software, and platform services provided through public, private and hybrid cloud models. (Harvey, 2017). Apple released the iCloud service focused on storing personal information. Also in 2011, Microsoft promoted the Cloud idea on television to inform the public about the ability and advantages of storing data with easy access.



**Figure 1. Cross evolution of different developments that led to the appearance of cloud computing**

## **Deployment Models**

The deployment model defines an access level to the cloud. There are four main types of models.

### **Public Cloud**

This type of clouds are open for the general public and the sets of data are created, stored and maintained on the third-party servers, as presented in paper Introduction to Cloud Computing (DIALOGIC, n.d.). The server infrastructure and resources belong to the provider, so clients don't need to buy and maintain their own hardware.

This type of model has a big disadvantage as no one knows where the data is kept and who can reach it. Because of this, public clouds often suffer outages and malfunctions.

The advantages of this type of models are that it is easy to set up and use, easy to access the data, scalability, and cost-efficiency. This model is often chosen and used by businesses that don't have higher standards about privacy.

The most popular applications that use public clouds are Google AppEngine, IBM's BluePages, Microsoft Azure and Amazon Elastic Compute Cloud, Microsoft Azure Salesforce Heroku.

### **Private Cloud**

From a technical perspective, there is not a big difference between the private cloud and public cloud, as their architecture are similar. However, the main difference is that a private cloud is owned and used by only one company, from here the name internal or corporate. The security of this model is higher since the data center architecture exists inside the company's firewall, as presented by the Evolution of Cloud Computing paper (SHODHGANGA, n.d.). Even though the organization runs their data loads and workloads in a private manner, the server can be maintained externally, by a third-party member.

The higher security comes from the idea that the data is kept in private storage and no general public can access or use it. More and bigger businesses and corporations choose private cloud as it comes with a lower number of risks.

The most known disadvantage is that the model needs higher costs because hardware and software components must be bought and staff must be trained to develop it.

This model is chosen by large companies or by companies that need a higher security standard for critical operations.

The main providers are IBM, Dell, Cisco, Amazon and Red Hat (bought by IBM in 2019).

### **Community Cloud**

The Community Cloud model is similar to the private one but has a large number of potential users. While the private type can be owned and use by one company, the community one can be shared between several organizations with similar backgrounds. (Pal, 2016)

This model is best for the companies that work together on joined projects because it helps the businesses achieve their common objectives. The model centralizes the development of the project, the management system, the test phase and the final part, the software implementation. This whole project lifecycle is more easily synchronized with this cloud type.

The Community Cloud deployment model has a lot of advantages, the more important are the costs are shared, the security is better than the public one and the collaboration is better.

### **Hybrid Cloud**

As we know from the hybrid definition, a hybrid cloud combines the best components of the cloud computing models explained until now – the public one, the private one and the community one. The Hybrid Cloud gives businesses the opportunity to mix and match the three types however they think is it best for them, as exemplified by Derrick Rountree and Ileana Castrillo in paper Cloud Deployment Model. (Derrick Rountree, 2014)

The advantages of this model are many, but the main ones are the security and privacy that are higher, the flexibility which is increased and the reasonable costs.

If the businesses can split in half their data into sensitive and non-sensitive types, this is the best type of cloud they can choose.

The table below provides a comparison between the four models of Cloud.

	<b>Public Type</b>	<b>Private Type</b>	<b>Community Type</b>	<b>Hybrid Type</b>
<b>Easy setup and easy use</b>	Basic IT requirements	Higher IT knowledge Ent	Higher IT knowledge Ent	Higher IT knowledge Ent
<b>Security and privacy level</b>	Low	Big	Big	Big
<b>Data control</b>	Almost none	Big	Big	Big
<b>Accuracy</b>	Vulnerable	Big	Big	Big
<b>Scalability and flexibility</b>	Big	Big	Fixed capacity	Big
<b>Costs</b>	The cheapest one	The most expensive one	The shared cost of associate businesses	Cheaper than a private model but more costly than a public one
<b>The need of own hardware</b>	No	If businesses choose	If businesses choose	If businesses choose

## Service Models

The companies that are offering computing services are called cloud providers. Each of these provers is giving specific features and functions with more or less control over their cloud, depending on the demand. (Solomon, 2016). The basic service models are three, presented below.

## **Infrastructure as a Service (IaaS)**

IaaS is the lowest layer of cloud solution. An IaaS provider will give pre-installed and configured hardware and software using a virtual machine. The client will have control and management of the operating system, storage, applications, and internet connectivity, but not the infrastructure.

The main IaaS providers are Google, Rackspace Cloud Servers, Amazon EC2, IBM and Verizon.

The advantages of this solution are the cost is lower, access to enterprise resources and infrastructure and liberty of extending or downgrading the requirements any time. (Solomon, 2016)

## **Platform as a Service (PaaS)**

PaaS is the higher layer, above IaaS. PaaS gives clients the ability to develop and deploy their own applications in a hosted environment. (Apprenda, n.d.) This service model provides a framework for development, testing, deployment and maintenance support. The system upgrades and platform support is assured by PaaS providers which has results on a more efficient and cost-reducing solution for software development. The network and operating system are managed by the provider which may have a result on some constrained on which applications can be deployed.

Examples include Amazon Web Services (AWS), Rackspace and Microsoft Azure.

The advantages of this model are that the upgrades and support of the infrastructure are done by the provider, the costs are lower because there are no investments in hardware or software and all the phases of an IT project (development, testing, deploying, support) are easier.

## **Software as a Service (SaaS)**

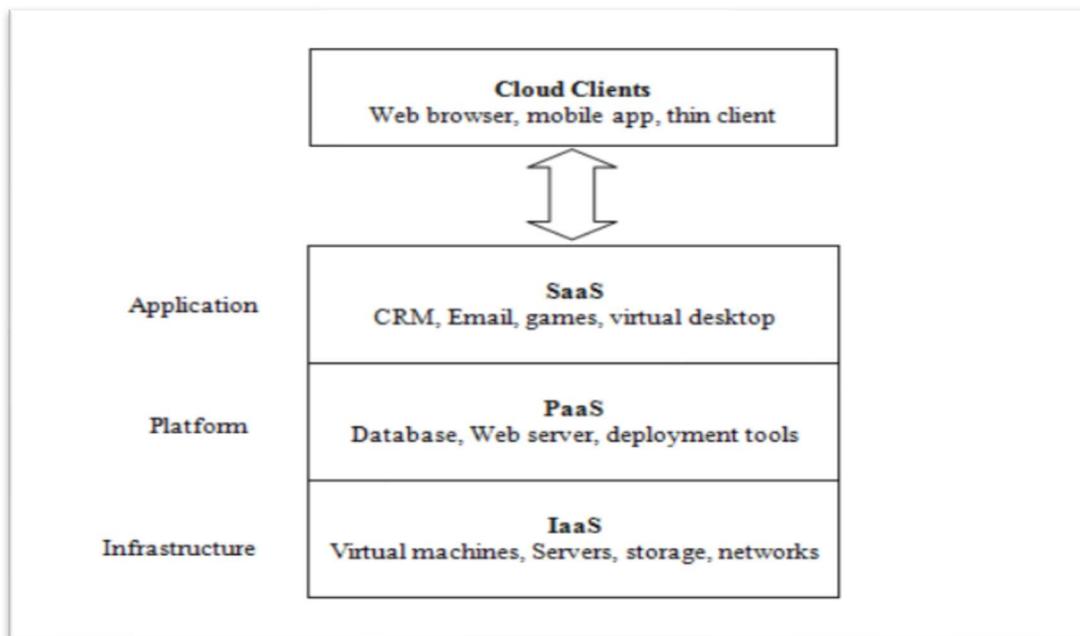
SaaS is the higher layer of service models. This model means that a client has the ability and opportunity to use an application via a web browser. The service providers host the application and their data in their location (Microsoft, 2019). This model is also referred to as “software on demand” (Apprenda, 2019).

The costs are reduced because all it is needed is a subscriber fee.

Examples of SaaS applications are Google Applications, Yahoo! Mail, ERP, and CRM.

The advantages of this model are the costs which are reduced, the accessibility from anywhere with a network connection and the concerns about infrastructure and development are erased.

Each of the service models inherits the security and management mechanism from the underlying model, as shown in the following diagram.



**Figure 2. The hierarchy and correlation between the cloud service models**

## Conclusions

In the last 10 years, the phenomenon of cloud computing changed the IT domain. Many experts are saying that this technology is the biggest discovery since the internet. As we demonstrated in our paper, more and more companies are changing their businesses models by migrating to cloud.

In this paper, we have shown the benefits of this new technology from two points of view. First, from a technical point of view, we have shown that cloud computing in the context of IT domain

history has changed the trend to centralized computing resources based on virtualization and application deployed via the internet. The second point of view, from a delivery point, the model for information systems changed. Cloud computing was the first big technology that did outsourcing which is a new delivery model based on flexibility, on-demand services, and pay-per-use basis.

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