Cloud Computing

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***Abstract*—Cloud Computing has been a part of the most recent computing revolution since the late 1990s. What was once expensive and used by large companies only, is now used worldwide by companies of all sizes and it is even used by individual people. This paper outlines the history of cloud computing, the services it provides, the four methods of deploying a cloud and how the cloud is now being used to enhance gaming.**

***Index Terms*—Cloud, Computing, Internet, Applications**

I. Introduction

Cloud Computing was merely a theory in the 1950's and it was not until the end of the century that the term "*Cloud Computing*" was first used by Professor Ramnath Chelllappa in 1997 according to Prekash (2012). Cloud computing is *"the use of technology, services, software, etc. on the internet rather than software and hardware that you buy and install on your computer"* according to Cambridge (2015). It is now one of the largest and most profitable computing infrastructures in the world.

The functionality of cloud computing relies on an efficient and reliable internet connection and while this is something that those in richer countries take for granted, there are still people in the world who could benefit from such a service but either they do not have enough money or their governments infrastructure is poor. Large companies such as Google are trying to combat this issue with new technologies but this requires huge investments on their part.

II. History

A. 1950s - The cloud concept

After World War 2, large servers and mainframes were in constant development. There was one thing however, that made them stand out and that was their significant cost. Something needed to be developed that would allow data to be accessed on different machines in a more cost efficient method and so the idea of sharing CPU time was introduced. The idea became more apparent in the late 1950s and by the 1960s the concept of the cloud was born, although at the time it was not named Cloud Computing as stated by Prekash (2012).

B. 1960s and 1970s - Licklider develops networks and his visions of the future

J.C.R Licklider was one of the first computer scientists to forecast the world of interactive computers and was also an internet pioneer who envisaged a worldwide computer network long before it was built. He introduced the intergalactic computer network in the early 1960s as head of the Information Processing Techniques Office where he had initiated three of the most important developments in information technology. This network idea expanded into a network of networks in the 1970s and eventually formed the basics of the internet. During the development of this intergalactic network, Prekash (2012) states that Licklider envisioned a day where everyone could access data and programs from anywhere. This vision describes exactly what the cloud is today.

C. 1970s-1990s - Time sharing and influential Computer Scientists

The internet and the cloud would not be what they are today without the development of time-sharing, which allowed people to share data by linking to a central computer according to Woo (2011). Many influential computer scientists worked on the development of time-sharing including Licklider and John McCarthy, the scientist who coined the term "*artificial intelligence*". The work carried out by McCarthy led to cloud computings first uses for censuses and financial transactions.

D. 1990s - Internet reliability and Salesforce

By the time the term cloud computing had been used, the internets infrastructure worldwide was reliable enough to provide enough bandwidth for sites to deliver applications and software. The pioneers in this area were *salesforce.com* who specialized in software as a service and created a sale automation piece of software which was launched in winter 1999.

E. 2000s - Amazon, Google, Microsoft and Apple

Originally aimed at becoming the worlds biggest book store when it was first founded in 1995, Amazon moved way beyond selling books and expanded onto the online marketplace selling many different goods and services. In 2002, Amazon began to venture into the cloud with Amazon Web Services which included cloud storage and computation. By 2006, a new cloud was introduced called the Elastic Compute cloud and this helped push the idea of the cloud being more affordable as it was aimed at small companies who wished to rent servers to run their applications.

The cloud would not be what it was today without some of the well-known companies that entered the market near the end of the most recent decade. Google was first with a preview version of its Google App Engine for developing and hosting web applications in Google-managed data centres, it was finally released in September 2011. Microsoft was the other big name that entered the market with Microsoft Azure which was a platform for deploying and managing applications which ran at Microsoft-managed and partnered data centres, it was released in February 2010.

Microsoft and Google also began to develop software as

a service products which would be aimed at personal and business use. Google Drive was launched in April 2012 and provided storage and file synchronisation with pieces of software similar to the Microsoft Office suite (Google Docs, Sheet and slides) at users disposal. Microsoft launched Office 365 in June 2011, it provides businesses with productivity software including exchange servers, SharePoint, Skype for business, Office online and the Office software. Consumers had access to Office online, the cloud storage and the Office software, but these features were dependant on the type of subscription they had.

Apple also entered the cloud computing market with iCloud in October 2011 after users expressed an interest in their data being synchronised between devices and also backed up to the cloud in the event of a device being lost or stolen. As of July 2013, the service had 320 million users.

III. Cloud Computing Services

These are services that are provided over the internet or a network, with delivery when it is needed and payment based on the usage or on the contracts length. The services can be full applications and platforms for development, or they could simply be the renting of a server, storage and virtual machines. The benefit of these services are that the costs align more to the actual usage of the service because of scalability and so this makes the cloud a cheaper alternative to buying the physical hardware. The services can also be utilised from anywhere as long as a device has an internet connection. This results in a better work flow with storage, sharing and protected content accessible at all times. Security is also enhanced with most services providing round the clock support.

Cloud computing services have common attributes as stated by EMC (2015). These are:

- Virtualisation - sever and storage virtualisation which helps allocate and reallocate resources
- Multi-tenancy - resources are shared across an array of users
- Network-access - the resources are accessed via different devices through either a web browser, a remote connection or a thin client
- On Demand - the resources are created from an archive of pre-defined configurations
- Elastic - the resources can be reduced or increased automatically (scaled)
- Metering/chargeback - the usage of the resources are tracked and this helps with billing and costs

The services are split into three categories. The categories make up the Cloud Computing Stack which can be seen in Figure 1.

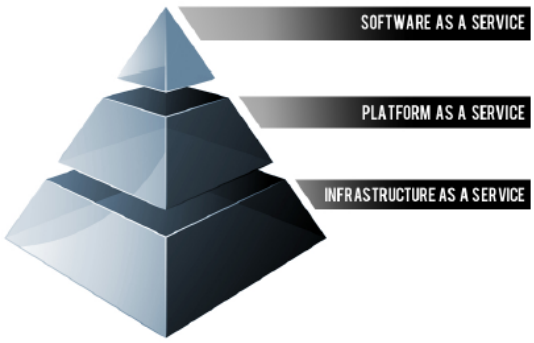

Fig. 1. Cloud Computing Stack
(Image - http://c179631.r31.cf0.rackcdn.com/cloudcomputestackimage1.png)

A. Software as a service (SaaS)

Salesforce (b) states that SaaS is when applications run on a separate machine, usually a server, and are delivered to the user over the internet through a web browser. This means that the user has not got to install and maintain the software on their physical device and so reducing the complexity issues that may be involved with management. The software is sometimes referred to as web-based software, hosted software or on-demand software. The provider of the server manages the access to the application; this includes security, availability and performance. The benefit of this system is that the application is accessible anywhere as long as you have an internet connection.

Examples include:

- Google Apps or Google Drive - which includes email, storage, messaging, calendar and document services
- Microsoft Office 365 - which includes email, calendar, storage and document services
- Salesforce Customer Relationship Management (CRM) product - which includes Sales Cloud, Service Cloud, Marketing Cloud, Force.com, Chatter and Work.com
- Citrix GoToMeeting - which includes features such as online meetings, desktop sharing and video conferencing

Some of these examples are free for small personal use, but can have costs if for example, more storage space is needed.

B. Platform as a service - (PaaS)

Salesforce (a) states that PaaS is model for sustaining applications without having to manage a hardware and software infrastructure. Companies of all sizes use PaaS solutions such as salesforce.com because of the simplicity, scalability and reliability. The features included in the model are also upgraded frequently and automatically which removes any issues when manually upgrading. The idea of PaaS is to remove the expense and complexity of evaluating, buying, configuring and managing all the hardware and software required to create a custom application. It also reduces the time spent developing the product and puts features such as an operating system, a database, middleware and web servers in one central place that can easily be accessed during development. Examples include:

- Windows (Microsoft) Azure - which includes an infrastructure for web apps, virtual machines, SQL databases, machine learning, mobile back-ends and RemoteApps
- Google Apps Engine - which includes the majority of the features in Azure, but also the ability to simply scale your traffic and data storage as your needs change

PaaS is mainly used by companies who wish to create an application without the need to purchase their own hardware.

A companies usage of this service is tracked and billed accordingly making this option extremely affordable and efficient.

C. Infrastructure as a service (IaaS)

Computer resources are virtualised over the internet in IaaS according to Rouse (2015). The model is based on the idea that a third party provider hosts hardware, servers, storage and other parts of an infrastructure for a user. Applications are now built into these systems, these include system maintenance, backup and resiliency planning. One of the big features of IaaS is the idea of scalable resources that can be adjusted on-demand. This means the model is perfect for workloads that may be temporary, experimental or where they may change unexpectedly. Other features that are included in IaaS include automation of administrative tasks, dynamic scaling, desktop virtualisation and policy-based services. IaaS does have its issues however and these include the idea that the provider owns the infrastructure and the provider may have downtime which can affect the customers workload. Examples of IaaS include:

- Windows (Microsoft) Azure - which includes virtual machines and a very reliable service which runs from Microsoft's data centres
- Google Compute Engine - which includes the ability to scale your traffic and data storage as your needs change

IaaS is mainly used by companies who are developing software products and wish to use a platform to test the application or run it. With IaaS being so simple, it is easy to remove the tested software and free the resources for another product. IBM (2015) states that it is the "*Fastest growing area of cloud computing*" and that "*Spending will reach $127 billion in 2018, A five year annual growth rate of 22.8%, which is about 6x the rate of the overall IT market*".
Support (2013) provides a more detailed explanation about the Cloud Computing Stack.

IV. Cloud computing deployment models

There are four main Cloud computing deployment models. What makes each one different is their size, the way they are accessed and what type of user they are aimed at. Victories (2015) states the four models. They are:

A. Public Cloud

This deployment model is usually run by large companies who deliver the cloud service over a network which is used by the public, in this case the internet. The services available are sometimes free or the customer is charged via a license policy like pay per user. The public cloud is used for both personal and business use. Having this public cloud allows people to access features such as their storage space anywhere with an internet connection. This also helps with one of the rules of data backups which is the idea that one backup of your data should be in a different physical location to your device and so the public cloud is perfect for this. One of the biggest examples of the public cloud is Google Drive and Docs, which is a free service to anyone with a Google account.

B. Private Cloud

This method is also known as the internal cloud and is usually run by the IT department of a company. The environment is secure and is safeguarded by firewalls. This security means that only authorised users can gain permission to user certain files and the organisation overall has better control of their data. The private cloud can be confusing at times because the physical computers running it do not need to be in the physical location of the company, but what makes this option better then the public cloud is that the company will know which data centre their system runs in, unlike the public cloud. Overall, the private cloud is better for businesses because they are more efficient then the public cloud and provide the administrators with more resource control.

C. Hybrid Cloud

A model which can be an arrangement of two or more cloud servers that are bound together but remain individual. This system can be managed on-site or by an external provider. Exchanges occur between the cloud servers as per the need and demand. Resources used by the company that are not urgent tend to be stored in the public cloud which is run by a third-party provider. Workloads that are critical to the functioning of the company are generally housed internally on the private cloud. An example of when the hybrid cloud is useful is when a website faces huge demand spikes. The extra resources required by the application on the site can be taken from the public cloud. This term is called cloud bursting. The hybrid cloud has the same features as the other models, including scalability, flexibility and security.

D. Community Cloud

This type of model focuses on the idea that a cloud set-up needs to be shared between many organisations that belong to a particular community such as a group of trading firms. It is a multi-tenant set-up that many organisations use because of their similar computing apprehensions. The companies share the same privacy, security and performance concerns and the idea of the community is to achieve their business related objectives in the simplest way possible. It can be hosted internally or externally by a third-party provider and the cost is shared between the companies making the system less expensive.

V. The cloud and gaming

In 2013, the market of gaming changed with the release of the next generation games consoles. They were the Playstation 4 by Sony and the Xbox One by Microsoft which can be seen in Figure 2.

Fig. 2. Xbox One
(Image - http://www.blackops3.co.uk/wp-content/uploads/2015/06/xboxone.png)

There was a feature that made the Xbox One stand out. When Microsoft held their reveal event in 2012, they announced a way for developers to create even more demanding game titles. 300,000 cloud gaming servers were being deployed to Microsoft's array of data centres. The idea of these servers is to help with the graphic and processor heavy tasks that would occur during certain periods of a game. Xbox Live Lead Programmer, John Bruno, said how *"it could change the way we think about gaming in the future"* according to Aguilar (2013). Bruno also mentioned how *"there is a thrust to turn more things server-side"* and that all developers would be offered the scalable dedicated server resources for free as they want to make Xbox Live the best place to play multiplayer games. The idea that the servers are dedicated also makes for a better play experience with less disconnects being promised and advantages other players may have due to their connection will be eliminated.

One of the big examples Microsoft used at the reveal of the console was the ability for the cloud servers to study how you drive in the newly announced Forza 5 driving game. The data collated from the study would help create a custom AI that behaves like you. You can then race the AI in-game and the AI also races other people online. This links to the idea of machine learning which is something that is found in the Platform as a service category of cloud computing.

Another game that is yet to be released which will use the power of the cloud servers is Crackdown 3. The games multiplayer has been known for its mayhem with destruction and free roaming across a city. The developers wanted the game to have a fully destructible environment and the cloud servers were needed for this. According to Cowan (2015), the cloud computing features will allow for twenty times the computational power of the Xbox One, resulting in enhanced detail and environmental destruction not possible with just the local resources of the Xbox. This cloud feature is not possible in the single-player mode of the game however, which may leave offline users of the Xbox One left out.

VI. Summary and the future of the cloud

From what was once a vision, then a concept and now a worldwide infrastructure, cloud computing has come a long way since the 1950s. With new cloud features available all the time and cloud access being as simple as making an account, this area of Computer Science is likely to continue to grow.

SaaS revenues are expected to reach $106 billion in 2016, increasing 21% over the projected 2015 spending levels according to Columbus (2015). The Cisco Global Cloud Index: Forecast and Methodology, 2013-2018 states that by 2015, 59% of the total cloud workloads will be SaaS, up from 41% in 2013. While SaaS continues to grow, total percentage cloud workloads for PaaS and IaaS will fall, however revenues will continue to rise.

As internet connections become more reliable across the world, the cloud could easily replace data storage on local devices and the software installed on them.

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