A Review on Cloud Computing Development

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***Abstract*—Cloud computing can provide critical services for business management, reducing IT costs and maintenance costs of hardware and software effectively. In the meanwhile, it can enable enterprises to access to professional IT solutions with less IT investment. Cloud computing is of great significance for the ICT industry of each country. It is now bringing enormous impact to the human society, especially the business world. In this paper, the basic concepts and the development of cloud computing were introduced, and then the current situation and development of cloud computing research from two aspects of technology and business were illustrated. Finally future trends of cloud computing were discussed.**

***Index Terms*—cloud computing, IBM clouds, Google clouds, Amazon clouds**

I. INTRODUCTION

Cloud computing refers to the logical computational resources (data, software) accessible via a computer network, rather than from a local computer. It refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS), so we use that term. The datacenter hardware and software is what we will call a Cloud [2].

Cloud computing is a concept put forward by Google, which is a new way to play with computer and Internet. It is a kind of computing which is based on the internet. Shared information is provided to computers and other devices on demand, like the electricity grid.

As a beautiful web application model, it is a paradigm following the transferring from mainframe to client-server in the early 1980s.The technology infrastructure “in the cloud” supports details without users controlling over. Cloud computing describes a new consumption, supplement, and delivery model for IT services based on the Internet. It usually involves over-Internet dynamic scalability and virtualization resources are often provided. This is a by-product and easy access to remote computers via the Internet web site results. It aims at relatively low cost of the network to the calculation of multiple entities into one powerful computing capability with the perfect system, and use of SaaS, PaaS, IaaS, MSP business models and other advanced computing power of this powerful distribution to terminal users’ hands. The word "cloud" is used as a metaphor for the Internet, used to represent mobile phone networks on the basis of the past, and later to depict itself as an underlying infrastructure that represents an abstract computer network mapping of the Internet cloud. Cloud Computing is a core concept of continuous improvement through the "cloud" of processing power, thereby reducing the processing burden on the user terminal, which eventually simplified into a simple input and output devices, simultaneously enjoying the "cloud" computing power of ability when needed. A typical cloud computing provider provides a common business online application which is accessed from another Web service or Web browser as software, and software and data are stored on the server. A paramount element of cloud computing is customization and the creation of a user-defined experience.

Many experts are researching cloud computing. In July 2008, HP, Inter Corporation and Yahoo! announced the creation of a global multi-data center, open source test bed, called Open Cirrus ,designed to encourage research into all aspects of cloud computing. In July 2010, HP Labs India announced a new cloud –based technology designed to simplify taking content and making it mobile-enabled. Site on Mobile is designed for emerging markets where people are more likely to surf the net via cell phones than computers. The IEEE Technical Committee on Services Computing in IEEE Computer Society sponsors the IEEE International Conference on cloud computing (CLOUD). CLOUD 2010 was held on 2010 in Miami, Florida [6].

Years ago, grid computing became the hot issue in the IT world for it opens a new era of integrating resources to solve problems. The same idea (distributed computing) is shared with cloud computing. However, cloud computing is considered to be the technology derived from grid computing with different problem-dealing-aspects of processing but core concept unchanged. The paramount notion of grid computing is collecting all available resources to solve problems (mainly scientific ones) that individual computing center cannot deal with. The most famous case of grid computing, SETI@HOME, searches for extra-terrestrial intelligence using the spare resources from the volunteer Internet-connected computing computers all over the world. On the other hand, cloud computing aims to supply efficient, qualified services with part of the available large scale of computing resources [5].

In this paper, we first introduce the basic concepts and the development of cloud computing. The second part is about key technology of cloud computing, including data storage, data management and programming model. Thirdly, the article will try to explain the impact that cloud computing brings to the business world by offering the examples of three widely accepted cloud services. The next part is about the future challenges of cloud computing. Summary is concluded in the last section.

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II. KEY TECHNOLOGY OF CLOUD COMPUTING

Cloud computing provides the most reliable and secure data storage center. Users no longer have to worry about data loss, virus attack and other problems. Because the world's most professional team are helping you manage information, and the world's most advanced data center is helping you save the data. The cloud computing has the minimum requirement on the client devices, which makes it useful and most convenient. In addition, you can easily realize sharing data and application between different devices. For network applications in the cloud model, data is only one, saved in the "cloud", on the other side. You only need all the electronic equipment connected to the Internet to simultaneously access and use the same data. Cloud computing provides us almost infinite possibility using the Internet. Personal computer or other electronic devices can not provide unlimited storage space and computing power, but in the "cloud" the other side, by the thousands, tens of thousands or even more servers composed of large clusters this can easily be done. Personal and individual devices is limited, but the potential of cloud computing is nearly limitless. In this part, we will introduce key technology of cloud computing, including data storage, data management and programming model.

A. Data storage

Cloud computing stores data in large scale distributed systems in order to provide the most reliable and secure data storage center. Users no longer have to worry about data loss, virus attack and other problems. Because the world's most professional team are helping you manage information, and the world's most advanced data center is helping you save the data. Cloud computing needs massive data storage, but also needs to meet high availability, high reliability and economy, etc. As a result, systems in cloud computing needs to support large data sets, process mode of write once and read many, and have high concurrency.

One of the most important data storage technology of cloud computing is Google File System (GFS). It is constituted by a Master and a large block of servers. Master stores all the Meta data of file system including namespace, access controlling file block information, the file block location information etc. GFS file are cut into 64MB blocks for storage.

GFS file system uses a redundant storage means in order to ensure reliability of data. Each data is saved by more than 3 copies in the system, including two copies in different nodes of the same rack in order to take full advantage of the bandwidth within the cabinet while the other copy is stored in different nodes of the rack.

After obtaining the location information of the target data block from the Master, the client does not read data through the Master but interacts the block server directly.

B. Data management

Cloud computing system has to process and analysis large data sets as to provide high efficient service. Thus data management technology should manage large data sets with high efficiency. What's more, how to find specific data in large data sets is also a key problem in data management [3]. The famous data management technology is the large-scale database system Big Table with the weak consistency requirements [4].

Data items in Big Table are arranged according to the order of line keyword in the dictionary. Each row is assigned dynamically into record tablet. Each tablet server node is responsible to manage for about 100 record tablets. Time stamp is an integer of 64 bit, which indicates different versions of the data. Column family is a collection of several columns, Big Table access permissions is controlled in family size for the column. Big Table system depends on the underlying structure of the cluster system, which includes a distributed cluster task scheduler; the GFS file system which has been addressed above, and a distributed lock service Chubby. Big Table use Chubby which is a very robust coarse-grained lock to save the pointer of Root Tablet, and use one server as master server to conserve and operate metadata. When a client reads data, first Root Tablet location information and meta-data table Metadata Tablet location information are obtained from the Chubby Server, second the User Table of location information including the target data location information are read from the Metadata Tablet, and then the target data location information item are read from the User Table.

Big Table's main server not only manages the metadata but also is responsible to remote manage remotely and allocate for the Tablet Serve; Client-side proceeds control communication with the main server to obtain metadata through the programming interface, and proceeds data communication with the Tablet Server that is responsible to deal with specific read and writing requests[1].

C. Programming model

In order to make customer enjoy cloud computing service more conveniently, programming model in cloud computing must be very simple. Nowadays, most cloud computing systems Map Reduce programming model.

Map Reduce programming framework is to support parallel computing. Map Reduce is not only the programming model that processes and brings about a large data set but also an efficient task scheduling model. It is through two simple concepts about the "Map (map)" and "Reduce (simplified)," that constitute the operation basic unit. The programmer can finish the distributed parallel program development who specifies the data processing to each block data in the Map function and how to regress the intermediate results of the block data processing in the Reduce function. When Map-Reduce program is running in the cluster, programmers do not care how to block, allocate and schedule the input data; even more the system will manage the node failure in clusters and communication between nodes. The implementation of a Map Reduce program requires five steps: inputting file, one file being assigned to many workers parallel, writing intermediate file (local writing), many Reduce workers running, outputting the final result

[1]. Writing intermediate file locally decreases the pressure on the network bandwidth and saves the time on writing intermediate file. If successful, it reads the data needed from the node where the intermediate file is with remote procedure call according to the location information of the intermediate file obtained from the Master.

Public or external cloud introduces the traditional mainstream consciousness in which resource is dynamically fine-grained, on the basis of self-service provisioning via the Internet cloud applications through the network (network service), from off-site third-party providers who bill fine-grained basis for utility computing. The idea of a Private Computer Utility was first illustrated by Douglas Parkhill in his 1966 book "The Challenge of the Computer Utility". The idea was based on direct comparison with other industries (e.g. the electricity industry) and the extensive use of hybrid supply models to counterbalance and mitigate risks. Private cloud and internal cloud have been described as neologisms, despite that the concepts themselves pre-date the term cloud by 40 years. Even within modern utility industries, hybrid models still exist despite the formation of reasonably well functioning markets and the ability to combine multiple providers. Some vendors use the term to describe the product in a virtual private network cloud. These products provide the ability to supply some of the benefits of cloud computing, while reducing the number of defects. These products use data security, corporate governance, and reliability considerations, during this transitional period, push the operation of the services from a product-based industry in a competitive market-driven [6].

III. BUSINESS APPLICATION

Early in the 1960s McCarthy (John McCarthy) proposed the computing capacity as a kind of utility available to users like water and electricity. Almost all the modern day features of cloud computing (elastic provision, provided as a utility, online, illusion of infinite supplying), the comparison to the electricity industry and the use of public, private, government and community forms was thoroughly explored in Douglas Parkhill's, 1966 book, "The Challenge of the Computer Utility". The actual term "cloud ", in which the telecommunications company, who until the 1990s primarily offered dedicated point-to-point data circuits, began offering a similar service and quality, but a much lower cost to virtual private network (VPN) services. Flow balance by switching use, as they see suitable, they can use their overall network bandwidth more efficiently. This cloud symbol is used to represent the cloud cut-off point between that which was the responsibility of the user from that of the supplier. The border extends to the cloud, including server and network infrastructure.

The first milestone in the cloud is made by IBM to supply an enterprise-level Web site of the application of the concept in 1999. Amazon played a key role in the development of cloud computing by modernizing their data centers after the dot-com bubble, which, like most computer networks, were using as little as ten percent of their capacity at any one time just to make room for occasional spikes. Having found that the new cloud architecture brought about important internal efficiency improvements whereby small, fast-moving "two-pizza teams" could add new features quicker and easier, Amazon initiated a new product development effort to provide cloud computing to external customers and launched Amazon Web Service (AWS) on a utility computing basis in 2006.Amazon uses Elastic Compute Cloud (EC2) and Simple Storage Service (S3) to provide computing and storage services for companies. Service charges, including storage servers, bandwidth, CPU resources, and monthly fees. Cloud computing is one of the fastest-growing businesses for Amazon. Google is the largest user in the field of cloud computing. Google's search engine is just on the establishment of more than 200 locations in the distribution of more than 100 million of support on the server. The number of these facilities is growing rapidly. Currently, Google has allowed a third party to run large-scale parallel applications by Google App Engine in the cloud computing of Google [6].

A. IBM clouds

Recently, IBM keeps emphasizing their new concept of 'Smart Planet' in nearly all conferences. One major part of the 'Smart Planet' plan is the cloud computing. The IBM clouds (Blue Cloud) is the combination of grid computing and virtualization, that is to say, the Blue Cloud uses the technical ways of grid computing to integrate resources into a resource pool and then virtualizes the server, separates and offers resources from the pool due to the clients' requests.

'Servers are the base of the computer systems' is a sentence widely spreads in IBM. The Blue Cloud focuses more on the professional or enterprise markets with the strategy of selling or leasing specific servers, software and services to the various enterprise clients.

IBM launched "change the rules of the game" of "Blue Cloud" computing platforms in November 2007, aimed to bring customers the cloud calculative platform which is available once purchased. It is to include a series of automation, self-management and self-repair virtualization of cloud calculative software, making global applications able to access distributed large server pool, allowing data center operation calculation in similar Internet environment. On August 2008, IBM announced that it would invest about 4 million U.S. dollars for its operations on cloud computing data center transformation in North Carolina and Tokyo, Japan.

B. Google clouds

Different from IBM which locates itself as an IT company offers services, Google always see itself as a company relevant and based on the Internet; different from the Blue Cloud, Google clouds faces mainly the common users of the Internet. This is why currently Google clouds are the best known clouds to the public. The core concept of Google's clouds is to offer the service platform in which the software is not run on the clients, nor is the data stored in the clients. Google clouds

gain requests from the users then return results: all process is completed on the Internet servers who offer cloud computing services – we can see examples like using office software (Google Docs) only with an Internet explorer. Technology architecture of Google cloud computing platform is shown as Figure 1.

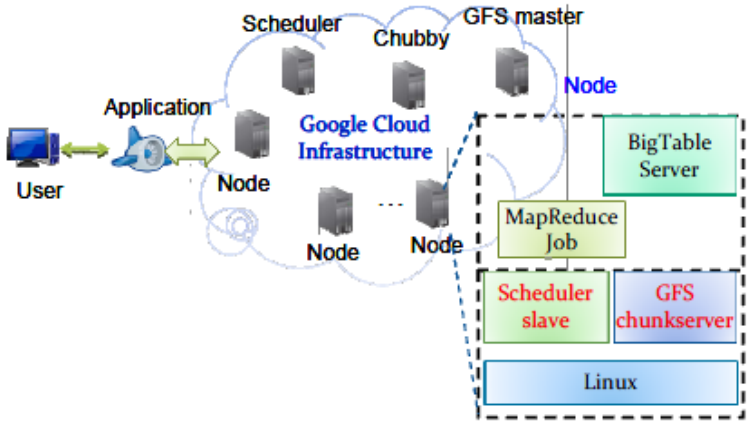

Figure 1. Technology architecture of Google cloud computing platform [1]

In Google's declarations, 'The Google File System demonstrates the qualities essential for supporting large-scale data processing workloads on commodity hardware.' By using their cloud computing technologies, the computational cost has been lowered to 1/100, and the storage cost has been lowered to 1/30. Five characteristics can result in such tremendous cost reduction:

- In Google's clouds, except the few managing nodes like GFS Masters, nearly all nodes in the Google cloud are symmetric. These nodes can store data, manage data and deal with tasks in the same time. So the cost of the equipment of nodes can be reduced by standardization and bulk purchases.
- Contributed by the data managing ways of distributed computing, the computing ability needs of individual cloud nodes is lowered so that expensive UNIX servers or SAN storage equipments are no longer essential to offer qualified services.
- Google clouds provide fault tolerance by constant monitoring, replicating crucial data, and fast and automatic recovery. Resource redundancy rate can be impressively decreased in such way.
- The cost of software in Google clouds is very low, because the majority of Google cloud software and applications are open-source or written by Google itself.

C. Amazon clouds

Amazon is considered to be the first company which provides cloud computing services on a large scale. Having reached the needs of offering sufficient accessing capacity, Amazon found that in much time its servers are partly used while the others remain free from load, and then began thinking of renting its idle servers to other companies. Of course, such renting is not in physical ways but on the Internet. Based on such will, Amazon develops a series of web services (Amazon Web Services, AWS), such as Amazon Elastic Block Store (EBS), Amazon Elastic Compute Cloud (EC2), Amazon Simple Storage Service (S3), etc.

Amazon EC2 is seen as the first typical mode of cloud computing since it has the features of virtualization, on-demand provisioning, and 'pay as you go' usage-based pricing. It is also proved that though Amazon EC2 might not be able to deal with extreme complicated scientific issues, it can easily satisfy the common computing or data managing demands of a company or an individual with no doubt. Different from both Blue Clouds and Google clouds, Amazon EC2 mainly offers service to neither enterprise nor personal usage but the software companies based on the Internet – can be seen as some sort of combination of Blue Clouds and Google clouds. Due to the strong computing ability and the mass storage capacity of Amazon clouds, EC2 attracts large amount of users and earns much money for Amazon. It is said that EC2 and other services play an important role in Amazon's defeating its rivals like EBay Inc.

Society and the family now has a personal computer which is called PC for short , of which only 30% of the computing power being used, or even lower, while the remaining 70% is actually being idle. The idle computer resources and computing power can be used effectively only through a distributed system, which can greatly enhance the computing power of a country. And computing power is a measure of national strength and research capabilities of a country index. Cloud computing is to connect the common server or personal computer to get functions of a super computer , but at lower cost. Cloud computing is to develop both technology and economy of a country, so it has a great potentiality.

Policy makers need adequate attention to this, so as not to miss the opportunity. According to a market research report from Ovum, cloud computing must be part of the ICT industry policy of each country. "National Cloud" will provide market opportunities for local ICT industry. In addition, the government can manage cloud computing according to their own demands, with its own regulations

and policies, ensuring their own security requirements [5].

IV. FUTURE CHALLENGES

A. Protocols reaching

As a newly found technique, cloud computing has an incredible speed of gaining focus and developing. Although the market of the cloud computing is now blooming, there is a serious problem that has to be solved – a world-wide-accepted protocol is missing. A major selling point for cloud computing is that it offers significant computing capability with low rent and easy accessing ways. As mentioned above, the three representative cloud serving companies provide cloud computing services oriented towards different groups of clients. Such mechanics could run well before the explosive development of cloud services. In order to become the technique in common use, cloud computing needs all-accepted or dominant protocols, like the TCP/IP Protocols in Internet surfing, or the factual protocol of PC operating systems – an OS like the Microsoft Windows®. With such protocol, clients or APIs to the cloud will be standardized, which will benefit the popularization or spread of cloud computing and lower the costs [5]

B. Performance Unpredictability

Multiple Virtual Machines can share CPUs and main memory surprisingly well in Cloud Computing, but that I/O sharing is more problematic. The average memory bandwidth for 75 EC2 instances runs the stream memory benchmark. The mean bandwidth is 1355 mbytes per second, with a standard deviation of just 52 mbytes per second, less than 4% of the mean. The mean disk write bandwidth is nearly 55 mbytes per second with a standard deviation of a little over 9 mbytes per second, more than 16% of the mean. This demonstrates the problem of I/O interference between virtual machines.

Another unpredictability obstacle concerns the scheduling of virtual machines for some classes of batch processing programs, specifically for high performance computing. Given that high-performance computing is used to justify Government purchases of $100M supercomputer centers with 10,000 to 1,000,000 processors, there certainly are many tasks with parallelism that can benefit from elastic computing. Cost associativity means that there is no cost penalty for using 20 times as much computing for 1=20th the time. Potential applications that could benefit include those with very high potential financial returns, financial analysis, petroleum exploration, movie animation, and could easily justify paying a modest premium for a 20x speedup. One estimate is that a third of today's server market is high-performance computing [2].

C. Data security and reliability

In 2008, the Gartner Company released a cloud computing danger report in which seven latent risks are mentioned: privileged user access, regulatory compliance, data location, data segregation, recovery, investigative support, long-term viability. As cloud computing is the way that clients access the resource in other physical addresses, to ensure data confidentiality, integrity, and availability (CIA), the cloud server must provide: a tested encryption schema to ensure that the shared storage environment safeguards all data; stringent access controls to prevent unauthorized access to the data; and scheduled data backup and safe storage of the backup media.

Needless to say, companies only builds their key databases on environments which are both secure and reliable. What is more, there should not be any restrictions to apply the cloud any time, any where with an Internet access. This means that the cloud provider should check their network connection all the time and might have to negotiate with the governments so that no restriction is added on their services. And this is also a reason why protocols are essential – with reached protocols, cloud servers are more likely to convince the governments, and with such protocols, the governments can be inspected by the whole world about the permission of qualified services. In a word, unless the cloud servers ensure the requirements mentioned above, there is no way for the whole worlds' confidence, which is indispensable for people accepting cloud computing as a working manner or lifestyle [5].

D. The Internet of Things

The Internet of Things is a new idea in the IT world which refers to the networked interconnection of everyday objects. In the wide-spread concept, such interconnection is a kind of wireless sensor network constructed in self-configuring ways.

One core technique of the Internet of Things is how to identify objects based on the information gain by the sensors. It is obviously impossible to store identifiable characteristics of everything in the sensors: if we do so, the sensors would become much more complicated than common-known sensors, they would need much more storage memory and processing ability, and then the cost would increase exponentially. The feature of cloud computing that it only needs simplest clients to provide input and receive output can let the sensors be the sensors: sensors gain statistics and upload to the cloud servers, then the cloud will deal with the statistics then return result of object identification to the sensor—or the client [5].

E.Data mining

Data mining is the process of extracting patterns from data, which means analyzing data from different perspectives and summarizing them into useful information. Data mining has always been the hot issue in searching techniques for it can decide how fast the searching process could be completed or how well the searching results fit the origin demands of the searchers. Another useful application of data mining is in business cases. Researchers use data mining to gain underlying relationship between or growing tendency of statistics in order to build up suitable (usually mathematical) models and make wise decisions of investment.

In the past, scholars are always busy finding better algorithms to fulfill data mining tasks with costs (mainly memory and time) as low as possible. But with cloud computing, researchers no longer need to worry about the

computing ability, which means the available memory can be considered infinite and the time running data mining programs can be considered extremely short. In other words, people could be able to solve those 'impossible missions' with cloud computing methods, like mining data from not only words or numbers but also images or even videos [5].

V. CONCLUSION

Cloud computing, seen as the great network-tech breakthrough, might bring us to the 'cloud society' after the PCs and the Internet brought people to the 'network society'. In the scheme of cloud computing, all the everyday usage of PCs will be transferred into the clouds (virtualized mass computational servers which cooperate on the Internet), all we need is an access to the Internet and then we do every work on it. Actually, we do not 'do' works on the access but require task-solving services from the cloud via the access, and the result is sent back on it. Undoubtedly, if such scheme comes true one day, the way that people live as well as work will be totally different then. However, cloud computing has been already changing the way that the business world runs; this is going to be discussed in this article.

By analyzing the cases mentioned above, cloud computing can surely make the business world more convenient and efficient and it is even potential to bring about revolutionary changes to the human society, people would use more and more 'Web-Based' applications instead of the current 'Desktop-Based' ones. However, after all, all the stuff that cloud computing can offer is only a platform and some new ways for running services. No matter how well the platform is developed, if the services provided are not brilliant enough, it will surely end up with an eventually failure.

PCs are welcomed by everyone not because of the characteristics itself but the software developed for it; the Internet becomes so charming because of the application based on it but not the direct but dull connection it offers by itself. So how successful will cloud computing be is also not decided by the techniques of itself but determined by the 'accessories' of it – the storage capacity, the software, the applications, all in one, the services it can provide [5].

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