# A Survey on Cloud Storage

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***Abstract*— Cloud storage is a new concept come into being simultaneously with cloud computing, and can be divided into public cloud storage, private cloud storage and hybrid cloud storage. This article gives a quick introduction to cloud storage. It covers the key technologies in Cloud Computing and Cloud Storage. Google GFS massive data storage system and the popular open source Hadoop HDFS were detailed introduced to analyze the principle of Cloud Storage technology. As an important technology area and research direction, cloud storage is becoming a hot research for both academia and industry session. The future valuable research works were summarized at the end.**

***Index Terms*—Cloud Storage, Distributed File System, Research Status, survey**

## I. INTRODUCTION

As we all known disk storage is one of the largest expenditure in IT projects. ComputerWorld estimates that storage is responsible for almost 30% of capital expenditures as the average growth of data approaches close to 50% annually in most enterprise. Amid this milieu, there's strong concern that enterprise will drown in the expense of storing data, especially unstructured data. To meet this need, cloud storage has started to become popular in recent years.

Cloud storage is a new concept come into being simultaneously with cloud computing, which generally contains two meanings: It's the storage part of the cloud computing, virtualized and high scalable storage resource pool. Cloud users access to cloud computing services based on the cloud storage resources pool, but not all storage part can be separated in cloud computing. Cloud storage means that storage can be provided as a service over the network to the user. User can use storage pass through a number of ways, and pay by the use of time, space or a combination of both. Obviously, such statement is not tightly defined this new concept of cloud storage. In addition, the relationship between the concepts of Cloud Storage, Storage Cloud [1][2], Storage as a Service, Cloud-Based Storage should be cleared.

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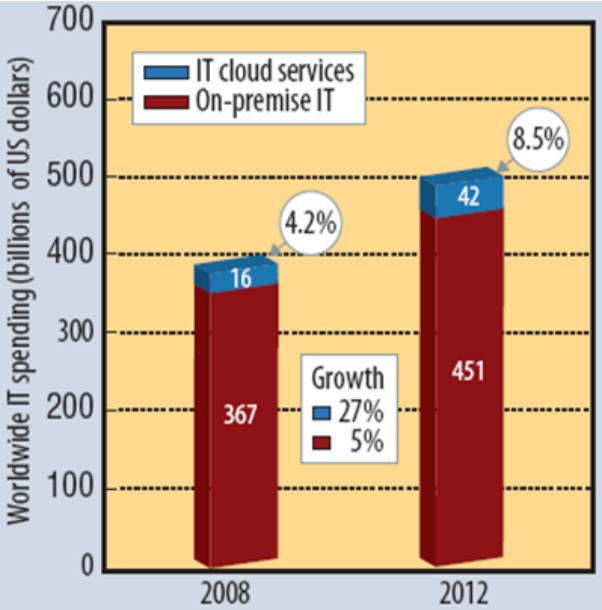


Figure 1. IT cloud services spending prediction from IDC

Cloud storage is divided into public cloud storage, private cloud storage and hybrid cloud storage. Public cloud storage is designed specifically for large-scale, multi-user cloud storage. All components are built on a shared infrastructure, and public storage devices were logical partitioned through virtualization technology, data access, data management technology, according users need. Also known as internal cloud storage, private cloud storage is designed for a specific user. Unlike the public cloud storage, private cloud storage running on a dedicated storage devices in the data center so as to meet safety and performance requirements. However, it's obvious disadvantage is the relatively poor scalability. The hybrid cloud storage is the cloud storage to integrate public cloud storage and private cloud storage. Generally, hybrid cloud storage was case-based in private cloud storage, supplemented by public cloud storage.

## II. INTRODUCTION FORMATION OF CLOUD COMPUTING


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In the past nearly ten years, the academia and business put forward similar “Cloud computing” concept and mode in succession, such as "Grid Computing", "On-demand", "Utility Computing ", " Internet Computing", "Software as a service ", " Platform as a service” and other, in order to achieve the target of make full use of network computing and storage resources, wide range of cooperation and resources sharing, high efficiency and low cost in computing, but the concept of “Cloud computing” formally advanced recently in 2 years. Because of its clear commercial pattern, Cloud computing has become the widespread concern and be generally recognized in both industrial and academic circles, as one of the ten most popular IT technology in 2009. According to IDC, the global market size of Cloud Computing is expected to be increased from 16 billion dollars in 2008 to 42 billion U.S. dollars in 2012, and the proportion of total investment is expected to rise from 4.2% to 8.5%, as shown in the Fig.1. Moreover, according to forecasts, in 2012, the input of Cloud Computing will take up 25% of the annual increase of IT investment, and 30% in 2013.

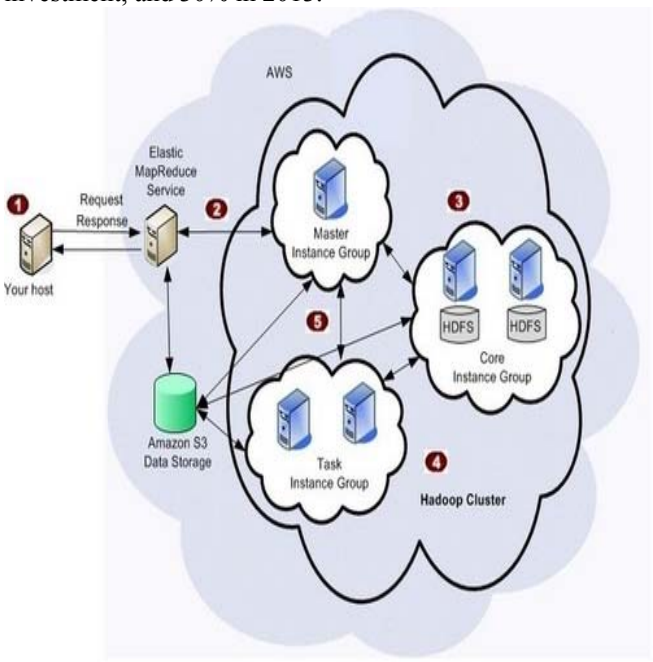


Figure 2. Amazon S3 (Simple storage Service) on EC2 (Elastic Compute Cloud) Platform

Amazon launched S3 (Simple Storage Service) and EC2 (Elastic Compute Cloud) [3][4], which marks a new stage in the development of “Cloud computing”. Fig2. Described the Amazon Storage Service on its EC2 platform.The network infrastructure services are provided to customers as new commercialized resources, and EC2 has become the current fastest growing business. Google has been dedicated to the promotion of the GFS (Google File System) [5], MapReduce [6][7] and BigTable [8] technology-based Application Engine for user’s massive data processing. In 2007, IBM launched the “Blue Cloud” computing platform, using the Xen, PowerVM virtualization technology and Hadoop technology, in order to help customers build cloud computing environments. Microsoft immediately set out from Live Service to open the market after the announce of Windows Azure cloud computing operating system plan, its architecture was shown in Fig.3. The first vMware cloud computing operating system vSphere4 points to the enterprise data center forward, and it transforms enterprise data centers into Cloud Architecture based on virtualization, and so as to help enterprise data center energy to the utility of 30%~50%. As one of the four cloud computing services categories, SaaS success stories include Salesforce CRM (Customer Relationship Management) platform, Alisoft SME management software platform, which also had a great impact. In addition, EMC launched cloud storage architecture, and Apple introduced mobile information services based "Mobile Me" cloud services.

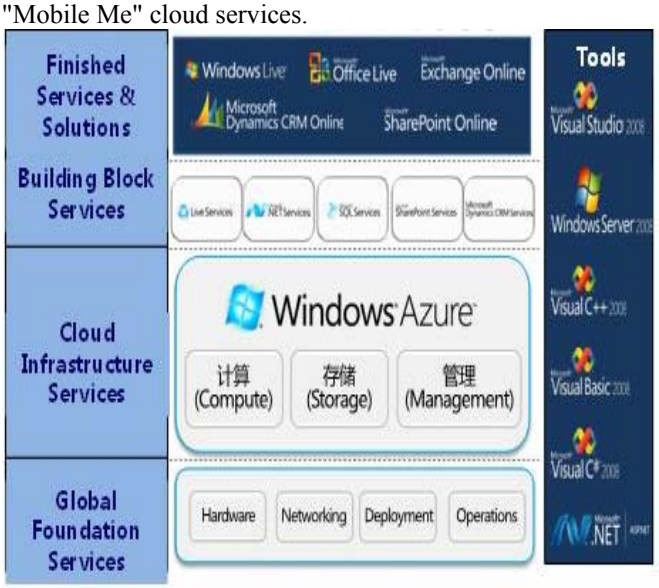


Figure 3. Microsoft Windows Azure cloud platform architecture

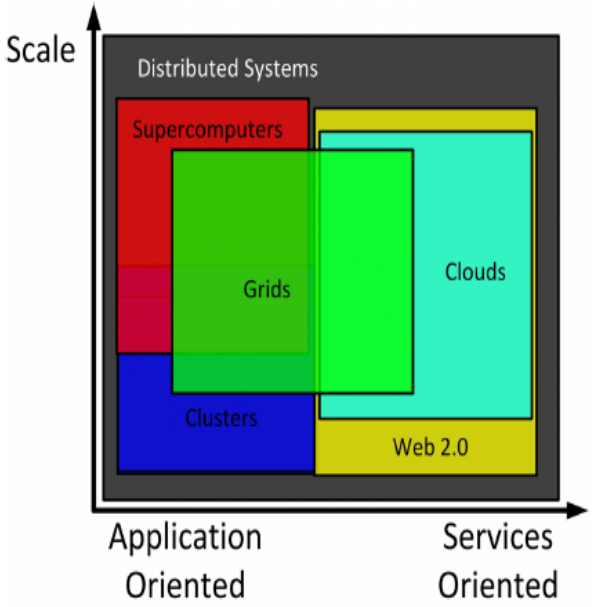


Figure 4. Relationship between cloud computing and related field

Cloud computing is the mixed evolution and jumped of Virtualization, Utility Computing, IaaS (Infrastructure as a Service), PaaS (platform as a service), SaaS (software as a service), and the latest developments of Distributed Computing, Grid Computing and Parallel Computing, or the commercial implementations of these computer science concepts. To distinguish the difference between the form of related calculations, will help us to understand and grasp the essence of Cloud computing. Fig 4. Is a description of the relationship between cloud computing and related field.

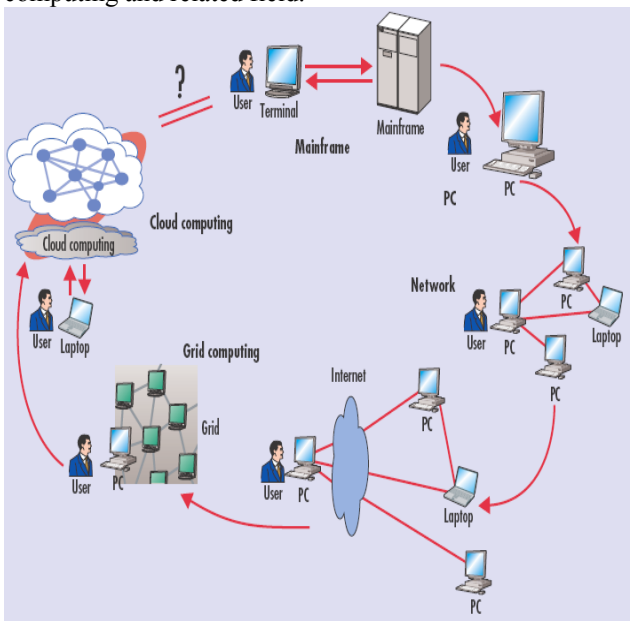


Figure 5. Six distinct phases of computing paradigm shift

In order to better understand and study "Cloud computing", many computer experts and scholars tried to define from different perspective and different way [9] [10] [11]. Based on all the point of view and our understanding, we put forward a reference definition [12] "Based on Virtualization technology , Cloud computing is the supercomputing mode to integrate massively scalable distributed computing, storage, data, applications and computing resources to work together and provide infrastructure, platform, software as services via networks." The goal of cloud computing is the lower cost of cloud computing resources than the resources user can provide, manage and control itself, but also has greater flexibility and scalability. As Fig.5 shows, a conceptual layer—a cloud on the Internet—hides all available resources (either hardware or software) and services, but it publishes a standard interface. As long as users can connect to the Internet, they have the entire Web as their power PC.

## III. CORE TECHNOLOGY OF CLOUD STORAGE

Storage technology has gone through the development course from the tape, disk, RAID to storage networking system. n recent years, the application demand for massive data storage is increasing, which directly contributed to the emergence and development of high-performance storage technology, and have produced some typical storage technology being fully applied in Cloud computing, such as the Google File System (GFS) [5], Hadoop Distributed File System (HDFS) [13], S3 [14], SAN.

Traditional storage means a specific storage device, or the assembly constituted by the large number of the same storage device. In using traditional storage, you need a very clear understanding of some of the basic information of the storage device, such as device type, capacity, supported protocols, transmission speed. In addition, regular maintenance of the equipment, hardware and software updates and upgrades need to be considered separately. Although cloud storage is composed by a large number of storage devices, storage devices can be heterogeneous and cloud storage users do not care about the basic information of the storage devices and its location. In cloud storage, issues such as equipment failures, equipment updates and upgrades were also be full considered, and can provide more reliable service.

The core of cloud storage is the combining of application software with storage device, to achieve the changes from storage device to storage service by application software. It's not directly to use storage devices but the Data Access Service provided by the entire cloud storage system for users. So in the strict sense, cloud storage is not storage but a service. Cloud storage provides directly data storage services for end users and indirect data access in application system, and other forms of service, with many service forms of network hard drive, online storage, online backup and online archive storage service.

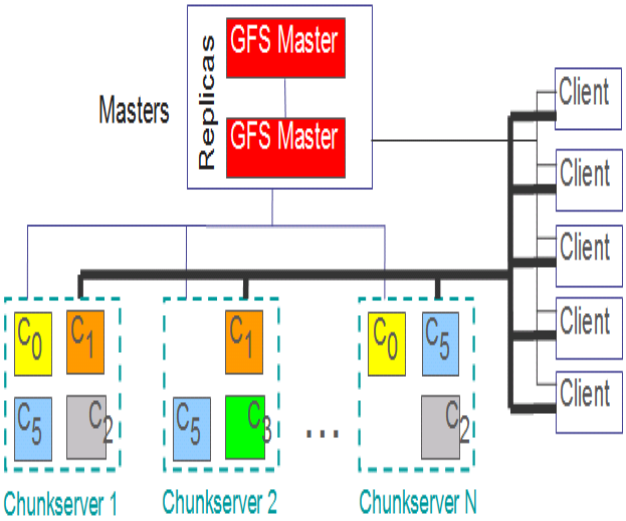


Figure 6. The Google File System Architecture

Operating system, service procedures, user application or the vast amounts of data are stored in storage systems, the basis role and status of storage is widely recognized by the industry in supporting the popular cloud computing. To achieve massive data storage, cloud computing service providers must build a huge database of globalization and storage center. For example, Google's great success in the field of cloud computing considerable extent thanks to its advanced cloud storage platform based on GFS. GFS is a distributed file system

to handle large-scale distributed data, Fig 6. Show its architecture [5]. A GFS cluster consists of a Master server and multiple block server (Chunkserver), and access by multiple clients. The Master server is responsible for the management of metadata, the name space of the stored files and blocks, the mapping relationship between the file to blocks and the storage location of each block copy. The file is split into blocks of fixed size (64M) and be storage in the Chunkserver. Blocks were processed as Linux files and stored on the local hard disk. To ensure reliability, each block was saved with 3 backups in default. The Chunkserver obtain the data directly back to the client after the client transmitting a data request.

## IV. Hadoop Distributed File System

After the analysis of Google's GFS massive data storage system, we will discuss the popular open source cloud storage system Hadoop's HDFS. Hadoop is an Apache open source organizational design of a distributed computing framework, its core technology HDFS, MapReduce, HBase were the open source implementation of GFS, MapReduce, Bigtable in Google cloud platforms. It is worth mentioning that Hadoop can run on a large number of cheap machinery and equipment.

Having many similarities with other distributed file system, the features of HDFS are also very obvious because of its targets and assumptions of Hardware Failure based design, Streaming Data Access, Large Data Sets, Simple Coherency Model, Moving Computation is Cheaper than Moving Data, Portability Across Heterogeneous Hardware and Software Platforms [13]. Although HDFS running on cheap commodity hardware, it can meet the data access requirements of high reliability, high throughput, large data sets.

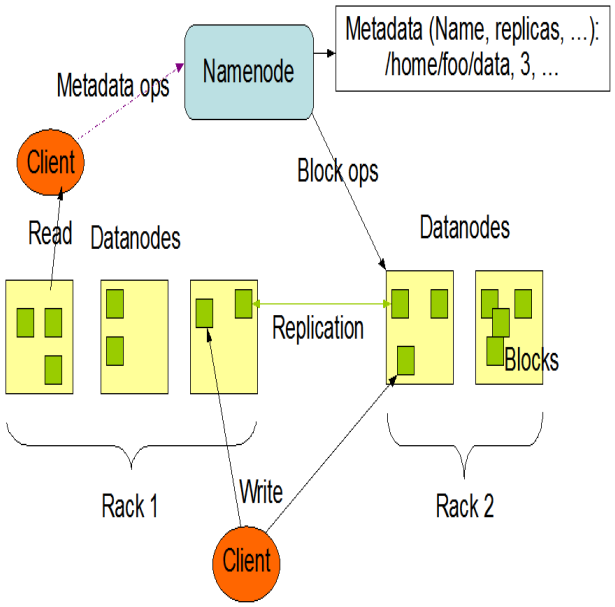


Figure 7. The HDFS Master/Slave architecture

As shown in Fig7, in HDFS Master / Slave architecture, every Cluster is composed of a NameNode and multiple DataNode and multiple Clients. The NameNode is mainly responsible for managing the file system namespace, cluster configuration information and stored block copying, storing Metadata of the file system to memory, and this information includes the file information, the file block information for each file, DataNode information of each file Blocks. The NameNode execute file operations, including open, close, rename, catalog maintenance, it also determines the mapping between the Block and DataNode. Internally, a file is divided into one or more Blocks. DataNode is responsible for the read and write requests from Clients, and executing instructions of Block establish, delete, copy and other, issued by the NameNode. DataNode stored Blocks and their Metadata in the local file system, and periodically sending information of existing Blocks to the NameNode at the same time. Clients are applications to get a file from the file system.

## V. Cloud Storage Researchs

In Cloud storage, data were distributed to plurality nodes of multiple disks, so the system needs simultaneously high-speed read and write to multiple disks. The speeds of disk data read and write should be prioritized after the basic problems of storage capacity in cloud storage architecture design. In fact, larger disk capacity can be obtained by combining multiple disks, along with the continued expansion of the hard disk capacity as well as hard drive prices continue to fall.

To achieve this purpose, there are two options in storage technology, a similar GFS, HDFS Sector [1] and other similar cluster file system, and the other is storage area network (SAN) systems based on block device. For example, in IBM's "Blue Cloud" computing platform [15] [16], the block device interface was provided by the SAN, while HDFS is a distributed file system built over the SAN, and their collaborative relationship were determined by applications in the cloud computing platform.

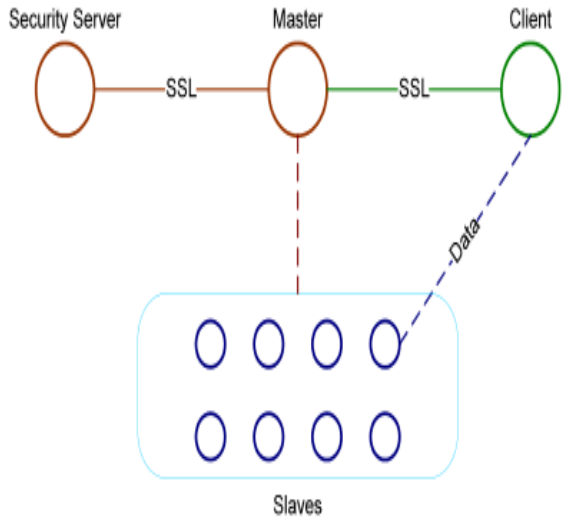


Figure 8. The Sector system architecture

At present, the main high-performance distributed file systems in cloud storage platforms, including Google's

GFS, HDFS [13] used in IBM "Blue Cloud" and Yahoo, Amazon's S3, etc.. In addition, Microsoft's SkyDrive, Sun's Honeycomb, HP's Upline, Alibaba's Alicloud, EMC's Atoms and other public cloud storage for end-users were also included. Of which, HDFS, KFS [16] Sector [1] are open source projects reference to GFS. Nirvanix's C1oudNAS [17], Parascale's Cloud Storage are typical organization internal private storage cloud solutions.

Academia cloud storage researches are also very popular. Robert L.Grossman [1] from University of Illinois, USA, proposed and implemented a compute and storage clouds Sector/Sphere [18], using wide area high performance networks, and the experimental test performance is better than Hadoop [19]. As shown in Fig8, in the Sector system [18], file access information, user passwords and user accounts, were maintained by the Security server. The authorized slave nodes IP addresses lists were also maintained, so illicit computers cannot join the system or send messages to interrupt the system. Figure 9 illustrates how Sphere processes the segments in a stream [18].

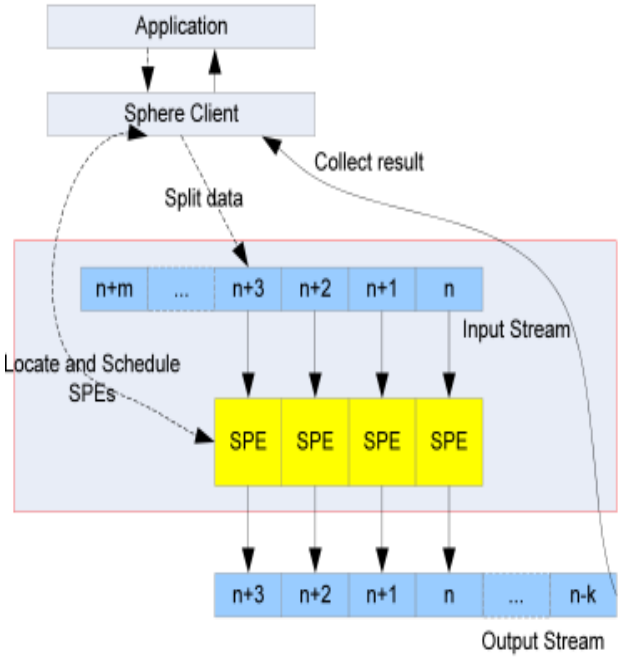


Figure 9. The computing paradigm of Sphere

James Broberg [20] [21] from University of Melbourne, Australia, designed and proposed the MetaCDN to integrate different cloud storage services of providers and to provide a unified, high-performance, low-cost content distribution storage and distribution services for content producers or creators. Kevin D.Bowers of [22] the RSA Laboratories proposed a high-reliability, completeness cloud storage model HAIL, and completed the experiment from safety and efficiency aspects. David Tarrant [23] from University of Southampton, UK, proposed a knowledge base storage model of cloud storage dynamic integrating with local storage.

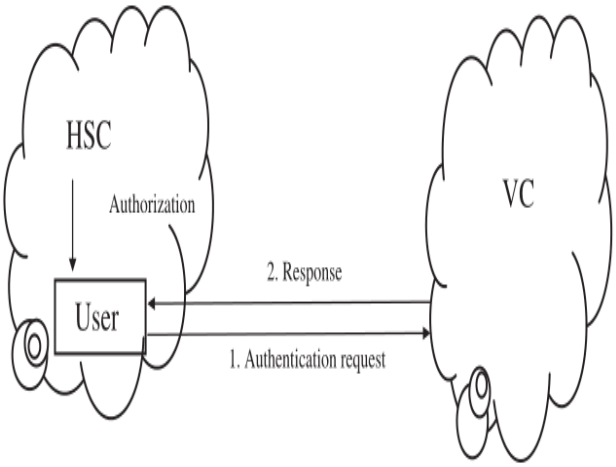


Figure 10. The novel one-round cloud authentication model

In paper [24], XIE of Hangzhou Normal University, China, proposed a novel one-round authentication protocol for cloud. As shown in Fig10, a home service cloud (HSC) registered user can pass through the authentication of the visiting cloud without the help of his HSC. At the same time, the proposed scheme is provably secure in the random oracle model. China Tsinghua University researchers designed and implemented a cloud storage platform composed with the data sharing service system Corsair [25] and distributed file system Carrier [26], to provide personal data storage, community-based data sharing and public resources data download service for teachers and students in the school. WU and HUANG [27] proposed a typical cloud storage platform architecture, including resource pool, Distributed File System, Service Level Agreement (SLA), Cloud service interface, cloud users five main parts.

## VI. Conclusions and Future Work

Cloud storage is better than traditional storage in functional requirements, performance requirements, cost demand, demand for services and portable needs. With the research and development of cloud storage, cloud storage will gradually go beyond the traditional storage and to provide user high-quality, high standard, high reliable service [28] [29] [30].

This article gives a quick introduction to cloud storage. It covers the key technologies in Cloud Computing and Cloud Storage. Google GFS massive data storage system and the popular open source Hadoop HDFS were detailed introduced to analyze the principle of Cloud Storage technology.

As an important technology area and research direction, cloud Storage is becoming a hot research for both academia and industry session. The future valuable research work including: Performance analysis, optimization, design and implementation of distributed file system similar to GFS; Storage virtualization technology [31] [32], storage network management technology; cloud data compression [33] [34], backup technology [35], deduplication technology [36] and data encryption technology [37] ; cloud storage platform

architecture design and implementation, integration and data interaction between heterogeneous cloud storage platforms [38] [39] [40]; private storage cloud, public cloud storage application model and QoS assurance [41][42]; CDN Technology and content distribution services; cloud storage study related to specific application such as Internet of Things [43], geographic information [44] [45], security monitoring, medical information, education information resources [46][47]; construction of mobile cloud storage [48], peer-to-peer (P2P) storage systems [49] [50], and social cloud [51] [52].

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