Construction of a New Network Information Resource Storage System

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Abstract. On the basis of introducing the function of information storage system, this paper analyzes the advantages and disadvantages of three kinds of traditional information resource storage systems: Direct Attached Storage (DAS), network attached storage (NAS) and storage area network (SAN) ct-Based Storage . Compared with the traditional storage mode, the storage system is intelligent because of the introduction of the concept of object. With the further development of object storage, this storage mode can realize all the functions of block or file, and also has the intelligent mechanism of self-management and self adaptation that block and file storage system do not have.

Keywords: Information Construction, Storage System, Network Storage

1. The function of information storage system

The development and progress of human society has always been inseparable from the storage and dissemination of information. In the early days, people used a variety of expression forms and storage methods to express and store information. Nowadays, with the development of computer and communication technology, the digitization of information resources has been accelerated, the speed of information exchange has been improved, and human society has entered a new era - "information centered" The era of computer network. With people's increasing dependence on information systems and networks, the value of information resources has been constantly improved, and has gradually become a strategic resource for national development. Furthermore, the loss or damage of information data will bring immeasurable loss. According to a survey of the global information industry, about a quarter of the respondents lost about US $250000 per hour due to data loss, and 8% of the respondents lost nearly US $1000000 per hour.

The basic functions of information storage are as follows[1]:

1. Improve the security protection and guarantee ability of data (the basic existing form of information) resources;
2. Ensure the access service of data resources, realize the permanent storage and uninterrupted access ability of data;
3. The distributed sharing of data resources and the unified management of distributed storage resources are realized;
4. Ensure the robustness and availability of the whole information application environment and system platform, simplify the information system architecture, and enhance the interconnection, interoperability and interoperability among the systems;

5. Reasonable and effective data storage can directly reduce the workload of information system, reduce the number of data migration, and realize the dynamic expansion ability of separating application system and storage system.

2. The influence of network on information storage

The peak computing power of high-performance computer has reached tens of millions to hundreds of millions of operations per second, and the channel speed of I/O system has also reached 10MB/s at that time, the highest performance hard disk capacity was only about 500MB, and the transmission rate was about 1.2mb/s, which is far from meeting people's requirements for high-performance applications of information system. In order to alleviate the I/O bottleneck of the storage system, many effective researches have been carried out, such as partitioning the data requested by the host and storing it in multiple disks, cross read and write technology for data stored on multiple disks; and distributed storage technology for global addressing of storage space of multiple disks so that data can be stored according to the storage space after global addressing\[2\]. Among them, the most representative is the redundant fault-tolerant disk array implemented by David A. Patterson of the University of California Berkeley in the United States, who first proposed the concept of RAID (redundant arrays of independent / nonexpensive disks), and gradually made the disk array the most important component device in the modern storage system. At present, the single block capacity of hard disk has exceeded 500GB, the transfer rate of IDE (integrated driver electronics) hard disk drive has exceeded 133mb/s, the transfer rate of new serial advanced technology attachment (SATA) bus interface is 300MB/s, and the transfer rate of serial SCSI (small computer system interface) bus interface is up to 600MB/s. Although the software and hardware technology of storage devices are constantly developing, and the performance is also improving, it still can not catch up with the development speed of computing and communication technology.

Through the research, it is found that the early information storage system has serious defects in its own architecture, which is the main bottleneck hindering the overall performance. For example, the performance of BAS (bus attached storage, also known as embedded storage) basically depends on the file server, and the storage device exists as a subsidiary part in the system. In this kind of storage system, the storage and exchange of data are server centered. When users access the information resources on the file server through the network, the accessed data will go through the "store forward copy" process of the server for many times, and finally be transmitted to the client. The data flow is shown in Figure 1. The storage device is connected with the server through the peripheral bus, and the server is connected to the public network through the network card. When the user requests the corresponding I/O service, the server responds to the request and calls the device driver to read and write the storage device through the file system and I/O system. Then, the result data is returned to the server by the same path and provided to the users[3].

![Storage access process of conventional file system](image-url)
In the traditional storage system, the server does not care about the content of the information data, and usually does not process the data itself, but the whole I/O request process requires the participation of the server. The constraints of this participation mode on I/O performance are mainly reflected in two aspects: (1) as the "adapter" of data interaction between users and storage devices, the server undertakes the conversion of a series of protocol standards to eliminate the differences among storage devices, distributed file systems and user applications. In the early era when the speed of computer system was generally slow, the restriction of this protocol conversion overhead on the system performance was not obvious compared with other factors, but with the improvement of processor speed and the emergence of high-speed network technology, the restriction of this overhead on the system performance began to highlight; (2) at present, the disk array has fast response speed and high data transmission rate, but due to the server and magnetic field Due to the limitation of I/O bus between disk arrays, the available bandwidth is much lower than the peak bandwidth of disk array. Moreover, the data flow of user I/O request has to be forwarded by the server, and the overhead of the intermediate links will eventually reduce the bandwidth. When users send out a large number of I/O requests, the server will produce a "bottleneck" of data access, which is mainly concentrated in the server's processor, main memory, storage device, master-slave channel and network transmission, as shown in Figure 2.

![Figure 2. Bottleneck problem of DAS](image)

Carnegie Mellon University research shows that these "bottleneck" effects will eventually lead to a reduction in storage resource utilization to about 3%[4]. Therefore, in order to improve the storage performance, we must break through these bottlenecks. In the improvement measures, the improved cache technology, prefetching technology, scheduling strategy and overlapping I/O algorithm are used to eliminate, hide and reduce the differences between all levels of memory, shorten the storage response time, and solve some bottleneck problems. However, as the development speed of disk and memory is far lower than that of processor and network, it is very limited to rely on a single expansion of hardware performance to improve the storage performance. Therefore, it is necessary to seek an improved and optimized storage architecture to meet the storage performance requirements of user expansion, capacity expansion and bandwidth expansion.

3. Traditional information resource storage system
The traditional information resource storage system can be divided into DAS (Direct Attached Storage), NAS (Network Attached Storage) and San (storage area network) according to the topology.

3.1. Direct Attached Storage——DAS
DAS (Direct Attached Storage), also known as SAS (server attached storage), refers to the data storage device directly attached to the I/O expansion interface of the server. The operation of these storage
devices will depend on the attached server, and the storage system itself is only a simple stack of storage device hardware, without any storage service management function.

**Figure 3.** Direct attached storage structure

As shown in Figure 3, DAS can be understood as a storage device directly connected to the host through a dedicated I/O bus. In fact, it is a server-centric storage architecture. Various storage devices are connected to the server through IDE or SCSI I/O bus. All user requests and data transmission must go through the server.

The reading and writing process of data is: "the user sends a request to the file server, the file server parses the request and sends the command to the storage device, the storage device reads and writes the data, returns the result to the file server, and the file server returns the result data to the user".

In the application environment of independent work, this method still has a strong storage advantage. But when the storage system needs to be used in the network sharing environment, the storage efficiency of DAS will become very low. DAS actually disperses the storage resources that should be shared in a centralized way in their respective hosts, resulting in an extremely unbalanced idle/busy layout of storage resources. For example, some departments need to constantly expand the storage space, while some departments simply can’t use up the existing storage space. In addition, the storage device is only connected to a server, and only the server can access and manage the data. When other servers need to access the storage device, they need to use remote data access tools or protocols. This kind of data sharing mechanism is inefficient and can not meet the needs of the rapid development of information network for data storage. Because the information is stored in the independent storage system of multiple servers, it will form "information island", which is not conducive to the integration of information and hinders the comprehensive utilization of information resources. Moreover, it also increases the difficulty of personnel to manage the storage system, reduces the management efficiency, and increases the cost investment.

Because this affiliation of DAS is greatly affected and limited by the server, its scalability is poor. Therefore, the server is the main performance bottleneck in DAS storage mode, which greatly reduces the utilization of the storage system. In severe cases, the utilization of the storage system is only 3%. Therefore, DAS storage mode can not meet the requirements of modern society for large capacity, high performance, dynamic scalability and other aspects of the storage system. To solve this problem, we must transform the storage access mode from "server centered" to "network centered", and make full use of network storage technology[5].

3.2. Network Attached Storage——NAS

In DAS (Network Attached Storage) mode, the storage device is directly attached to the server or client. The volume manager in the file system manages multiple disk devices, abstracts them into a logical storage space, and presents them to the operating system and applications. Therefore, when users need to increase the storage capacity, they only need to add disk devices on their own machine. If users only need simple storage services, DAS can still meet the needs. But if users need a lot of storage capacity and services, and continue to add storage devices, it will be a disaster for DAS
structure. With the evolution of information system architecture, servers begin to be specialized to reduce unnecessary workload and improve work efficiency, as shown in Figure 4.

![Diagram showing server modes](image)

**Figure 4.** Universal server transform special server

Professor Randy H. Katz of the University of California first proposed the concept of network attached storage. Then, combined with the high performance storage system (HPSs) project, a prototype of network attached storage controller was introduced, which simplified the server function and increased the disk array to expand the capacity and fault tolerance. This is the earliest NAS. According to the definition of Storage Network Industry Association (SNIA): NAS is a storage device that can be directly connected to the public network and provide file level services to users. As a storage device, NAS has a compact dedicated file system, which combines hardware and software to provide file access services. Usually, NAS is composed of multiple microcontrollers, large capacity RAID disk array, optimized operating system, corresponding interface and management software. It removes unnecessary interfaces and external devices (such as keyboard, mouse, etc.), and removes software modules unrelated to storage. The storage function is separated from the general file server to make it more specialized, so as to obtain higher access efficiency and lower storage cost[6].

Of course, NAS has some disadvantages. First of all, with the increasing amount of data flowing in the network, when NAS transfers file data in LAN, it will divide a large amount of whole block data into multiple packets, resulting in the transmission process taking up too much NAS resources, which directly affects the NAS response to user requests and the provision of storage services. Secondly, the traditional LAN is not designed for reliable transmission of large amount of data. Therefore, NAS will compete with users for network bandwidth in specific use. Moreover, NAS data backup is not separated from the user network, so the consumption of network resources in the backup process is very huge. In terms of resource integration, NAS can only integrate and manage its own attached storage devices, and can not span multiple different NAS devices to achieve unified management of multi device storage resources.

3.3. Storage area network——SAN

In the mid-1990s, HP and Sun company proposed a storage system using high-speed optical network to connect disk storage, which is the original model of San. San is a network centric storage structure. According to the definition of SNIA, it connects servers and storage devices into a special network by using internet protocol such as fibre channel, and transfers data between them. San uses independent
interconnection technology (such as FC) to build a special storage network different from the user network. Block level I/O data exchange mode is adopted between storage devices and application servers, as shown in Figure 6. Therefore, San can be understood as a network topology of storage system to replace the SCSI I/O bus connection between host system and storage devices. Specifically, it is a private network connecting one or more systems to the storage subsystem. It can establish direct contact among storage devices, servers and users. It supports three high-speed data transmission modes: server to server, server to storage device and storage device to storage device.

Figure 5. Storage area network structure

With the development of information technology, information is widely distributed in the network. The original server centric storage method can not meet the requirements of I/O performance of user data requests in the network. Therefore, people follow the concept of dedicated I/O system for mainframe and construct San with high-speed serial FC technology. San can be described as a "back-end" network specially responsible for storing I/O load and handling block level I/O operations, while the "front-end" network (public user network) is responsible for routine network operations. San is actually an extension of shared storage bus structure. It extends the concept of traditional I/O bus to the network environment, changes the storage mode of traditional Das structure, promotes the storage device from a specific server, and no longer belongs to a specific server on the network. So it can be shared by all servers and workstations on the network, which eliminates the storage bottleneck in the traditional storage mode and greatly improves the access performance of the storage system. San is composed of a communication system which provides physical interconnection and a management layer. The communication system can use FC, SSA (string storage structure), ESCON (enterprise systems connections) and HIPPI (high performance parallel) The management layer is responsible for organizing the interconnected storage devices to ensure the security and reliability of data transmission.

San supports rich interconnection and topology, which makes it superior to traditional bus connected storage system in capacity, performance and distance expansion. The basic physical topology of San is shown in Figure 6, which is mainly divided into three categories:
4. **A new information resource storage system -- object based storage pattern (OBS)**

With the increasing popularity of NAS and San technology, their defects and deficiencies in storage security, system expansion and data management are gradually emerging. Therefore, the author combines the idea of object design with data storage, and realizes a new network storage mode -- object-based storage (OBS).

With the increasing popularity of NAS and San technology, their defects and deficiencies in storage security, system expansion and data management are gradually emerging. Therefore, researchers combine the concept of object design with data storage, and realize a new network storage mode -- object-based storage (OBS).

The standard of object storage originally came from the "network attached secure disks, NASD" project of the parallel data Lab (PDL) of Carnegie Mellon University (CMU). The goal of the project is to build a high bandwidth, low latency, secure, scalable network storage system. CMU initiated a working group in the national storage industry consortium. The group includes HP, IBM, Seagate, StorageTek and Kunteng. Based on the NASD research of CMU, the working group established SNIA's object storage device working group in 2017 and released ANSI x3t10 standard. Since then, object-based network storage system has appeared frequently in the documents and device prototypes of major manufacturers and research institutions. At present, researchers have extended the SCSI command set based on NASD project, and named the extended command set OSD-2. The existing commercial object storage systems include panfs of Panasas company and luster of cluster file system company.

Different from block level I / O, object is a storage container with file interface, which can effectively represent the integration of multiple network storage systems. It can use virtual abstraction technology to realize cross platform data sharing and policy based advanced security technology. It can also realize the direct access between data and users and the dynamic expansion ability based on switching network. From the perspective of space allocation and data access, the external performance of object and file is the same, but the difference is that it provides other interface functions, such as locking mechanism, query mechanism and so on. An object is variable in length and can be used to store any type of data, such as files, databases, geographic images, audio and video, etc. In addition, a single object can be expanded to store the whole file or database system. In practice, the content stored in the object is determined by the specific storage application. Because the size of the object can be changed dynamically, the storage device will be responsible for the management of all the storage space of the object. Object is composed of data, accessible attributes and metadata information. Among them, the data stored in the object is opaque to the object storage device; the accessible attribute describes the characteristics of the object, which can be divided into transparent and opaque;
the metadata information is the additional information describing the object, which includes the dynamic information and static information of the object, describes the behavior of the object, the expected read-write rate, the most likely access mode, and the access mode to the object Life cycle of the elephant.

Object based storage devices can create self-management, secure shared network storage system. It migrates some underlying management functions to the storage device and provides standard object interfaces. OBSD (object based storage device) can exist in many forms, such as from single disk to multi disk array system. OBSD is a random access device. The difference between OBSD and block device is the interface. Block based file system can be roughly divided into two parts: client and storage device. The client side uses logical data structures to represent user applications, such as files and directories, and provides interfaces to access these data structures; the storage device side maps data structures to physical devices[7]. In object-based storage, the user part remains unchanged, while the storage management part is moved down to the storage device, and the device interface changes from block interface to object interface, as shown in Figure 7. Moving metadata down to storage devices makes data sharing between different storage applications easier. The obvious advantage of object-based storage is to realize cross platform data sharing and security. It also optimizes the layout of storage devices and data, and realizes intelligent self-management function.

![Figure 7. Contrast structure of block storage model and object storage model](image)

Object storage raises the level of data blocks, using a set of objects instead of addressing by logical block numbers. Each object is its own storage container, including object data, metadata and access interface. Object storage also provides a high-level security mechanism, through the local storage space management, increased scalability, through the end-to-end entity management mechanism, increased intelligent management function.

Object level network storage completely changes the status of storage devices in computer information system, gives storage devices more independent power and intelligence, and eliminates the bottleneck effect of file server in I/O data path. However, in practical applications, there are still some problems. For example, in the process of object level network storage system transferring the
storage management functions of file system and operating system to storage devices, it will involve making great changes to the operating system, file system, driver, etc.; in order to form a unified file system structure view on the server side, multiple storage devices and servers should be connected. Because of the low efficiency of network transmission, high bit error rate and format conversion, the cost of managing storage devices through network channel is larger than that through peripheral channel.

5. Conclusion

DAS is a kind of storage system in general file server environment, which is based on data block. Das storage device itself does not have the ability to manage, its management and services are completed by the general file server, which provides users with logical views and file interfaces. Therefore, from the perspective of network connection, DAS provides a file storage service for users, while from the perspective of storage devices, DAS is a data block storage service.

NAS is a storage system based on dedicated file server. Its architecture is basically the same as that of traditional storage system, and the storage data still needs to go through the server. Different from NAS, NAS integrates dedicated file services and storage devices to provide file sharing storage services for users in the network. From the perspective of network connection, NAS is a whole storage device, which directly provides file level storage for users, and users do not need to understand its internal block level operation. From the perspective of architecture, NAS system architecture is more compact than DAS, belonging to tight coupling state.

San builds storage system based on private network. Its storage devices are interconnected in private network, and provide storage and management services for users through metadata server. San directly uses the SCSI block level protocol, and users have to go through the file server to access it[8]. In fact, San can be abstracted as a Das with the ability of remote connection. In addition, San is to share storage space, while NAS and Das are only to share data resources.

OBS is an object-based storage system. In essence, its basic structure is not very different from other storage systems, but the basic storage unit becomes an object. Due to the introduction of the concept of object, the storage system is intelligent. The early OBS is only a storage system which is stronger than block storage but weaker than file storage. With the further development of object storage, it can realize all functions of block or file, and also has intelligent mechanisms such as self-management and self-adaptation, which block and file storage system do not have.

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