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Survey on Recent Technology of Storage Area Network and Network Attached Storage Protocols

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Abstract: With the increasing requirement for large storage repositories, network storage has become important for large data storage. Huge amounts of new data are generated by humans every year. Humans and applications use data in various format including texts, video, audio and images. It is very much vital to the network storage system that should be high capacity, high availability and scalable. With the help of SAN and NAS, storage can be efficiently utilized. Both technologies alleviate the need to eliminate direct attached storage to aid more flexible storage access. SAN and NAS use open industry-standard network protocols to provide storage facility. NAS uses the NFS and CIFS protocol and SAN uses the iSCSI, FCP and FCoE protocols to provide the storage facility. This paper provides the basics and survey on new technologies of these protocols.

Keywords: NAS (Network Attached Storage), SAN(Storage Area Network), iSCSI(internet small Computer System Interface), FCP (Fibre Channel Protocol) , CIFS(Common Internet File System), FCoE(Fibre channel over Ethernet), reliability, multipathing, disaster tolerance.

I. INTRODUCTION

Large data storage has become one of the main problems in the development of networks because of rapid increase in the data storage. With the mass capacity, high I/O transfer speed, and high system availability, a network storage device can be used for information access and data sharing. One survey predicted that from 2005 to 2020, the digital universe will grow by a factor of 300, from 130 exabytes to 40,000 exabytes, or 40 trillion gigabytes. From now until 2020, the digital universe will about double every two years[1].

The investment in spending on IT hardware, software, service, telecommunication and staff that could be considered the "infrastructure" of the digital universe and telecommunications will grow by 40% between 2012 and 2020. As a result, the investment per gigabyte (GB) during that same period will drop from $2.00 to $0.20. Of course, investment in targeted areas like storage management, security, big data, and cloud computing will grow considerably faster[1].

The information digitalization processes have presented numerous new challenges is to design advanced storage system to meet the demanding requirements for high performance, high capacity and strong reliability. Most end users prefer the network storage server to their local disks for various reasons: Availability from any place; quality of the storage device, security among others, it results demanding pressure is high on the central storage server. With the advent of high speed LAN technologies such as gigabit Ethernet, IP storage has become increasingly common in client-server environment.

Over the years the storage market has witnessed major technological innovation ranging from faster peripheral channels to dedicated SAN, finally to the NAS. As new storage architecture emanate, the storage area network technique provides a solution to the problem of how to achieve information integration and data sharing; it also offers easy manageability and high security. Because the storage area network introduces a network-oriented storage structure and complete separation between data storage and computing, it has many desirable features such as flexible addressing ability, long-distance transmission ability, high I/O speed, and the ability to share data.

The storage networking industry Association (SNIA) Technical Dictionary defines the NAS as: A term used to refer to storage elements that connect to a network and provide file access services to computer system. A NAS system is usually a special-purposed device designed to provide clients with files on a LAN, which has advantages like sharing files in a hetero-architecture, making full use of the existing LAN architecture, easy installation, operation and management, good connection compatibility and network adaptation, low costs and so on [2].

We can classify storage device interfaces into two abstractions. Block, is a simple, un-typed fixed size (block), memory like interface for manipulating non-volatile magnetic media. Traditional disk drives (IDE or SCSI), disk arrays or even SAN rack systems essentially are all block device. The other interface, which is a richer, typed variable-size (file), hierarchical interface. NAS systems provide a file interface, which is similar to that of a traditional local file system. Storage appliances are in fact intelligent devices that provide file interface services by hiding the details of managing internal nonvolatile media through a block interface.

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Guo at el. Proposed a IP-SAN technology, Disaster Recovery system to build a SG186 network VPN remote disaster recovery channels. At present, the disaster tolerance system has many deficiencies, cost is high, investment is huge because of the solution includes both software and hardware. Flexibility is poor. The existing disaster tolerance system does not support unit for the backup volume group., Universality is poor. The production of a variety of disaster recovery products manufacture is not compatible with each other and also has the problem of I/O operation efficiency is low. Computer technology, communication technology and database technology to build the data disaster recovery system provide favorable technical foundation.

According to a survey about 80% of attacks are directed at the static data[4]. Because of this, more attention has been given to the encryption technique for static data. Xu Xuedong proposed the method for the disk static data in IP SAN [5]. Providing data security in large storage network is very important. New security techniques that is encryption and authentication mechanisms should be used to provide data integrity and security.

The fig 1. shows the typical SAN (Storage Area Network). SANs are networked infrastructures designed to provide a flexible, high-performance, and highly scalable storage environment [6]. SANs accomplish this by enabling many direct connections between servers and storage devices such as disk storage systems and tape libraries. High-performance Fibre Channel switches and Fibre Channel network protocols ensure that device connections are both reliable and efficient. These connections are based on either native Fibre Channel or SCSI (through a SCSI-to-Fibre Channel converter or gateway). Because SANs offer excellent scalability, they are increasingly becoming the infrastructure of choice for large enterprises and service providers that face rapidly expanding data storage requirements. One of the key benefits realized in SAN environments is vastly improved reliability and scalability of enterprise data backup and restore operations [6].

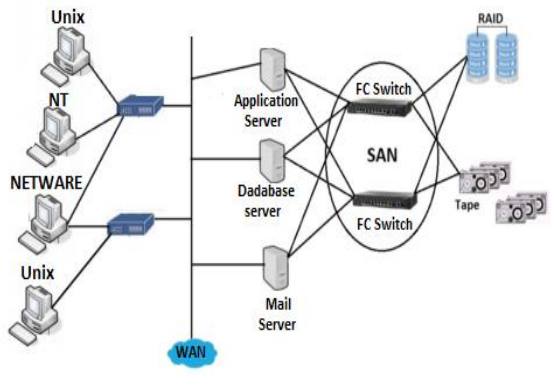

Fig.1. SAN Architecture

NAS solutions are typically configured as file-serving appliances accessed by workstations and servers through a network protocol such as TCP/IP and applications such as Network File System (NFS) or Common Internet File System (CIFS) for file access. Most NAS connections reside between workstation clients and the NAS file-sharing facility. These connections rely on the underlying network infrastructure to function properly.

Fig.2.shows typical NAS architecture. NAS enables organizations to quickly and easily add file storage capacity to their technology infrastructure. Because NAS focuses specifically on serving files while hiding many of the details of the actual file system implementation, NAS appliances are often self-contained and relatively easy to deploy. Typical interaction between a NAS client and an appliance involves data transfers of relatively short duration and volume. NAS performance constraint is the ability of the network to deliver the data since network congestion directly affects NAS performance.

NAS works well for organizations that need to deliver file data to multiple clients over a network. NAS appliances also function well in environments where data must be transferred over very long distances [6]. In addition, NAS appliances are relatively easy to deploy—enabling widespread distribution of NAS hosts, clients, and appliances throughout the enterprise. Properly configured, NAS provides reliable file-level data integrity, because file locking is handled by the appliance itself. Although deployment is fairly straightforward, organizations must be careful to ensure that appropriate levels of file security are provided during NAS appliance configuration.

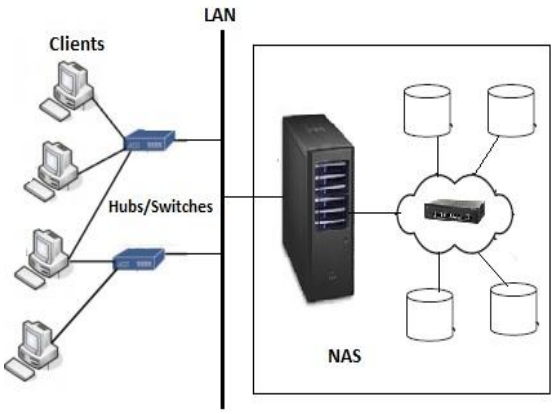

Fig.2. NAS Architecture

II. NAS PROTOCOL

A. NFS protocol

NFS is a distributed file system protocol. It allows the user to access files over a network using client computer which is similar accessing the local storage. NFS similar to other protocol builds an Open Network Computing Remote Procedure Call(ONC RPC) system.

Version 2 of the protocol originally operated only over UDP. NFS version 2 of the protocol keep the server side stateless with locking(for example) implemented outside of the core protocol. NFS version 3 supports TCP as a transport protocol in addition to support for 64-bit file sizes and offsets, asynchronous writes on the server to improve write performance and supports additional file attributes. Version 4 includes performance improvements,

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mandates strong security, and introduces a stateful protocol.

Bo Li et al. proposed and implemented a high performance Write-Write design of NFS over RDMA also proposed a HCA-based memory protection extension of Infiniband to guarantee the security of the Write-Write design. Amith Sahrawat et al. proposed new method to reduce the browsing time in a single client NFS system. The implementation of this method shows that 44.6% performance improvement over a conventional one [7]. Latesh Kumar K J, introduces a method for implementing NFS protocol for larger block/network packets transfer over to NAS from highly available clients. In this method NAS supports file sharing between peer clients serving on highly available cluster services, Clients access the file shares from anywhere in the organization[8].

Parallel NFS (pNFS) is a standard protocol for parallel I/O access in various storage environments. Weikuan Yu et al. gave an initial characterization of two pNFS prototype implementation lpNFS(a Luster-based parallel NFS implementation and spNFS (it's a reference implementation from Network Appliance, Inc.). They show that lpNFS and spNFS can achieve the primary goal of pNFS, i.e. aggregating the I/O bandwidth from many storage servers [9]. Matthias Grawinkel et al. present extension that integrates the client's ability to provide hints and I/O devise to metadata server [10].

B. CIFS protocol:

The *Common Internet File System*(CIFS) is the common way that computer users share files over the corporate intranets and the Internet. CIFS (Common Internet File System) is a modern dialect of server message block (SMB). It will operate as an application layer network protocol. It is mainly used for providing shared file access, printers, serial ports and other communication between nodes on a network. CIFS provides inter-process communication mechanism with authentication facility. CIFS pass the information between networked computers using series of commands[11].

The CIFS messages can be widely categorized as, Connection establishment messages, Namespace and File Manipulation messages, redirector send the printer messages to a server and other Miscellaneous messages are used to write to mails and named pipes. CIFS supports various platforms include Microsoft Windows OS. UNIX, VMS, Macintosh, IBM LAN server MS-Net, MS-net and 3Com3+open. CIFS satisfy Hypertext Transfer Protocol (HTTP) while providing more modern file sharing and file transfer than older protocols, such as FTP[11].

CIFS ensures the data integrity and concurrency by preventing conflicts when multiple users sharing the file using file locking method and also ensures only one file copy is active at a time in order to avoid data corruption. CIFS protocols has been optimized so that it suits also well for slow-speed connection. CIFS provides greater security features for files by using secure transmission of files and authenticated access to files. CIFS supports Unicode file names so that we can give file names using any character set. CIFS protocol performance and scalability is high because it is highly integrated with OS and uses maximum system performance. CIFS supports Global File Names so users not necessary to mount remote file system, users can refer remote files directly with global significant names.

SMB2 reduced the number of commands to just nineteen from hundred command in the previous version of the protocol. It has pipelining facility to send additional requests before the response to a previous request come, thereby improving performance over high latency links. SMB2 has the ability to combine multiple actions into a single request, which improves the performance by significantly reduces the number of round-trips the client needs to make to the server.

SMB2 includes support for symbolic links. SMB2 protocol's other improvements include caching of file properties, improved message signing with HMAC SHA-256 hashing algorithm and better scalability by increasing the number of users, shares and open files per server among others. SMB2 uses 32 or 64-bit wide storage fields, and 128 bits in the case of file-handles, thereby removing constraints on block sizes, which improve performance with large file transfers over fast networks[12]. SMB 2.1 introduced some performance enhancements with a new locking mechanism.

SMB 3.0 was introduced with Windows 8 and Windows Server 2012. It brought several significant changes, such as the SMB Direct Protocol (SMB over RDMA) and SMB Multichannel (multiple connections per SMB session), that are intended to add functionality and improve SMB2 performance, notably in virtualized data centers. SMB 3.02 has been introduced with Windows 8.1 and Windows Server 2012 R2.

III SAN PROTOCOL

A. iSCSI protocol

iSCSI is a proposed industry standard that allows SCSI I/O commands to be sent over a network using the popular TCP/IP protocol. The iSCSI standard is also supported by SNIA. iSCSI connectivity can be implemented in different ways. In the first method, iSCSI device driver is installed in a server to accept application I/O request and send them over a LAN using the iSCSI protocol. The target storage device could directly attached to the LAN. An alternate method is iSCSI device would be to use a router(Protocol converter) that connects to the LAN, but has fibre channel port on the "other side" so that it also connects to a storage device that supports Fibre channel attachments. This allows storage products without native iSCSI ports to be accessed via iSCSI and allows server to access that storage without needing a fiber channel host bus adapter card.

iSCSI is a mapping of the SCSI I/O protocol to the TCP/IP protocol. iSCSI and NAS devices both attach to the IP networks. TCP/IP based network can potentially support longer distance than can pure fibre channel SANs. iSCSI

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uses the SCSI I/O protocol therefore, it is a block I/O-oriented. iSCSI backup management is done using any method that supports SCSI-attached volume. SANs currently have more storage –related management tools than iSCSI. iSCSI performance is better than NAS due to reduced protocol overhead, since it handles SCSI directly rather than translating between file-I/O protocols and SCSI. Handling of the TCP/IP protocol in iSCSI requires processor at both ends. Therefore it is likely best suited for situation of relatively low I/O activity. An iSCSI SAN likely has a lower cost than a fibre channel SAN because iSCSI network hardware such as Ethernet host adapters are generally lower cost than fibre channel adapters. An iSCSI SAN can be built more quickly and with fewer new skills than a fibre channel SAN.

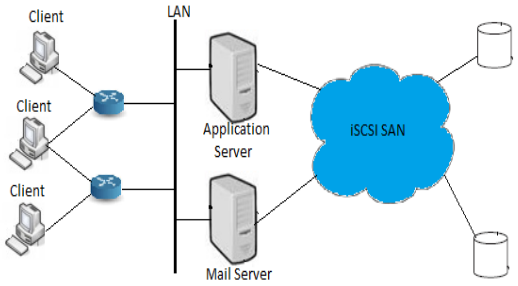

Fig.3. iSCSI SAN

When clients (initiator) wants to read/write data at the server (target), the initiator sends a connection request to the target, then iSCSI begins to login and establish the session. When the initiator requests I/O operation to the target once longing is completed, iSCSI command is encapsulated as the iSCSI protocol data units when it passes the iSCSI layer, at last it is encapsulated as IP packets and sent to the target through the TCP/IP protocol. Once the target received the IP packets, the SCSI commands are recovered and sent to the terminal storage device by removing the encapsulated it in the reverse order. When the process is done, the target encapsulates the SCSI response and data as the iSCSI protocol data unit and sends them to the initiator.

He Jun Wang Li et al worked on iSCSI security mechanisms; they improve the performance by a secure iSCSI scheme based on SSL. They implemented iSCSI system by adding SSL functions to iSCSI protocol. The results of this experiment shows that throughput of the security iSCSI based on SSL increased 25% and CPU utilization rate decreased 50%, when compared to secure iSCSI based on IPSec[13]. Sandor Acs et al. proposed an architecture for AoE(ATA-over-Ethernet) based storage support in OpenNebula cloud. This was implemented by novel storage solution and AoE based storage provides bettter(32.5-61.5%) compared to the prior iSCSI storage and the AoE storage solution requires less CPU time (41.3%) to provide the service[14].

According to Tody Ariefianto W et al. there is a need for iSCSI protocol optimization in order to improve the performance and reliability. They also analyze the iSCSI SAN to handle the broken link. Implementation results shows that internet protocol multipathing enhance performance and reliability of iSCSI SAN system[15]. C.M. Gauger et al. proposed a models for iSCSI write requests over TCP/IP networks, e.g., as used in asynchronous mirroring applications.This model evaluated with the session under a realistic request traffic model with and without interleaving. In this evaluation, Among the impact of RTT on the maximum throughput and the duration of the write request , the trade-off between network QoS and processing power has been pointed out[16].

Jiang Guo-song et al. worked on iSCSI out-of-band storage visualization design and implementation. The communication between initiator and target devices in fully accordance with initiator and target model defines in iSCSI specifications, but made a change on the flow to meet the storage virtualization requirement [17]. Xu Xuedong et al. proposed and realize a SAN storage and encryption system, it is based on iSCSI technology to achieve a static data encryption [5]. This realized a flexible security management strategy by multiple-key and multiple layer encryption system to project the physical resources through iSCSI protocol stack and virtualization technique. This system shows that it saves about 10% of the conversation expenditure.

B. FCP protocol

Fibre Channel Protocol (**FCP**) is a transport protocol that mainly transports SCSI commands over Fibre Channel networks. FCP was originally developed as a backbone technology for the connection of LANs. Fibre channel is only one of the transmission technologies with which storage area networks can be realized. FCP supports different topologies including point-to-point, arbitrated loop and switched fabric. FCP uses different ports including E_port, F_port, G_port etc. The port connects to the topology through a link . The link is a fibre optic cable. A link used to interconnect nodes, switches or both.

Nodes and Ports have unique 64-bit addresses that are used to identify them in an FC technology. These addresses are called as node names and port names, and when they are worldwide unique, they are referred to as Worldwide node name (WWNN) and Worldwide port name(WWPN). FCP uses the LUN masking and zoning as access control methods. The fibre channel technology may not be always acceptable and affordable because of high cost and complexity. The performance is same as for iSCSI for storage application.

De-zhi han proposed an architecture which provides high performance, high availability, high scalability, improved manageability and storage sharing by creating new storage network which merges NAS and SAN(SNINS) so that NAS can be merged with SAN which uses the Fibre channel as a prominent technology[2]. A SAN system , the TH-MSNS (TsingHua Mass storage Network System) proposed by Jiwu Shu et al. is based on Linux SCSI and Fibre Channel Protocol(FCP) and its storage node has

cluster or multiprocessor architecture. The software for the new storage area network is implemented as a module in the kernel mode to improve its efficiency. The storage management software adopts distributed architecture, which enables higher interoperability and compatibility with different kinds of management protocol [18].

Manshi Chaudhry et al. proposed a method to reduce the FCP deployment cost. They proposed the iSCSI over Ethernet and Fiber channel over Ethernet. The former recovers from packet losses relying on the services of TCP , and the latter enjoys lossless transport using the Data Center Bridging(DCB) suite of protocol[19].

C. *FCoE protocol*.

FCoE is one of the protocols that support Fibre Channel over Ethernet, that is Fibre channel data encapsulated in Enhanced Ethernet. FCoE does not use TCP/IP for transmission and hence a lower CPU overload but require lossless Ethernet switch to provide reliable and high performance storage connectivity [20]. FCoE protocol specification replaces the FC0 and FC1 layers of the Fibre Channel stack with Ethernet. FCoE encapsulates the Fibre Channel frames into Ethernet frames, allowing them to run hand-in-hand with the traditional Internet Protocol traffic. The advantage of this technology is it allows convergence of traffic, less I/O ports so less power dissipation & less cooling efforts. With FCoE, FCoE runs over Ethernet, along the side of Internet Protocol (IP) traffic. FCoE works directly above in the network protocol stack, contrary to iSCSI which runs over TCP and IP. As a result, FCoE is not routable at the IP layer, and does not work across routed IP networks. Traditional Ethernet is a family of frame-based computer networking technologies for local area networks (LANs), whereas Fibre Channel is used for storage area networking (SANs).

FCoE uses the Host Bus Adapter (HBA) interfaces to connect a host system to other network and storage devices. SAN architecture is a highly available, high-performance dedicated storage network that connects servers and storage in a secure, flexible and scalable architecture. It is a pool of storage devices that can be used by any host within the storage network. Fibre Channel is reliable, scalable, mainly used for Storage Area Network but higher cost is one of the disadvantages of FC. FCoE requires the deployment of three components: CNA, Lossless Ethernet Links and FCoE Switch. Computers can connect to FCoE with converged network adapters (CNAs), which contain both Fibre Channel HBA and Ethernet NIC functionality on the same adapter card.

There are significant research works carried out for protocol improvement. The paper [21] presents a summary of the Fibre Channel architecture, explains about the extensions needed for Ethernet to be lossless, and discusses the architectural models of FCoE. It also how FCoE leverages the Universality and cost of Ethernet networks while preserving the infrastructure, strengths, and tools of the existing Fibre Channel Storage Area Network (SAN). R. J. Recio, explain in his paper [22] cluster convergence scenarios where performance is critical, in large enterprises where storage availability, security, quality, etc. are important, the dominant storage solution is based on Fibre Channel (FC), resulting in separate networks for storage, LAN, and IPC traffic. Yueping Cai et al. presents a survey on Converged Data Center Networks with DCB and FCoE, focusing mainly on their motivations and key functionalities[23].

IV. CONCLUSION

In this paper, we have summarized the important technologies for both SAN and NAS. We also provided brief explanation for SAN and NAS protocols and recent research and development of these protocols. This paper provides details and storage network protocols information to the storage network beginners.

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