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Exploring Host Interface Technologies in Solid State Drives: A Comparative Study

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***Abstract*— Now a day's amount of data growing day by day accordingly the size of storage media is also increasing rapidly. In most of the storage devices flash memories are used one of them is Solid State drive. Solid state drives i.e. SSDs are non-volatile data storage devices which store persistent data in NAND or NOR i.e. in flash memories, which provides similar functionality like traditional hard disk (HDD). In this paper we studied internal architecture and functionality of SSDs as well as comparative study of host interfaces like Serial ATA (SATA), Serial Attached SCSI (SAS), PCI Express (PCIe), Non-volatile Memory Express (NVMe) etc**

***Keywords*— Solid-state drive, Host Interface, Serial ATA, Serial Attached SCSI, PCIe, NVMe**

I. INTRODUCTION

Solid state storage devices are trading over the hard disk drives in many Enterprise and Client requests due to their improved performance, smaller formula factor, lower power consumption and diversity of device interfaces. Solid state drive also called as electronic drive or usually known as SSD is storage device which usage solid state memory to store persistent data in the same manner of providing access in the traditional hard disk drive. In hard disk drives data is stored on spinning metal platters and whenever we need some data a needle like component call head move over the data platters but in SSD there are no such mechanical arms. Basic structure of SSD is as shown in the figure 1.

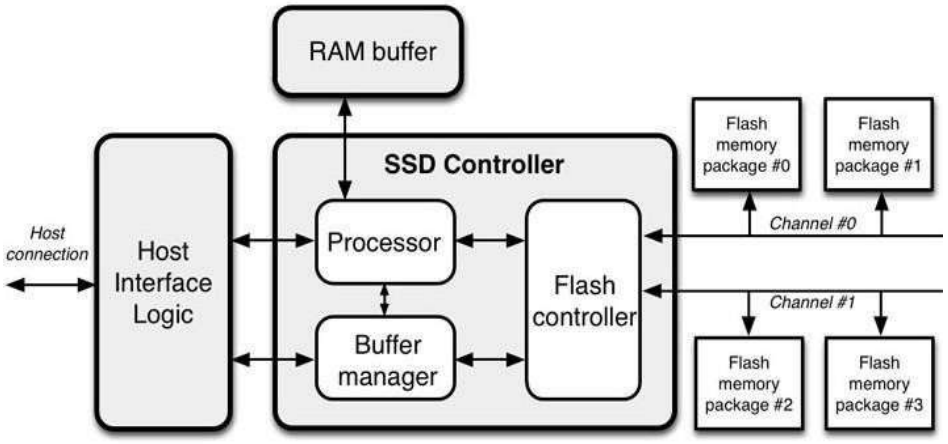

Fig 1 SSD Block Diagram

As shown in above Fig.1, most of the traditional SSDs are composed of NAND flash, DRAM and SSD controller. Generally, SSD use the same interface as HDD, thus easily replacing them in most applications. However, Different from HDD, as the NAND flash memory must erases pervious data before writing operation. To compete with a hard disk and expose an array of logical sectors to the upper level host system, storage device based on NAND Lash use Flash Translation Layer (FTL) to exchange data with the host. Its major functions include: logical to physical address translation, Garbage Collection (GC), Wear Levelling [1].

In recent years, because of their shock resistance, high energy efficiency and high I/O performance solid state drives having flash memory chips becomes popular alternative to the Hard Disk drives. In order to be compatible with the existing storage interface i.e. logical block address (LBA), each SSD needs to keep track of the address translation information is usually maintained / cached in the internal RAM space of the SSD. In hard disk which are made up of magnetic materials holds data in the form of zeros and ones so having the ability to write same data at every position. Afterwards when that data is been deleted stain would be erased but it will be still accessible on some sectors which are unused where these deleted files will be recoverable at any time. The TRIM i.e. removing space in storage performs a deletion of invalid data from the memory of SSD's to assure that performance of rewrite function is well regularly.

This feature in the storage devices called as garbage collection and self- corrosion in SSD's which also removes the deleted data permanently in the background from sectors. All these done immediately or within few minutes of deletion of data. Based on data generated it declares that decompose of the proof issue in non-volatile memory and refined use of TRIM commands origins hardening in forensics investigation. The main distinction of efficient TRIM mechanism could once enable for file system whereas collecting the deleted data that sometimes gets stores even after deletion.

Components of SSDs:

1. *Flash Memory:* Flash memory-based storage device i.e. SSD can offer much faster arbitrary access to data and faster transmission rates. Also, SSD capacity is now at the point that the drives can attend as rotating-disk substitutes. But for many submissions the host interface to SSDs remains a holdup to performance. Non-volatile storage referred as the flash memory erases data at block level. In modern SSDs existing data stored in flash memory can be deleted initially along with rewritten again on those memories.
2. *Partition Alignment:* Physical sector size of storage disk denoted as partition alignment utilise by the operating system. Partitions of the sectors check by the hard disk is the most significant variance of SSD and HDD. For example, Custom physical sector size of HDDs is 409 bytes which also deciphered by firmware up to 512 bytes while in SSDs comparing to sectors of HDDs utilization is 16 KB to 8 KB pages. When we are copying data from the regular HDDs to SSDs partition alignment goes significant at time as results of clusters from HDD writes to various pages of SSD. For achieving supreme performance and toughness of the storage devices partition alignment is essential.
3. *Embedded Controller:* Embedded controller occurs for completing the read and write actions all over the microchips among the SSDs so that it completes the wear levelling of the hard drives [2].
4. *Wear Levelling:* wear levelling is the memory management way established for elevating the life of flash memory. The supplier regularly offers supplementary storage when designing hard drives that are unapproachable by traditional ways could improve the wear levelling a lot better. Generally, in SSD's, data are reserved in blocks which may be rub away and rephrased number of times. For performing imaginatively and for encompassing the lifetime of storage devices wear levelling would grip and approve the deletion and rewritten cycles units which are build from the TRIM commands. Statics and dynamic are the two types of wear levelling techniques.
5. *TRIM:* Flash memory controller erases the information or data existing on the block sectors which has been deleted by users and is marked as deleted this procedure is called as TRIM function. Deterministic zeros after TRIM (DZAT) or the deterministic read after TRIM (DRAT) implemented in SSD's returns all zeros directly when the TRIM query is executed on the certain block of the data. Because of TRIM function SSDs will returns original data which is base on the garbage collection formula applied in the different operating systems. There is another definite concern for encrypted bulks on SSD's, as several crypto containers implement massively totally diverse methods of handling SSD TRIM commands [4].
6. *Self-Corrosion:* self-corrosion can be denoted as the process within hard drives in which erased files are removed over time that are essentials for performing forensic examination. In Mordern's SSD's Deleted data making it complicated for the forensic examiner to recover it [5].
7. *Garbage Collection:* The non-volatile memory which is using NAND controller, SSD's uses the garbage collection for removing and rephrasing of data into blocks. Data that is deleted by the user and clear as unacceptable by the operating systems is called as garbage collection. The garbage collection isn't considered as the standby for the TRIM functionality with SSD's, because of TRIM function garbage collection becomes additional effective and advance performance. The key reason for the data to be written on the identical blocks in SSD's are the wear levelling and garbage collection.
8. *Encryption:* Applying password or secret key to attain the security is also referred as encryption simultaneously it improves the security of storage devices from the intrusion. SSDs marks the removed data as unacceptable but not necessary to remove that data from pages in the flash storage. It means if data is not encrypted correctly during process of erasing and handling of data then it is improved for drive preservation from security theft. Technical expertise use encryption techniques and methods for securing their drives as well suggests using third party data encryption tools like TrueCrypt [8], PGP, BitLocker and another normal tool to achieve the highest level of data security in SSD's.

II. RELATED WORK

Solid state drives even other storage drives have various logical or host interfaces like SATA, SAS, PCIe, NVMe etc. As SATA and SAS are traditional host interfaces where PCIe and NVMe protocols have speed advantage. Basically, PCIe connected in backplane while SATA can be backplane connected to servers.

SATA connectivity can distribute 10 times more latency as compare to PCIe, so expertise claimed to use PCIe connectivity by removing the SATA-based SSDs in need of intermediate protocols. Also, they shared that SSD remains the prime contributor by overcoming the platform latency issue [6]. They determined HBAs having optimised host interface enables processing effectiveness 20K CPU cycles per input/output. They also found maximum processing expenditures lay in cost of generic device or operating system functions not on the storage specific functions like ATA or SCSI processing. For enabling system architecture development, the performance reports of SSDs decorations in literature, market-oriented performance measurements and observed study alone are insufficient. SCSI-based and ATA-based disks in Linux were first implemented by Accardi and Wilcox [5]. They found that performance of SCSI-based version is not better than the performance of ATA-based simulation. It shows that SCSI adds significant expenditures. In the SCSI layer due to the acceptance of RAM disk, their enquiry did not consider expenses due to hardware or software collaboration, nor another operating system processing. New technologies involve revealing basic relationships.

III. HOST CONTROLLER INTERFACES

To make our server faster implementation of SSD is the best way though transmission speed or performance speed varies for different types of SSDs like SATA, SAS, PCIe etc. Most common host interface SSDs are SATA due to its omnipresent nature and its companionable interface. Another traditional interface i.e. SAS is aimed to the enterprise storages over SATA HDDs but, after since 2004 new interface grows up i.e. PCIe due to 3D NAND flash-based storage becomes cheaper and appealing. We can say by making speed advantage PCIe-based drives bypass the backplane connecting server drives i.e. SATA-based or SAS-based drives. At last we mustn't forget the NVMe which provides substitute by connecting between host system and exterior storage device to the SCSI standards and ATA standards.

A. Serial Advanced Technology Attachment (SATA)

Serial-ATA primarily host interfacing with HDDs for doubling the transmission speed between host system and connected storage device that's the reason for further implementation by the SSDs and hybrid drives improved over time. SATA protocol uses point to point connection for transmission of data information and control using host bus adaptor. The host bus adapters and storage devices interconnect over a high-speed serial cable with two pairs of conductors, one for differential transmission and one for differential reception. The Serial ATA Commands Logger intercepts the ATA commands sent by the host bus adapter to an attached storage device and sends the intercepted commands to a serial console. The set of intercepted commands are compliant with the ATA/ATAPI Command Set specification.

B. Serial Attached SCSI (SAS)

SATA-based solid-state drives being omnipresent in nature as replacing to hard drives in servers hence in need for enterprise storage solid state drive were implemented by SCSI protocol i.e. by SAS interface. Due to higher availability and greater data redundancy SAS drives are appropriate in multi-port storage arrays. SAS factually has been used by enterprises running large-scale storage, mainly to support direct-attached storage or hard drive controllers for enterprise server farms. Some professionals forecast SAS could overtake SATA as the overriding interface for SSDs and HDDs in enterprise storage systems.

While differencing between these two traditional type of drives SAS and SATA, SAS drives supports multiple data path this is the key reason for favouring SAS drives in enterprise backgrounds. SAS drives also provide better end to end data veracity than SATA drives. One more plug in suggestion by storage technologist if server supports SAS interface then it can support both SATA or SAS drives but in case of SATA interface SAS drives plug in won't work. If sever needs low capacity drives, then SATA drives should be preferable for least expenditure over SAS drives.

C. Peripheral Component Interconnect Express (PCIe)

By introducing new fasted interface protocol over traditional interfaces is PCIe. Exclusive reason for using PCIe based storage devices is maintain speed of transmission for heavy data with low latency for example sharing of high display videos. PCIe is all around electronic signalling based on point to point topology. PCIe also allows the fastest communication between the storage device and motherboard. PCI express is one of the trends towards replacing parallel buses with serial interconnects like SATA, USB, SCSI etc.

D. Non-volatile Memory Express (NVMe)

NVMe is a storage protocol to accelerate the data transmission between client systems and enterprise drives over high-speed PCI express host interface bus. Main benefit of NVMe drives over different types of host interface drives is potential low power consumption, reduce in latency in host software loads and high input/output operation speed per second. As we can say that NVMe is one of PCIe host interface with upgrading transmission speed hence the comparative and basic overview between SATA, SAS and PCIe is as follow:

TABLE I
BASIC OVERVIEW ON SATA, SAS AND PCI EXPRESS

Terms	**Host Controller Interfaces**		
	SATA	**SAS**	**PCIe**
Transmission	Half Duplex	Full Duplex	8 Times more than SATA
Bandwidth	Medium	Low	High
Interface Speed	0.6 GB/Sec	0.6 GB/Sec	1 GB/Sec
Read/write Speed	6 GB/Sec	12 GB/Sec	2000 GB/Sec
Flash Storage Capacities	Large Capacities	Low Capacities	Limited Capacities
Cost (if x be the price value)	X	4x	3x
Ideally use for	Personal & desktop use, tablets & data centres	Data centres, mission critical enterprise applications	Some data centre environments, video editing, financial modelling, simulation. High end gaming

IV. CONCLUSIONS

Here, as we focused on the internal structure and components of Solid-state drives becoming hot plug over Hard-disk drives. By losing the mechanical arms moving on the rotating magnetic disk to support of flash memory chips to store data and in case of host controllers, SATA SSDs should preferable for the client-based host systems as well for enterprise system where the SAS and PCI express SSD drives should preferable for servers or high capacities storage drives. Now a days there are number of technologies beating the market for solid state devices including NVMe drives offers massive improved performance and set new standards in storage industries. In addition, NVMe is trading over all different type of host interface solid state drives because of high speed as per market demand.

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