Demonstrations for the Designs of Three-dimensional Optical Massive Storage

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Abstract—The preliminary design of optical stereoscopic massive information storage has been declared a national invention patents. This technology has combined the advantages of optical disc and optical tape and abandoned both of the disadvantages. The most important improvement is to change the storage from a plane storage to a three-dimensional storage so as to achieve more than 100 times effective storage by using the same volume. Meanwhile, it still has the characteristics of random access and high-speed read. The technical integration of CD and light band produces new equipment, which bears the character of cheap price, convenience, fast and free access, and mass storage. That is the inevitable trend for technology development. Due to insufficient knowledge of design, most of the research power overlooked their joint strength and left this area untouched. Although there is difficulty in combining their strength, it is not beyond reach. And once it is solved, 3D, high speed and mass storage will be available.

Keywords-massive storage; three-dimensional; high-speed read; data Mining; optical disks

I. INTRODUCTION

For only a couple of years, the one-side storage capacity of frequently used CD for optical information storage increased from 640M to 4.7G. Then blue-ray DVD technology expanded its storage space into 5 sides and the storage capacity amounted to 25G. Meanwhile market demand speeded up along with it. And the 863 Program has set the technology as mass storage of optical optical information as Key Research Project in 2010. Till now CD technology uses only one μm-level side of the CD. And the effective storage medium is less than 0.1 cm3. Most of the storage space is left for basis and cover-layer. To solve this problem, one choice is to try multi-layered CD. Despite that approach, the effective storage medium is still less than 1 cm3.

And the increased layers and their interference limit the application of this technology. Another choice is light band conveyor, which functions like cassette tape and dramatically increases the effective storage medium. Due to the terribly slow speed of operation, difficulty in speeding writing and reading, and challenge to realizing the free and speedy access, it stays far from wide application[1-4]. Consequently, by analyzing the strength and weakness of CD and light band, we find the new optical storage device. It combines only the strength of CD and light band and its storage capacity is over 100 times more than CD within the same space of storage. At the same time, it is characterized by free and speedy access.

II. DESIGN ARGUMENT

A. The strength and weakness of the in-use CD and light band storage

Ever since its invention by David Paul Gregg, CD has attracted immense focus. With the maturity of CD recording technology, CD storage increasingly becomes common in the consumer market, for example, movies, pictures, data and music can all be stored in various-sized CDs, which are mostly branded as Laser Disc, Compact Disc and Mini Disc. They use the same basic structure and phase modulation. The technology is outstanding for the following reasons: long-time storage, theoretically 100 years; safe storage; resistance against virus and hackers; offline saving; convenient expanding. And its weakness is limited capacity. If we save a lot of offline- information on CD, we have to buy CD towers and CD servers, which charge tremendously.

For its one-layered or multi-layered structure, the basis and cover layers take most of the space, CD does not work for large and medium-sized memory system. Furthermore comparing its volume of the CD-ROM player, the effective storage part takes a relatively small proportion.

While CD is dominant photo-memory medium, light band, a different optical medium, bears a much bigger storage capacity. Compared with the auxiliary medium, its effective medium is overwhelming. A roll of light band can be treated as a 3D CD, of which the layers can mount to thousand. That is impossible for ordinary CDs. For its strength in massive storage, light band is a better choice than CD for some kind of storage, for example, recording and playing HDTV program.

Light band, a tape-shaped optical storage medium, once recorded, can be repeatedly read. Base band is a multi-layered polyester film with metal reflective coating made of active layer and cover layers. Above the metal reflective coating, lays the active layer of transparent PP containing infrared absorption dye. The drive mechanism of light band is similar to that of open reel tape recorder. The 35~light band on a tape reel with a diameter of 300~ can store data of 1 T13. in order to get fast access to the massive data and leave no damage to them, high precision is required of the transmission part. Tape reel and driving wheel is directly driven by Brushless DC Motors. Each motor is equipped with speed encoder. The speed of the three shafts can all be measured. Hence, the torque for constant tension will be available by calculating. And the drive current of motor can be adjusted when needed.

One of light band's weakness is its sensitiveness to those mistakes brought by dust, smog and other speck. To CD, the recording layer includes some tags with width less than 1.0 micron. For a typical dust particle, its diameter is 1 micron. If the particle directly touches the storage technology.

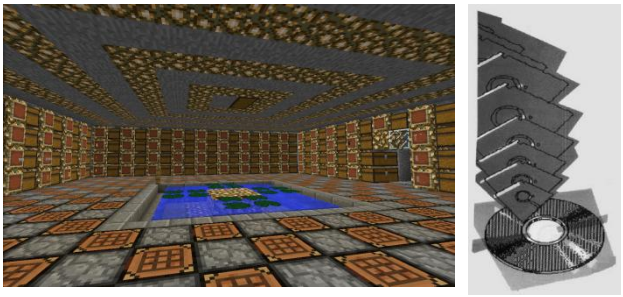

Figure 1. The model of new massive

Recording layer, it may make the tags below obscure. In CD technology, suppose the diameter of numerical aperture laser beam for reading or writing is 0.5, the diameter of light beam on the cover layer is 1mm, much bigger than typical dust particles.

Unlike CD, light band must bear good function and high density storage. The tag on the record level of a typical light band is of the same size to that on CD, sometimes even smaller. A typical light band is 25 micron in thickness, among which includes the thickness of the cover layer that covers the recording level. The typical cover layer of light band is 2-10 micron, about 0.5%-0.1% of CD. That makes it fragile to dust and get the tag on recording level obscure.

American patent, No.5272689 under Tsujioka, and et al, declares an approach against dust and other pecks. The patent offers optical signal reader, a transparent contact component, which contacts the cover layer of the light band and finds no difficulty in cleaning dust particles. To make up the distance of optical path lost by contact and abrasion, some adjustment of the focus of object lens should be made.

American patent, No.5215808 under Barnard makes public a solution to the obscurity caused by dust. It offers to fix fluid bubble, such as gas pocket or vacuole confined between the record level and cover layer. During the process of recording and reading, the controlled bubble clear the dust from the focus area of the reading and writing light beam. Along with the movement of the band moving, the bubbles remain below the light beams.

Another method to solve the dust and particle problem is simply to place the light band in an air-sealed bandbox. American patent, No.4814925 under Beaujean makes known an air-sealed bandbox installed with recording tape. In the bandbox, there is inert gas of low pressure. The gas will not interact with the cover and conducting edge.

However, air-sealed bandbox leaves it difficult for mechanic movement into the box. American patent, No.5077724 under David Paul Gregg solves the problem. In the patent, the light band is transmitted through a transparent hole into a record bridge in the air-sealed bandbox. A pair of internal and external plugs controls the bridge and records the focus and orbit of the light beam, and makes sure it is on the standard points.

Another weakness of light band is as follows: the challenge for a higher speed, mechanic control, precision, to keep balance in high-speed operation, to speed up recording and reading, and difficulty for random packing.

B. The challenge for present technology to meet the increasing storage demand

Upon the expanding business and increasing visitors, organizations and industries, such as education, telecommunications, airlines, insurance companies and government, get respective demand in centralized data storage system. For example, in the industry of insurance, each company has the problem of proper use and storage of customer information. The old method of information management and use is an obstacle to business expansion. Accordingly, insurance companies establish unified storage structure and realize unified information, centralized storage, management and application, which is the trend. Meanwhile, organizations and industries, such as education, telecommunications, banks, airlines and government get the same challenge. There are some data proportions of storage.

For example, how organizations such as Guangxi branch of China Construction Bank, China Life Reinsurance Company, Peking University, Travel Sky and CNC, meet their need and application in constructing storage networking. The increase out of the expanding need is overwhelming. See airlines, according to the data released by State Tourism Agency, the number of foreign tourists amounts to 0.15 billion till the year of 2010. Upon that dramatic change, Travel Sky starts implementing the plan to ensure the high reliability, storage consolidation and protection of data.

1) Guangxi branch of China Construction Bank

Like most of commercial banks, Guangxi branch of China Construction Bank integrates its information infrastructure to meet customers' diversified services, consequently all accounting and the savings system in Guangxi Province has been centralized. But a serious problem arises: coupled with a lot of historical data, core business produced 700MB-1GB data every day, as a result, the original data storage system can't meet current need of data storage any more.

To solve the problem, Guangxi branch of China Construction Bank uses 3 IBM-S80 systems: storage system host, accounting system host and accounts centralized system host. By two fiber-optic lines, all three

hosts connect with two IBM Shark storage servers. One of the severs is used for the online processing service including saving card system and public business system, another for historical data storage as well as other access. For example, one NAS300G host is not only connected with mail server on IP network and Tivoli storage management server, but also serves as cache of Hiberarchy storage management.

2) China Life Reinsurance Company

China Life Reinsurance Company is one of the largest financial and insurance institutions, after many years of information construction, China Life Reinsurance Company has established its own data center, and formed its direct attached information office system, which is not sufficient to meet the massive growth of business data yet. For the centralization of business data storage, protection and integration, China Life Reinsurance Company decides to build new IT infrastructure based on building new machine room and purchasing both new servers and storage systems.

Through needs analysis, China Life Reinsurance Company has come to it that its need is a unified framework for information storage. One project has been executed to construct a unified and integrated storage system, which shows all the advantages: open connection, high reliability, good performance, high extension and easy management. This project appears to add new "insurance" to its own insurance data, so all the information is centralized for application and management. Information utilization ratio was significantly improved and working efficiency was greatly raised, thus the company's business development has been effectively promoted.

3) Shanghai Social Security Card Service Center

Shanghai social security card service center is a data exchange center of population information. Its information system is of large scale: a database for share information of a population of 20 million, a data exchange platform for management, a personalized system to annually issue 8 million cards, social security card service covering 200 communities and replacement card offices in the 19 districts and counties of the whole municipality. Because of the needs for long term data storage and increasing of customer data, storage expansion becomes urgent. At the same time, massive data and frequent access presents higher requirement and standard for the data storage. To end this problem, the Shanghai social security card service center constructs storage system using the network structure. The main production server connects with two optical switches via two fiber-optic links. Each optical switch connects with the center-XP512 disk arrays via several links. The tape library device is connected to the C3000 workstation or NT server, and C3000 workstation or NT server works as a backup server to control the entire system backup of all hosts.

4) Peking University

The network information storage system, as part of the i-campus project and five-year development plan, mainly offer data storage service for the whole campus. Since 1999, the amount of students and data access has been increasing. The old data base could no longer meet the demand. And a more reliable and effective direct-attached storage mode is palced on the agenda. Through thorough studies, they decided to transform the storage system from DAS to SAN for quicker access and centralized data management.

The old DAS in Peking University included RAID box tape library made by Fujitsu Limited and more than 10 servers made by Sun. To enhance the backup capacity, Peking University purchased library backup system equipment for tape storage. And the bare capacity of disk amounts to 20TB. That change ensured of sustainable development of storage system for the coming 5 years the university. And it also makes it ready to integrate the isolated storage systems among branch campuses.

5) China Network Communications Corporation

CNCnet' application of IP/DWDM to construct high-speed broadband information network of large scale is the first case of its kind. And high performance is the key point. As the supporting system, the storage system bears the primary importance. After one-year feasibility study, CNC determined to design their storage system professionally.

Broadband dramatically speeds access. And visitors can enjoy fast serf. That also increases the need for concurrent data access. To ensure sound network operation, CNC lists requirements as follows: high standard for storage system; shared function for file system to ensure a balanced loading; to realize data transfer and level management, so a lot of data is moved from disk array to tape library.

C. The scientific basis of the technology for 3D optical storage design

To meet the increasing storage requirement, people move their choice from disk and dick technology to CD, and then to one-layered and multi-layered CD. But that cannot go on without limit, for there is interference between the layer, and that increases with the number of layers. If that does not end in technology disability, it will end in high price.

The technology of light band is different. It rolls a very thin band with high-density and effective storage space. It makes cheap and massive storage device possible. Its weakness hinders popular market application. And that problem can be solved. Now the rising market need brings it back into the focus.

This paper, via study, tries to offer some approaches of design, which bears not only the high speed and convenience of CD, but also light band's mass storage.

1) Market Demand

As mentioned before, market demand for size of memory rises. Upon the expanding business and access, Organizations, such as education, telecommunications, airlines, insurance companies and government, need centralized data storage system desperately. For example, in the insurance industry, each company has the challenge of how to save and utilize the customer information. The old method can neither protect the data, nor centralize and use the data properly. That disability is an obstacle to their business expanding. So it is inevitable to establish unified storage system. And for education, telecommunications, airlines and government, the problem is the same. At this multi-media era, the effective use of pictures is becoming increasingly important and the mount is also rising.

2) The Basic Support for the Development from Related Technologies

CD-ROM, born in 1991, got its speed quadrupled in 1995. Data transfer rate was 600KB/S, the average is no longer than 250ms. After that, CD-ROM became the major target of technology development for different companies. With its technical maturity, the price reduced to an acceptable level. And CD-ROM begins to become popular now.

Light band storage combines the advantages of high-density from light storage and expandable storage from disk storage. Compared with the two, light band's storage is 2 or 3 magnitude more. Considering the change of short-wave lasers and technical development in near-field optical, super-resolution and information processing, the storage capacity of a CD will proximately be 109 bytes and that of a light band will be 1012 bytes.

3) Tshe possibility to solve the existing problems by designing approaches

The technical integration of CD and light band produces new equipment, which bears the character of cheap price, convenience, fast and free access, and mass storage. That is the inevitable trend for technology development. Due to insufficient knowledge of design, most of the research power overlooked their joint strength and left this area untouched. Although there is difficulty in combining their strength, it is not beyond reach. And once it is solved, 3D, high speed and mass storage will be available.

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