

LTO Program:

The First Year

Introduction

In the tape storage industry, Hewlett-Packard, IBM, and Seagate see a common set of problems affecting customers in the midrange and network server areas. Multiple tape options are available, each offering certain strengths in terms of capacity, performance, data integrity, reliability and cost, but no single option appears to meet all of these customer needs effectively.

The Linear Tape — Open (LTO) program is a joint initiative of Hewlett-Packard, IBM and Seagate Technology. The three companies set out to enable the development of best-of-breed tape storage products by consolidating state-of-the-art technologies from numerous sources. The three companies also took steps to protect customer investment by providing a four-generation roadmap and establishing an infrastructure to enable compatibility between competitive products. Other companies who are sponsoring proprietary technologies have yet to make public detailed roadmaps of future tape plans or take as many steps to provide for competitive, compatible product offerings.

The LTO technology objective is to establish new open-format specifications for high capacity, high performance tape storage products for use in the midrange and network server computing environments, and to enable superior tape product options.

LTO — The First Year

The LTO initiative was announced in November of 1997, through a joint press release announcing that Hewlett-Packard, IBM and Seagate Technology had reached an agreement to offer new open format tape specifications to simplify the complex enterprise and network tape storage industry.

Work among the three companies had actually begun six months earlier in April 1997. The first meeting was initiated by executives of the three companies' tape business units, and explored possible relationships which would establish more open formats within the industry, and still allow the three companies, and others, to compete effectively. A series of technical and business meetings followed throughout the summer of 1997, and led to a formal agreement among the three companies just one week prior to the November announcement.

On April 7, 1998, a more complete announcement was made, introducing the LTO tape format (Ultrium), technology roadmaps for the format, and the availability of licenses for the new technology. An LTO Web site was also established at that time.

There has been substantial progress since. Sixteen companies, including the three LTO Technology Provider Companies, HP, IBM, and Seagate (the "TPCs"), have become LTO technology licensees. Four meetings have been held with the licensees to clarify and enhance format definitions, to review technical license documentation, and to establish a forum for questions and exchange of information on the technology. These meetings will continue, as needed, at two to three month intervals.

Major progress has also been made in defining the technical strategy for accomplishing format compliance verification among the licensees, and an independent Compliance Verification Entity (CVE) has been selected. Announcements covering this process and the CVE company were made on May 11, 1999.

In the meantime, independent product development work continues by the LTO licensees. This work is expected to result in initial LTO product debuts before year-end.

Co-Operation

The Technology Provider Companies have all made significant contributions of time and expertise to the definition of the LTO format specifications. All have deep knowledge of customer needs, and all have provided expert knowledge and engineering skill in the critical areas of magnetic recording technology, mechanism design, media materials and cartridge design. There is no doubt that this cooperative process has created stronger LTO format definitions than any of the individual companies would have developed working alone.

The LTO initiative defines the new format that is different from formats used in tape products available today. The LTO TPCs intend to establish a new opportunity by meeting critical customer needs with Ultrium, and offering customers solid reasons for changing from the formats they currently use.

LTO program cooperation goes beyond the initial three companies. LTO format specifications have been made available to all who wish to participate through standard licensing provisions. LTO program technology has already attracted a number of other industry leaders, so that LTO specified products (tape drives and tape storage cartridges) will reach the market from multiple manufacturers, not just the Technology Provider Companies. This is critical to meeting an open market objective, and is accomplished through open licensing of the technology.

The licensing process is being administered by an independent third party, the law firm of Ladas and Parry, in Los Angeles, California. The licensing structure offers a Basic Package that includes the technical information about the format necessary to develop mechanisms and cartridges that interchange between products of the same format. This package does not include any patent or trademark licenses.

An Enhanced Package includes all the technical information provided with the Basic Package, and additional information about tolerance interdependencies, interchange verification testing and presents a conceptual overview of the design. This Enhanced Package also provides certain applicable patent rights and a license to use certain trademarks of the Technology Provider Companies, upon successfully passing and maintaining compliance verification requirements.

All licensees are encouraged to participate in regular meetings, during which questions on technical specifications are answered, license documentation issues are resolved, and information on the format specifications is exchanged. Cooperation is also evident in the LTO program requirement that all products produced by licensees be technically certified annually. The primary objective of this certification is to help determine whether LTO format cartridges will be exchangeable across drives produced by different Ultrium manufacturers.

Competition

All of this cooperation among the licensees, which include the TPCs, is focused on the development and promotion of the format.

Product development and delivery, however, are a completely different matter, and competition is expected to be strong. Licensees must demonstrate compliance with the format specification to be allowed to use the LTO trademark logos, but have complete freedom in product implementation details. Time-to-market, engineering

excellence, manufacturing quality, product cost, and marketing skill will inevitably lead to differentiated products.

Customers will be the beneficiaries, just as they are in all competitive environments.

Co-Opetition

"Co-opetition" is a word coined in the early '90's, that became popular and better understood through publication of the best-selling book Co-opetition by Adam Brandenburger and Barry Nalebuff in 1996. Central concepts of co-opetition are that businesses cooperate when they create a new opportunity, and then later compete for a share in that opportunity. Creating value that can then be captured is the essence of the theory behind co-opetition.

The LTO initiative is a strong example of "co-opetition."

LTO Format

LTO specifications have been developed for the Ultrium cartridge format.



Ultrium Tape Cartridge

The Ultrium cartridge uses a larger single-reel design and half inch wide tape to provide ultra-high storage capacity. Tape will be extracted from the cartridge by the tape drive through a leader pin, and wound onto a take-up reel contained within the drive itself. This design is focused on customer requirements for very high capacity and performance, such as server backup applications.

The Ultrium format builds on known, successful baseline technologies in use today, and so offers some of the technical security of an evolutionary approach. But these specifications leapfrog more traditional rates of evolution, and should provide performance and capacities well beyond anything available today.

Furthermore, the specifications define four technology generations, with each generation technically achievable at approximately two-year intervals. In the first generation, Ultrium is intended to provide four times this capacity, 100 GB - uncompressed, and similar transfer rates. These capacities and transfer rates are expected to double in each successive generation, reaching 800 GB and 80-160 MB/second for Ultrium in the fourth generation.

In addition, advanced LTO compression techniques should typically double the capacities and data rates cited above for most applications. Achievement of the objectives in this roadmap will enable tape storage costs to decline at rates similar to what has been seen in the hard disk drive area. This will be a major change for tape technologies, which have traditionally been on much flatter cost/capacity curves.

LTO Core Technologies

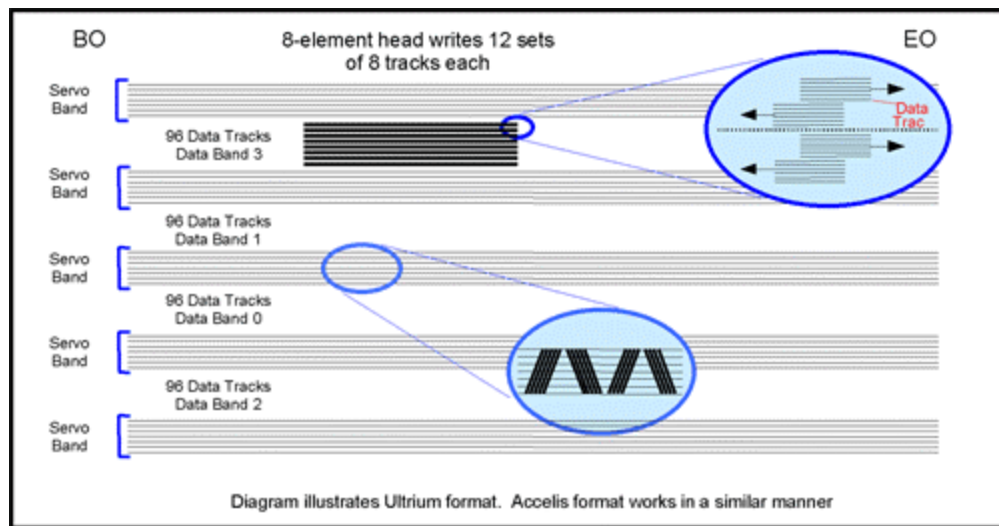
Multi-channel linear serpentine recording is at the core of the LTO format. It enables an optimum balance of reliability and data integrity, performance and high capacity.

In the LTO recording format, data is written in tracks that run down the length of the tape. The Ultrium format illustrated below, records 384 tracks across the half inch of tape width, or 768 tracks per inch. This linear recording format has a "serpentine" characteristic. The drive mechanism will make multiple passes from the beginning of the tape (BOT, in the illustration) to the end of the tape (EOT) and back to BOT in order to read or write the full 100 GB capacity of the cartridge.

In the Ultrium format, the 384 tracks are split into four bands of 96 tracks each. Data is written to the innermost bands first, to provide protection to the data recorded earliest in the process, by writing it in the center, the most physically stable area on the tape. Data is also verified as it is written.

On "pass one" of a round trip down the length of the tape and back, eight tracks are read, or written, concurrently. At the EOT, "pass two" of the round trip starts. The read/write heads are indexed and positioned over eight new tracks, and the tape reverses direction back toward BOT to complete the round trip.

For the next round trip, the heads are again indexed to a new position over a new group of 8 tracks.



Because track densities are so high, and because the tape is subject to some lateral movement as it is moved, it is critical to performance and data integrity that the read/write heads always be positioned precisely over the correct tracks. This is accomplished through a technique called timing based servo. This technique enables high track densities, now and in the future, and the ability to read data, even with media imperfections.

In the LTO system, electronic signals are generated through the real-time reading of servo data bands that are prerecorded on the LTO tape. These signals enable the servo system to dynamically control the positioning of

the read/write heads across the width of the tape. Less advanced, but similar magnetically-based, track-following servo systems are proven in tens of thousands of tape drives in use today.

The LTO format also utilizes advanced error correction codes (ECC) for data integrity. These systems are designed to automatically correct most cross-track errors, and provide data correction even if a full track is lost. Data is further protected by demarcation of bad areas of the tape, for example where servo signals are unreliable, and through dynamic rewriting of bad blocks.

Cartridge memory (LTO CM) is embedded in Ultrium cartridges. A non-contacting RF module, with non-volatile memory capacity of 4096 bytes, provides for storage and retrieval of cartridge, data positioning, and user specified information.

Summary

The LTO initiative is unique. It was created by three industry leaders, and is now backed by over 30 other companies, in a shared effort to establish open tape format specifications that allow widespread manufacturer participation and extensive options for buyers. Independently administered technology licensing and format compliance verification protect the interests of manufacturers and buyers alike.

Ultrium is based on proven, yet extendible technologies, and provides a clear roadmap for growth in performance and capacity. It is intended to meet the current and future needs of midrange and network server users, and deliver superior tape product choices. The LTO program initiative is an example of co-opetition at work. New opportunities are being created for both customers and manufacturers.