



IBM and Fujifilm Increase Tape Density — Raising the Bar on Tape Capacity

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Management Summary

For the past few years, okay, maybe a decade, many IT analysts and professionals have been forecasting the demise of tape as a storage medium. Unfortunately for them, but fortunately for you, companies such as IBM and Fujifilm refuse to listen. It was less than four years ago that this partnership leapfrogged the storage competition with a revolutionary technology that not only raised the bar for tape media capacity, but it also raised the storage stakes for media capacity in general. With that previous announcement of a tape density achievement of 6.67 billion bits per square inch that could produce tape media with a capacity of 8TB, IBM and Fuji had laid the basis for multi-TB tape cartridges that will be appearing within a few years in both commodity and proprietary tape technologies. Currently, the enterprise tape media market is divided into high-end, proprietary offerings, like IBM's *TS1130 Tape Drive* and Sun's *T10000B Tape Drive* and, for the open systems world, *LTO-4* technology. Both the *TS1130* and the *T10000B* support 1TB media, uncompressed, while *LTO-4* technology deploys 800GB cartridges, uncompressed. We already know that the LTO Program has announced the next generation of LTO drives, *LTO-5*, with an uncompressed capacity of 1.5TB¹, and that the *LTO-6* roadmap, has a projected capacity of over 3TB. We suspect that the next generation of proprietary tape drives from both IBM and Sun cannot be far behind.

We also know that enterprise information is doubling every 12 to 18 months. Enterprise data centers are running out of both capacity and energy at a precipitous rate. The continuing growth of enterprise data means that, in the long term, *additional* storage systems will be required. Unfortunately, many data centers do not have sufficient floor space to support additional tape libraries or the space and energy required to operate additional Disk-to-Disk (D2D) storage targets or Virtual Tape Libraries (VTLs), even with the implementation of data deduplication techniques. Moreover, even if the physical resources were available, the ancillary costs to operate, maintain, and manage them might submerge the IT budget. The cost of building a new data center is even more prohibitive.

This is where the continued innovation from companies such as IBM and Fujifilm provides the data center with a light at the end of the tunnel. On January 22nd, IBM and Fujifilm announced another breakthrough in storage capacity. With the cooperation of scientists from Fujifilm, IBM has recorded data onto magnetic tape with a density of 29.5 billion bits per square inch – almost 39 times the data density of *LTO-4*, today's most popular tape product. For those of you who misplaced your slide rule, this could equate to a tape cartridge storing 35TBs of uncompressed data. If you want to ensure that the light at the end of your tunnel is not an oncoming freight train, please read on.

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¹ See [The Clipper Group Navigator](http://www.clipper.com/research/TCG2010002.pdf) dated January 31, 2010, entitled *LTO Program Announces Next Gen Tape – LTO-5 Raises the Bar for Tier-3 Storage*, available at <http://www.clipper.com/research/TCG2010002.pdf>.

Today's Enterprise Data Center

With multiple tiers of data proliferating the enterprise, there is a need for a wide variety of storage devices throughout the enterprise. Mission-critical applications demand high-performance, high-availability disk drives to ensure high performance and high availability. These Tier-1 devices are more expensive than the high-capacity Tier-2 disk drives needed to satisfy many of the business-critical large-scalability demands of a rapidly growing enterprise. The typical enterprise data center also maintains a scalable Tier-3 tape environment to satisfy its long-term storage, archiving, and data protection requirements. Magnetic tape devices and media historically have satisfied this Tier-3 requirement, due to their low cost structure and low energy demands. Despite the predictions of some pundits, especially those with no skin in the tape business, tape continues to thrive in the enterprise data center.

The data center of every enterprise faces many of the same issues. In order to support thousands, or even tens of thousands, of users with petabytes of data, and growing, the enterprise needs to have a scalable, and inexpensive, long-term storage solution that will endure for many years into the future, protecting valuable corporate assets. This solution cannot increase the TCO of the data center continually because of the acquisition cost of a new architecture and moving vast volumes of data or ancillary costs due to maintenance, systems management, floor space, and energy. The IT staff needs to maintain a consistent architectural infrastructure for the data center as is possible. In order to do this, they have deployed an infrastructure that uses the latest magnetic tape technology. To preserve that consistent environment, they need to have compatible storage devices that can maintain historical archives, back-up files, images for disaster recovery, and compliance retention data that will support their infrastructure for years, and decades, into the future.

Whether you are dealing with a purpose-built mainframe architecture or a scale-out commodity infrastructure, tape has provided the data center with an upgradable format for decades. The IT staff can replace the drives in the tape libraries with the latest architecture, with little concern for backward compatibility: tomorrow's drives typically can read media that is two gener-

ations old and can write onto media from the previous generation. The concern is often how many cartridges, and therefore library frames, will be required to store the necessary data and how much data can be stored on each cartridge. In the open systems arena, we have seen LTO develop and progress with outstanding performance from 100GB capacity in 2000 to 1.5TB capacity in 2010. IBM and Fujifilm continued on the path they established in 2006 to establish continuity in the data center and provide a tape capacity that will enable the largest enterprises with enough headroom to maintain their tape architecture, high-density of storage, and control the TCO of their long-term storage and archiving capability for at least another decade. Introducing the 35TB tape cartridge!

A New Media Technology

Researchers from both IBM and Fujifilm, working at IBM's Zurich lab, have recently demonstrated the capability to record 29.5 billion bits of data per square inch on an advanced prototype tape. This is a record for areal density on linear magnetic tape, about 39 times the density achieved today with LTO-4, the most commonly used tape architecture in every open systems data center. Moreover, according to IBM scientists, this stop is just a checkpoint on the way to achieving areal densities of 100 billion bits per square inch and beyond. This is the technology required to keep up with the rapid increase in digital information.

This new media uses a dual-coated magnetic tape, using barium ferrite particles. Combined with several key technological advancements, a single cartridge containing 800m of tape could enable the data center to protect 35TB of data, about 44 times the capacity of LTO-4. This is a capacity sufficient to store the text of 35 million books. One of those new technology innovations is the dramatic improvement in the precision for controlling the position of read-write heads, resulting in a 25-fold increase in the number of tracks that can be written to a half-inch-wide tape. Another is a new, advanced detection methodology to improve the accuracy of reading tiny magnetic bits, increasing the linear recording density by more than 50%. For a more detailed description of these and other innovations from IBM and Fujifilm, see Exhibit 1, above.

Exhibit 1 – IBM/Fujifilm Technology Innovation

- **A new high-density, dual-coated particulate magnetic tape** - Developed by Fujifilm in close collaboration with IBM, this next-generation version of its *NANOCUBIC* tape uses a new ultra-fine, perpendicularly-oriented barium-ferrite magnetic medium that enables high-density data recording without using expensive metal sputtering or evaporation coating methods.
- **Advanced servo control technologies for ultra accurate head positioning** - Three new servo control technologies have been developed by IBM Research Laboratory in Zurich, leading to a more than 25-fold increase in the number of data tracks that can be written onto a half-inch-wide tape:
 1. A new servo pattern, enabling the generation of high-bandwidth nanometer-scale position information;
 2. A new method for detecting and decoding the position information encoded in the servo pattern; and
 3. Advanced state-space-based control concepts that, combined with the other two technologies, culminated in the demonstration of an extremely precise track-follow performance of less than 24 nm standard deviation from the target track position.

These technologies were instrumental in reducing the track width to less than 0.45 micrometers.
- **Innovative signal-processing algorithms for the data channel** - An advanced data read channel based on a new data-dependent noise-predictive, maximum-likelihood (DD-NPML) detection scheme was developed at IBM Research Laboratory in Zurich to enable the accurate detection of the data despite the reduction in the signal-to-noise ratio resulting from the use of an ultra-narrow 0.2- μm data reader head. With this technique, which also takes the noise characteristics of Fujifilm's BaFe medium into account, a linear density increase of more than 50 percent relative to LTO Generation 4 was achieved.
- **Low-friction GMR (giant magneto-resistive) read/write head assemblies**: Two new head technologies have been developed by the tape development and research teams at IBM Research Lab in Almaden: a new reduced-friction head assembly that allows the use of smoother magnetic tapes and an advanced GMR head module incorporating optimized servo readers. These head technologies were critical for achieving the required track-follow performance mentioned above.

Source: IBM – Fujifilm announcement, dated 1/22/2010

With these new technologies, IBM and Fuji are well positioned to lead the next wave of magnetic tape storage into the data center, enabling every enterprise with the capability to effectively plan for the future.

Conclusion

We are living on an increasingly smarter planet. As the computer systems that surround us, collecting more information about everything from our health to our financial condition, become even more intelligent and interconnected, there will continue to be explosive growth in the rate in which data is created.

Tape systems cost significantly less than hard disk systems on a per gigabyte basis. In addition, tape cartridges are the ultimate green storage medium, because they use no energy unless they are being accessed. As enterprises and government agencies continue to use tape to

store and protect an ever-increasing volume of structured and unstructured data, the need for cost efficient media will increase.

This new technology proves that the data center can increase tape storage capacity for years to come. Tape storage is indeed alive and well, continuing to provide the data center with reliable, cost efficient data protection. Tape, now in its fifties, has gotten better with age. Isn't that what we all really want? Better check it out!



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