SERVER STORAGEIO® LAB REPORT

INSIGHTS FOR INTELLIGENT APPLICATION SERVER STORAGE I/O ACCELERATION

INTRODUCTION

This Server StorageIO® Lab Review solutions brief looks at Enmotus (www.enmotus.com) MicroTiering™ FuzeDrive™ technology. In this solution brief, we look at data center and application performance, storage space capacity along with economic issues as well as how Enmotus address these and other challenges. Also included are hands-on test drive experiences and proof points using Enmotus FuzeDrive MicroTiering technologies with different application workloads.

HIGHLIGHTS AND SUMMARY

Enmotus MicroTiering enabled FuzeDrive technology supports various applications and Performance Availability Capacity Economic (PACE) criteria. FuzeDrive adapts to various environments and applications to address common data center issues and challenges. Benefits include boosting the performance of lower cost, high-capacity storage while reducing application disruption associated with implementing SSD flash storage. FuzeDrive includes easy to use, management tools providing real-time insight and awareness into SSD as well as HDD storage performance.

Key benefits and takeaways:

- Improves server efficiency
- Supports more work/VMs per server
- Applications run faster
- Seamless SSD implementation
- Increases IT productivity

Being agnostic to different applications, operating systems, and hardware, the flexibility of the Enmotus MicroTiering technology and its granularity allows it to work for you and your organization. FuzeDrive is a good solution for addressing various information factory aka data center issues and challenges. Continue reading in this StorageIO® Industry Trends Perspective Lab Review how FuzeDrive addresses data center and application bottlenecks with fully automated real-time MicroTiering optimization.

DATABASE PERFORMANCE SYNOPSIS

Enmotus FuzeDrive supports various applications including database workloads boosting transactions per second (TPS) performance combing the speed of flash SSD and space of high capacity HDDs.

Database Transactions Per Second (TPS)
RAID 5 (4 x 7.2K HDD) vs. FuzeDrive (NVME + R5) vs. FuzeDrive + 8GB Cache vs. NVME PCIe Card
Database (SQL Server) TPCC Scale = 750 (60GB)

25 Users

- R5 (4 X 7.2K HDD): 75.7 TPS
- FUZE(NVME+R5): 280.2
- FUZE(NVME+R5) + Cache: 287.7
- NVME (PCIe card): 278.6

Source: StorageIO Labs

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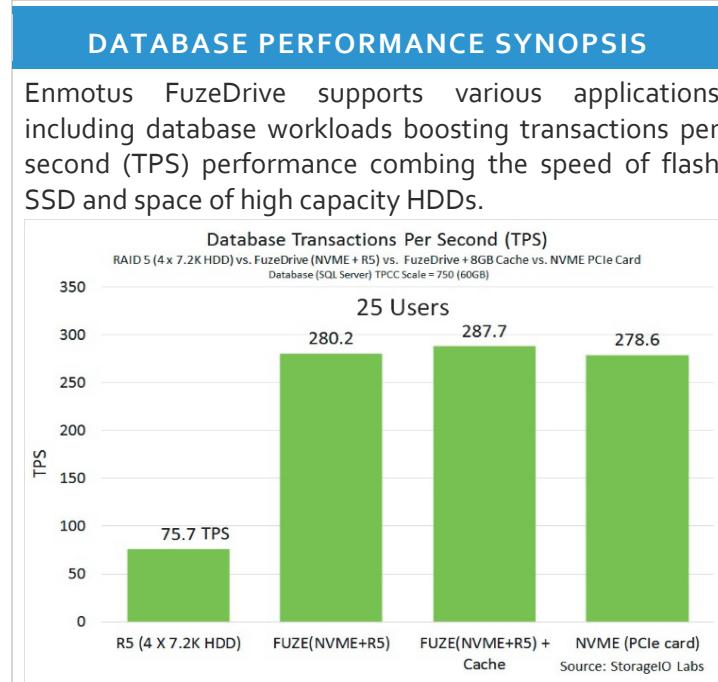
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DATA CENTER AND APPLICATION CHALLENGES

IT data centers also known as information factories are evolving supporting new and emerging along with legacy applications. These environments in addition to containing a mix of legacy and new applications (and data) are also a hybrid of physical, virtual, cloud and other technologies. Applications include content processing, serving, protection and preserving of digital data, as well as database, large and small file as well as object serving, email and messaging among many others. Users of IT applications (or information services) expect fast access to their information, including quicker than in the past.

Data center challenges include a greater volume (quantity) of data; some data is also getting larger (size of data records, files, objects, images). Tied to the size of data expanding, I/O operations from applications to memory and storage devices are also getting larger. In addition to requiring the data to be served faster to reduce information wait times, data is being retained for longer periods of time requiring more space.

Another challenge is that data is being kept longer both for availability and protection, as well as for unlocking untapped value from it in the future with new applications including analytics or other emerging big data functionality.

Balancing PACE Attributes
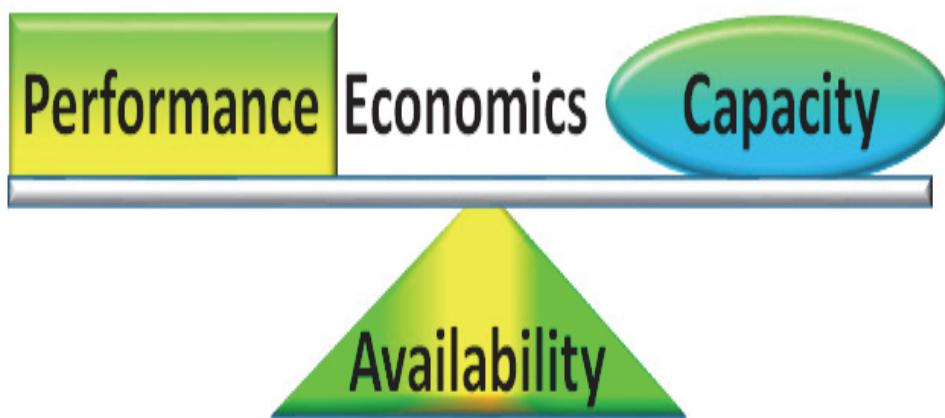
All applications require some amount of **P**erformance, **A**vailability (durable, secure, protected), **C**apacity (space, bandwidth) and **E**conomics (e.g. **PACE**) attributes along with corresponding data center infrastructure resource (servers, storage, I/O, hardware, software) needs that need to be balanced.

Even though there is no such thing as an information recession, there are budget and economic realities. The result is a balancing act of **PACE** attributes. What this means is that organizations need to support faster access to data that is protected, preserved longer while stretching budget dollars further.

TECHNOLOGY CHALLENGES AND OPPORTUNITIES

Demand drivers for keeping data longer is that over time, unlocking the additional value of information with new applications such as analytics can occur. Organizations need to support faster access to data that is protected, preserved and served longer while also stretching budget dollars. Fast applications need access to fast resources (storage, servers, networks) to quickly and cost effectively transform data into information. This means eliminating bottlenecks and speeding access to data boosting organizational productivity.

Traditional monolithic storage hypervisors (storage virtualization) have thick heavy stacks designed for sitting in the data path adding data services around storage pooling that can result in increased application latency. Many software defined storage virtualization hypervisors are focused on replacing traditional storage system functionality as opposed to complimenting, and accelerating their capabilities.

Likewise, traditional information lifecycle management (ILM), data and storage tiering solutions while providing a space capacity benefit, does so with the addition of complexity (and cost) while compromising on performance. Even though their performance is outpaced by persistent Non-Volatile Memory (NVM) including NAND flash-based Solid State Devices (SSDs), Magnetic Hard Disk Drives (HDDs) continue to be a cost per capacity price performer in many environments, particular for older, less frequently accessed data.

Storage Class Memories (SCM) that provide persistence with performance closer to traditional DRAM (e.g. RAM) are emerging. SCMs along with DRAM (RAM) enable more data to be kept close to applications (e.g. locality of reference) to

NVM/SSD IS LIKE REAL ESTATE

NVM including SSD along with emerging SCM as well as volatile DRAM are like real estate. Location matters! There are different types of SSD and real estate for various needs. They have different Performance (Presence), Availability (Access), Capacity (space) and Economic (PACE) considerations. Another commonality is that a little bit in the right location can have a big benefit, otherwise both end up cost a lot of cash. Another commonality is that both real estate and SSD tend to be compared based on cost per capacity or square foot space instead of their other PACE capabilities, or usage needs.

This means maximizing your investment in higher cost, higher productivity store front (or storage) as a point of presence (for fast access). Meanwhile leverage lower cost, larger warehouse and factory (slow storage tier with higher capacity space). Key real estate and storage (SSD and HDD) is quickly and intelligently moving items between locations without performance delays (e.g. waiting for items to arrive) without introducing extra cost or complexity.

improve productivity. Another trend is using higher capacity, lower durability, and less costly flash SSDs as a capacity tier combined with a higher performance SSD fast tier. While NVM improvements result in higher capacity, better availability and durability, there are still challenges with implementing SSDs based solutions. These challenges include the complexity of implementing with existing applications and technologies, along with transparent, non-disruptive data movement, migration and application integration, as well as cost and durability.

ENABLING APPLICATION PRODUCTIVITY

Fast applications rely on having frequently accessed data as close as possible to the processor itself. To speed up applications, they need faster server processors, more compute cores, more memory and, even more storage resources. These resources provide better responsiveness, more space, and improved consistent, predictable performance).

Keeping active data as close as possible to where applications are running (e.g. locality of reference) reduces wait times, improving productivity and performance.

Enabling application performance with effective resource usage is having insight and awareness (figure-1) into your environment. It's time to move beyond a focus on the cache, memory or storage utilization efficiency expanding to the effectiveness of how resources are used to improve upon application services delivery and productivity.

LOCALITY OF REFERENCE – KEEP DATA CLOSE TO WHERE APPLICATIONS ARE LOCATED

Locality of reference spans from processor based registers and on-board memory caches, to DRAM and storage based tiers. The higher in the memory storage tier hierarchy the faster and better locality of reference.
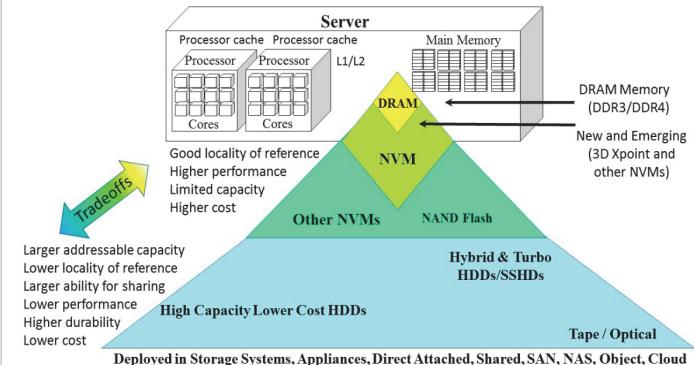
However the challenge is the cost and amount of available or addressable memory (storage is persistent memory). The solution is having different levels or tiers of memory and storage that become lower cost with increased capacity, granted with lower performance as you move downward in the memory storage pyramid hierarchy.

Keep in mind that a little bit of SSD in the right place can have a big benefit while being cost effective. On the other hand, without insight and awareness or automation, a lot of SSD as cache or storage capacity can end up costing you a lot of cash for your application cache
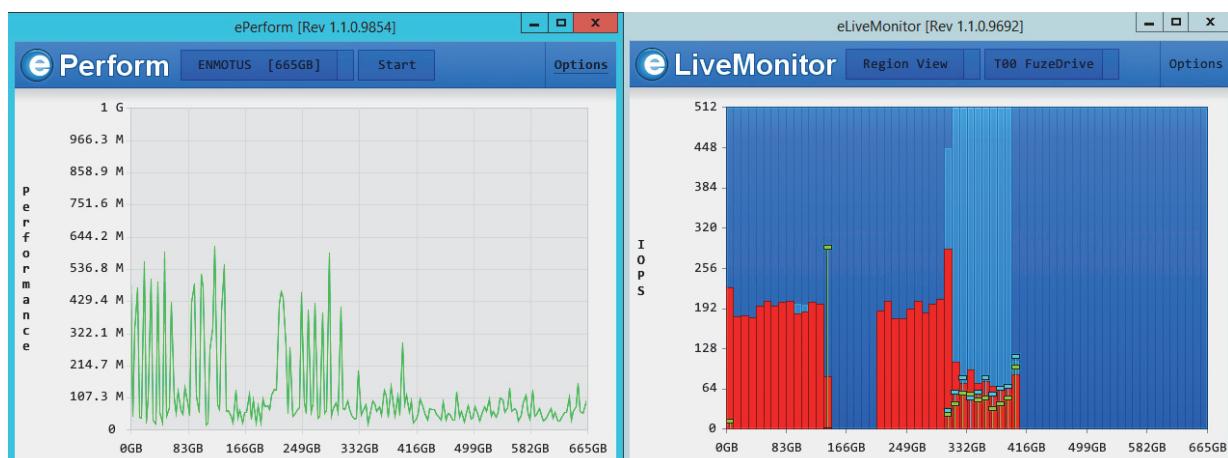

Figure 1 - Gaining insight and awareness into your server and storage I/O data infrastructure effectiveness

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Enmotus FuzeDrive MicroTiering

SSDs provide speed to meet application needs. However, the cost for space capacity remains several times higher than traditional spinning magnetic media such as HDDs. Enmotus FuzeDrive® MicroTiering is a software defined, light-weight thin stack based storage hypervisor with a focus on data and application acceleration, while maximizing storage space capacity in a cost effective way.

Unlike traditional storage hypervisors whose focus is on adding data services resulting in extra latency, MicroTiering keeps as much processing out of the data path as possible. The light weight MicroTiering engine leverages insight gained from watching application I/O activity. That information, along with adjustable user policies implements real-time automated storage tiering to meet different PACE needs.

FuzeDrive MicroTiering

Enmotus MicroTiering sits below databases; file systems and software-defined logical volume or other storage management tools while being agnostic to underlying storage resources on various operating systems. MicroTiering provides a hybrid solution to application and data center bottlenecks by aggregating the effective bandwidth of storage tiers in a FuzeDrive, along with the performance of the fast tier.

To avoid thrashing and associated overhead found with some tiering and caching solutions, MicroTiering promotes or demotes storage pages on various granularity ranging from 128KB to 4MB. This flexibility, along with adjustable policies including normal and aggressive, read or read/write I/O among others allows MicroTiering to adapt to different application needs across different FuzeDrive volumes. Also, FuzeDrive supports "pinning" of files into a fast tier. For example tuning server storage I/O QoS for reads, writes, mixed I/O, larger or small, random and sequential workloads. In other words, FuzeDrive adapts to your applications and environment with the flexibility of on a per tiered volume basis.

INTELLIGENT MicroTiering

Enmotus MicroTiering technology has the ability to use all of the capacity of the fast tier as user storage as opposed to being dedicated to being a cache or location exclusive for Meta data. FuzeDrive

The intelligent MicroTiering data migration engine keeps detailed statistics (e.g. has insight) of each virtual page in the applications data volume. This intelligent and insight allows the light-weight MicroTiering engine to determine if and when any pages should be moved (promoted or demoted).
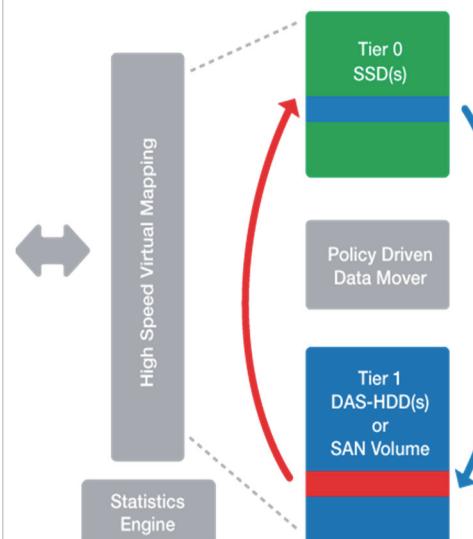
Any movement of data is transparent to the user, applications, database and filesystems. Policy settings are automatically set or customized by the user or administrator. Once a threshold for a page is achieved, the page is then scheduled for a promotion to the faster tier and moved in real-time.

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Enmotus FuzeDrive Features

Enmotus FuzeDrive and MicroTiering features:

- Transparent to applications and operating systems
- Agnostic to various storage devices and interfaces
- Low latency that boosts applications productivity
- Non-disruptive conversion of existing HDD-based data
- Reduces disruption of implementing SSD solutions
- Available in Workstation and Server editions
- Supports various operating systems
  (Windows 2008-2012 R2 along with Linux)
- Intelligent lightweight MicroTiering engine
- Application insight and storage I/O intelligence
- Multiple FuzeDrive's and FuzeDrive volumes
  (16 devices in a fast, as well as 16 in a slow tier)
- Stripe or concatenate JBOD and RAID devices
- Command line and GUI tools for management
- Compatible and transparent to OS and third-party tools
- Granularity of policies per volume including file pinning
- Real-time performance monitoring tools of tiering
  (FuzeDrive and Non-FuzeDrive's)
- Reduces cost and complexity of implementing SSD

FuzeDrive Lab Proof Point

With software-defined anything, seeing is believing. StorageIO Labs has reviewed and used Enmotus MicroTiering FuzeDrive in various configurations across different application workloads including transactional database processing.

Note, performance will vary with your applications, server and storage resources as well as a choice of FuzeDrive settings. For best results that are reflective of your applications, StorageIO recommends doing your own proof of concept and test drive to see how FuzeDrive adapters to your environment.

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OLTP DATABASE TPS AND FuzeDrive

Following shows relative TPCC (OLTP database) transactions per second (TPS) across different Devices Under Test (DUT's). From (left) a four (500GB) drive (SAS 7.2K RPM) hardware RAID 5 configuration (1.363TB usable). Second from left is a FuzeDrive combing a 800GB (745GB usable) for a total aggregate of 2.108TB usable space. Third from the right is a 2.108TB usable space FuzeDrive along with an 8GB Enmotus RAM Cache, right is the 745GB usable space NVMe device (PCIe AiC).

Database Transactions Per Second (TPS)
RAID 5 (4 x 7.2K HDD) vs. FuzeDrive (NVME + R5) vs. FuzeDrive +8GB Cache vs. NVME PCIe Card
Database (SQL Server) TPCC Scale = 750 (60GB)

25 Users

DUT	TPS
R5 (4 X 7.2K HDD)	75.7 TPS
FUZE(NVME+R5)	280.2
FUZE(NVME+R5) + Cache	287.7
NVME (PCIe card)	278.6

Source: StorageIO Labs
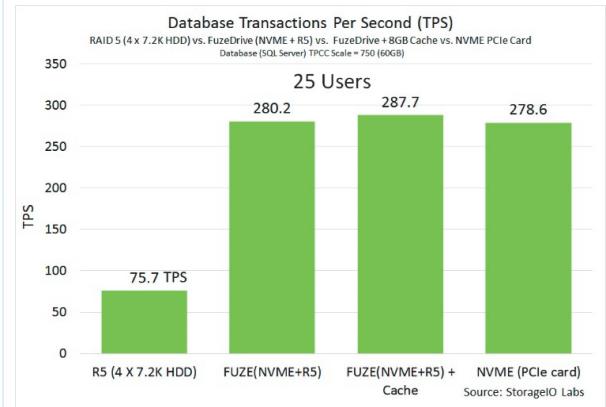
TPC shown for 25 users across the different DUT configurations using a TPCC database scale factor of 750 (60GB database). Both the main database (mdf) and log (ldf) files were placed on the DUT to simulate a heavily loaded configuration. Likewise SQL Server RAM was reduced to 4GB to create additional I/O activity. Note test objective was not SQL Server tuning, rather how different DUT configurations handled the workload. Best practices would place mdf and ldf on different volumes and increase the amount of SQL Server RAM as applicable to meet your specific application and environment needs.

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FuzeDrive AND OLTP DATABASE PERFORMANCE

After obtaining baseline performance profile of Devices Under Test (DUT's) using fio.exe, a Microsoft Windows Server 2012 R2 with SQL Server 2012 was configured with a database instance. For an application workload, Dell Benchmark Factory (part of the Toad tools) was used to generate TPCC (OLTP) activity. Go to the Dell website and download a version of Benchmark Factory (BMF) that in addition to TPCC, also supports TPCD and TPCE along with other workloads while collecting and storing robust results for follow-up analysis and reporting.

Tools used included FuzeDrive command line utilities for configuring and status, as well as GUI configuration, eLive and ePerf for performance monitoring. Other tools included BMF for workload generation and reporting of Transactions Per Second (TPS) metrics. Microsoft SQL Server command line and SQL Server Management Studio (SSMS), as well as Dell Spotlight on Windows (SoW) to monitor overall server performance and resource usage were also used.

For database workloads (figure 2), OLTP (TPCC) were run driven by BMF. Note that the SQL Server RAM buffer cache was de-tuned reduced to 4GB to force more actual I/Os to see how they are handled. The side benefit is that less overall system RAM is needed, or the existing RAM can be used more effectively. TPCC workload consisted of 45% new orders, 43% payments, 4% order status, 4% delivery and 4% stock level transactions. Tests were run for an hour with each group of users, per type of test, per DUT. The results show database TPS per group of users across different DUT's for database only workload activity.

| Database (TPCC) TPS per number of users	1	25	50	75	100
R5 (4 X 7.2K HDD)	39.8	75.7	68.1	63.4	54.2
FUZE(NVME+R5)	99.0	280.2	154.6	125.4	114.6
FUZE(NVME+R5) + Cache	99.0	287.7	159.7	124.9	105.5
NVME (PCIe card)	98.5	278.6	156.7	126.6	108.5
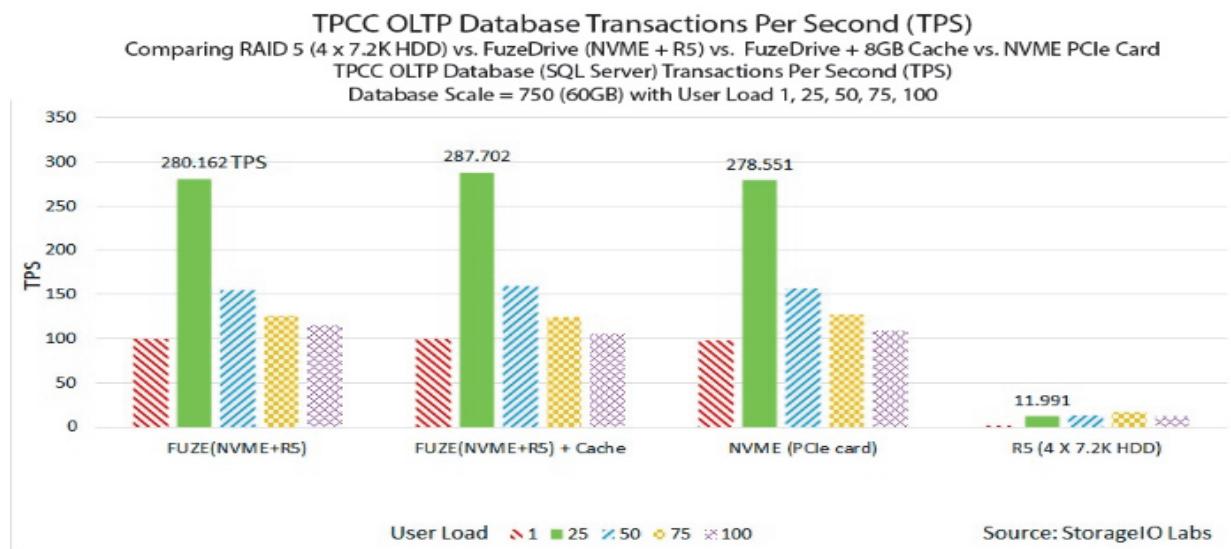
Figure-2 Database workload across DUT's and numbers of users

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FuzeDrive GENERAL STORAGE I/O PERFORMANCE

Figure-4 shows results of a StorageIO Lab test drive running the fio.exe workload performing 4K random reads (70%) and writes (30%) consisting of 32 jobs (threads) against a 100GB file on various DUT's including non-FuzeDrive and FuzeDrive configurations.

Left to right in figure-3 are a non-FuzeDrive RAID 1 600GB (2 x 15K HDD), FuzeDrive with 1TB capacity using 400GB PCIe NVMe + RAID 1 600GB (2 x 15K HDD), non-FuzeDrive 400GB 12Gbps SAS SSD and a non-FuzeDrive 400GB PCIe NVMe card. Note the FuzeDrive with 1TB storage space capacity is within about 8% of a single 400GB PCIe NVMe card.
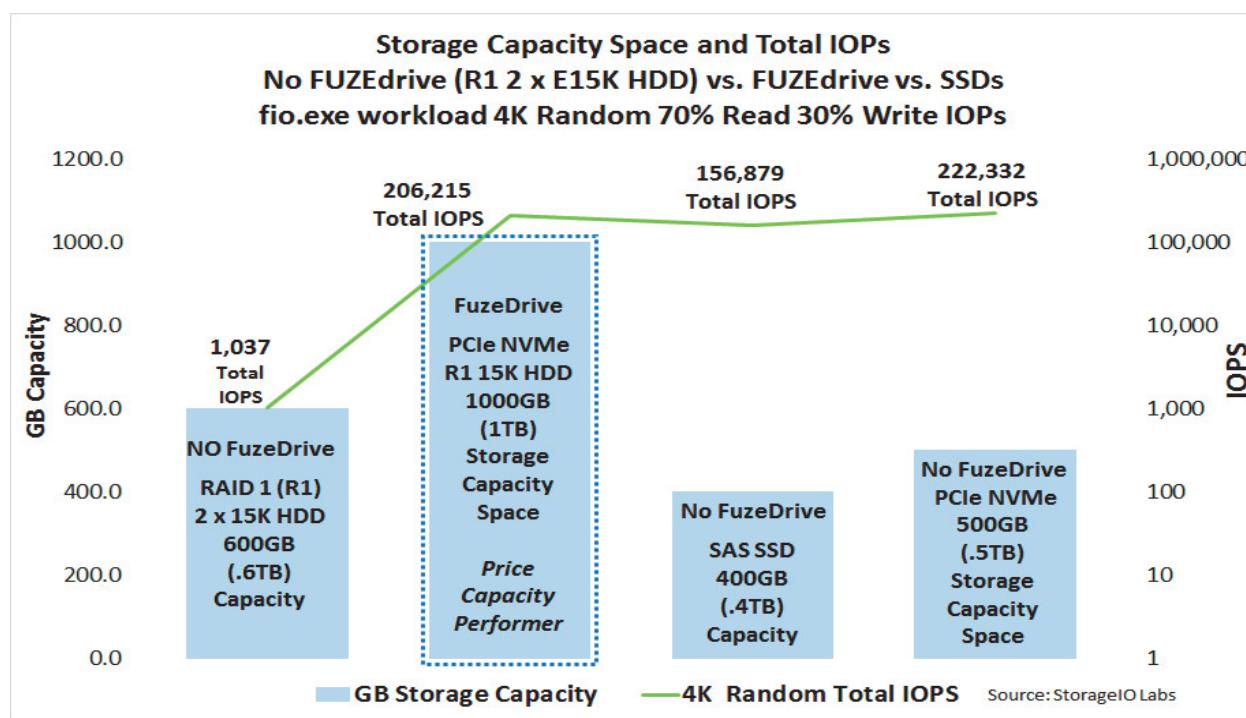
Figure-4 Comparing relative effectiveness and efficiency of FuzeDrive and MicroTiering

Figure-4 shows MicroTiering FuzeDrive can perform with similar low-overhead, high-performance comparable to popular server hypervisors vs. bare metal. This shows the benefit of the Enmotus MicroTiering™ FuzeDrive™ technology to balance performance, capacity in a cost effective way.

WHAT TO LOOK FOR

Look for solutions that can address PACE needs transparently across various applications. This includes transactional and reference database, little and big data, ERP, media and entertainment, software development and DevOps, video and imaging including medical, financial and life science, email, messaging and collaboration such as SharePoint as well as file sharing and analytics among others. This also means looking for solutions that can work with various operating systems in bare metal as well as hypervisor or cloud deployments. Solutions should be flexible to adapt to different workloads from small random to large sequential, reads, writes as well as hybrid or mixed activity.

- Investment protection of HDD and NVM SSD resources across various interfaces
- Support older operating systems environments such as Windows 2008 or Windows SBS 2011
- Agnostic to underlying hardware technologies including SCM, NVM/SSD, and HDDs
- Transparent to upper-level filesystems, volume managers or operating system software
- In place non-disruptive migration from existing storage volumes to accelerated volumes
- Non-disruptive implementation of NVM/SSD technology without data migration
- Scalable to support multiple accelerated volumes, with many fast and slow devices per volume
- Flexible to support different numbers and types of JBOD as well as RAID SSD and HDDs
- Automated promote/demote vs. simple cache, or complex data movement and migration.
- Intelligent QoS policy based automation of tiering to meet application PACE needs

WHAT THIS ALL MEANS, WHERE TO LEARN MORE

Enmotus MicroTiering enabled FuzeDrive technology supports various applications and PACE criteria, along with different environment configuration resources. Being agnostic to different applications, operating systems, and hardware, the flexibility of the Enmotus MicroTiering technology and its granularity allows it to work for you and your organization. FuzeDrive is a good solution for addressing various information factory aka data center issues and challenges.

Unlock the value of your IT assets (hardware, software) balancing application PACE needs with available IT resources and capabilities. Solutions should removing complexity and subsequently reduce cost, vs. introducing bottlenecks or compromising on PACE application needs. Look for solutions that work for you and your environments applications instead of adapting to fit the capabilities of a given solution.

Visit www.enmotus.com to learn more, as well as try it yourself to see how you increase your return on investment, as well as drive return on innovation using enabling technologies such as Enmotus MicroTiering enabled FuzeDrive.

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Greg Schulz is Founder and Sr. Consulting Analyst of independent IT advisory consultancy firm Server StorageIO and UnlimitedIO LLC (e.g. StorageIO®). He has worked in IT for an electrical utility, financial services, and transportation firms in roles ranging from business applications development to systems management, architecture, strategy and capacity planning. Mr. Schulz is the author of the Intel Recommended Reading List books "Cloud and Virtual Data Storage Networking" and "The Green and Virtual Data Center" via CRC Press and "Resilient Storage Networks" (Elsevier). Greg is a Microsoft MVP and seven-time VMware vExpert. Learn more at www.storageio.com and www.storageioblog.com. Follow on Twitter @StorageIO.

DISCLOSURES

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