Lab Insight

High-Performance Backup in Enterprise Environments

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April 2019

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Evaluator Group

Executive Summary

Data protection continues to be one of the most important aspects of IT operations for a variety of reasons. Evaluator Group recently completed an in-depth survey and analysis of more than one hundred enterprise information technology professionals regarding their strategies, goals and plans for data protection. Many insights may be gleamed from the research although one aspect that stands out is the fact that traditional backups are still the leading method for protecting data, while cloud offerings such as "Backup as a Service" are deployed at significantly lower rates.

Additionally, Evaluator Group's research indicates that a significant majority of respondents include the use of tape as a part of the current data protection operations, and nearly a third intend to continue using physical tapes. With the natural affinity between virtual and physical tapes, virtual tape library (VTL) products enable disk performance with tape like operations. For other firms moving away from tapes, native file-based backup targets such as NFS, SMB or other file like protocols may be more appropriate. Moreover, it is clear that disk backup targets with both file and VTL interfaces can play an important role in current and future enterprise data protection strategies.

In this Lab Insight, Evaluator Group analyzed FalconStor's backup target in a test scenario designed to represent an enterprise environment. A leading, enterprise backup application was configured to backup multiple systems with a single FalconStor VTL system as the target. The enterprise backup application was configured to utilize the FalconStor via FC connectivity with the system presenting multiple virtual tape libraries, tape drives and media. Multiple Terabytes of file data was created resulting in data with an overall 7:1 reduction rate, consisting of duplicate and compressible data.

A single FalconStor VTL system was able to achieve an aggregate backup rate of nearly 40 TB/hr. This was achieved utilizing an industry standard 2 socket system, along with multiple FC cards, back-end FC attached storage for retention and FalconStor VTL software.

FalconStor VTL Performance:

- **Single node VTL delivered a nearly 40 TB/hr backup rate**
- Price / Performance of 3X – 6X better than a leading competitor
- Design provides data protection that scales with additional CPU and I/O channels
- Architecture enables independent scaling of VTL processing, storage performance and capacity

Additionally, Evaluator Group Research offers analysis of FalconStor and competing VTL and backup appliance capabilities, which is available for subscribers at **www.evaluatorgroup.com**

Scale Out Performance

The Scalability is an important aspect of modern system design, and typically must be designed into a product from its inception. While it is possible to enhance a product's scalability, products that are retrofitted to add scalability typically suffer many limitations. In contrast, products and systems designed to scale are typically able to scale efficiently and with few limitations.

The ability to scale capacity is a widely supported feature among many products, as supporting more storage devices is a well understood problem. However, the ability to scale performance with additional resources is often a far greater challenge.

While testing FalconStor VTL software, we found that performance scaled nearly linearly with additional resources. The primary resource required to scale are CPU cores and I/O interfaces along with memory. The FalconStor design was able to utilize each additional CPU core available within a system to scale performance and capacity as long as I/O connectivity was sufficient to support the data rates required.

Cost of Ownership

A full TCO analysis is not presented in this analysis. However, it is possible to compare a FalconStor data protection solution to alternative solutions. Shown below is pricing and performance of a FalconStor system compared to a leading competitor's system with similar performance claims.

FalconStor vs. Leading Competitor

- **FalconStor has a 2.7X better (i.e. lower) price, and 2.7 X – 5.5 X better price / performance**
  - (Competitor $239,217 / FalconStor $86,283.75 = 2.77 X price advantage)
  - Competitor = 20TB/hr VTL – 40TB/hr OST; FalconStor = 40 TB/hr VTL
- Leading competitor's system GSA pricing = $239,217.88
  - Performance in VTL mode = "to 20 TB/hr"
  - Performance using offloaded reduction (requiring addl. Licenses) "to 40 TB/hr"
  - Includes 48 TB of raw capacity and included licenses
- FalconStor software along with Dell server and storage GSA pricing = $86,283.75
  - Support for 40 TB/hr in VTL backup, no additional offload required
  - Dell server, including CPU's memory and 6 – 16 Gb FC cards
  - Dell SCv3020 all-flash storage, 35 TB capacity
  - FalconStor VTL software license for capacity up to 50 TB

The two largest competitors to FalconStor both deliver an appliance, which bundles hardware and software together for a complete solution. While this model can simplify deployment, it typically

complicates the upgrade process. Appliances are supported for a number of years, until a new model is introduced, which then requires a new appliance acquisition.

In contrast, FalconStor utilizes a disaggregated model, which provides the ability to upgrade compute, storage, connectivity and application software independently. Compared to appliances, separating compute, storage and application software provides more increased flexibility, but may add complexity during deployment. Over a multi-year horizon, the cost of upgrades can add significant costs to the total cost of ownership. With the flexibility to upgrade portions of a system, it is possible to better align costs with requirements, adding capabilities when needed rather than at artificial dates dictated by a vendor.

Test Environment

Evaluator Group conducted testing in the Evaluator Group lab in late 2018. All equipment was located on-site with configuration and testing performed by Evaluator Group personnel. The test environment was designed to be similar to real-world production IT environment, utilizing servers, storage, networking and hypervisors. FalconStor offers multiple deployment options, the one utilized for testing is referred to as "VTL-S", which is a single appliance that is both a backup target and provides in-line data deduplication.

Specifically, the configuration consisted of the following:

- Client systems = 4 x compute systems, each running VMware ESXi 6.7 hypervisor
- Backup media servers operated as a VM, with a direct mapped FC card for VTL access
- Each Media server was allocated 3 TB of local NVMe storage
- VTL system = Industry standard x86 server, with 24 CPU cores and 128 GB RAM
- FalconStor VTL software version 9.0
- VTL storage repository = FC attached storage - all flash array
- Storage connectivity = 16 Gb FC between VTL and switch, 8 Gb between clients and switch
- Enterprise data protection SW to manage data backup operations
- Data reducibility was set to 7:1 (3:1 dedupe-able and 2.5:1 compressible data, yielding =~ 7:1)

This environment was designed to reproduce a typical enterprise environment, with particular attention focused on the bandwidth between clients and the FalconStor target system. Each media server was dedicated to backing up several TB`s of local, NVMe storage to a single FalconStor target, accessed as a virtual tape library target.

> ***Evaluator Group comments: Perhaps the most important aspect of the performance is that fact that the FalconStor VTL did not show any architectural performance limitations. Resources such as CPU and I/O were utilized fully when available, indicating additional resources could provide additional scale. Together with FalconStor's software licensing, this enables companies to upgrade resources when business requirements change.***

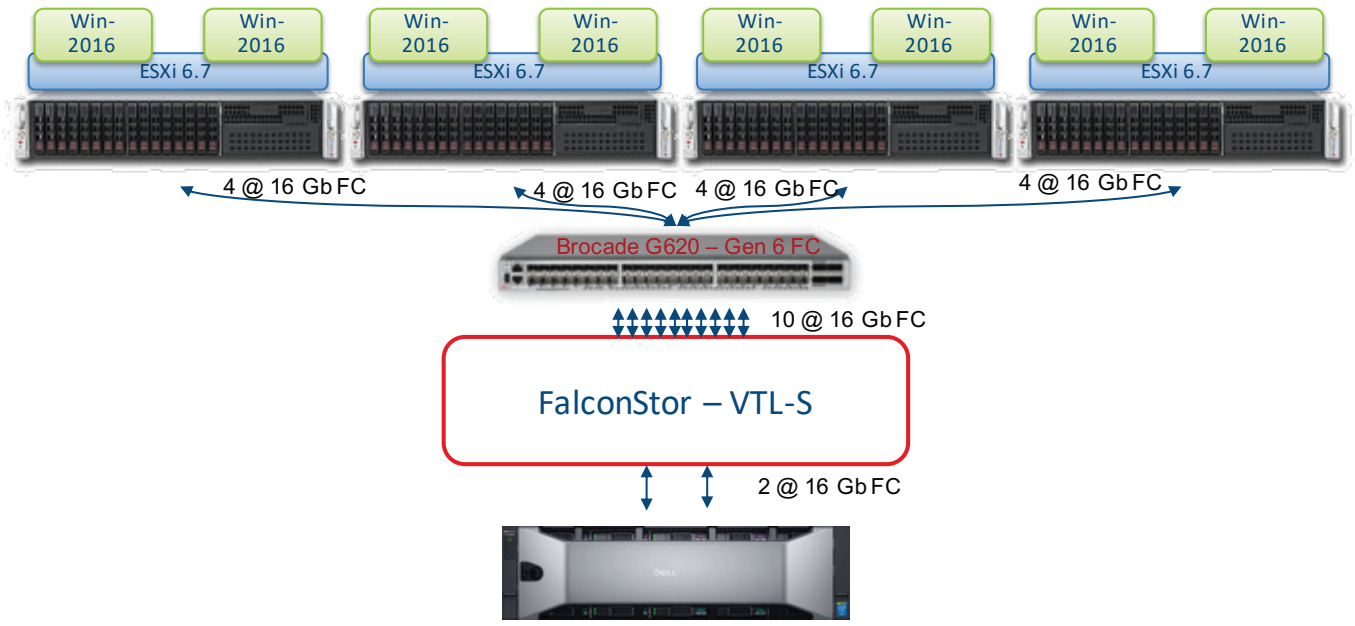

Figure 1: Test Environment Configuration

Performance Results

As indicated previously, The FalconStor VTL target system was able to sustain high data rates from multiple media server backup clients, all running simultaneously. The maximum single stream performance was found by optimizing the backup clients and backup software settings. One particular setting was the buffer size used for the backup application. Increasing this from the default value of 64KB to 512KB resulted in a 7X performance increase, with a maximum single stream backup rate of over 500 MB/s achieved.

Next, the system was optimized to achieve a maximum aggregate backup data rate, by utilizing multiple media servers, each with multiple backup streams. Maximum performance was achieved when the total number of streams consumed the CPU threads available in the target VTL system. For the test scenario, 40 streams achieved the highest performance, with an average data rate of 279 MB/s per backup stream.

With this configuration the aggregate data rate of 10.9 GB/s, or 39.24 TB/hr was achieved. Other tested configurations included both fewer streams and a greater number of streams, which both resulted in reduced performance. Using fewer streams does not fully utilize all resources, while a greater number of streams results in contention for CPU and memory resources, both leading to lower total performance.

One important aspect of achieving a data rate of nearly 40 TB/hr was to provide sufficient storage network connectivity and throughput.

Evaluator Group Comments: The performance of the FalconStor VTL increased with additional media servers, I/O streams and fibre channel ports. The results scaled from a single backup stream at 500 MB/s, up to the maximum aggregate rate of 10.9 GB/s achieved using 8 media servers and 40 data streams, with each stream over 275 MB/s . These results show that performance continued to improve up to the limitation of the CPU and I/O interfaces of the test configuration.

Test Summary

Several configurations were tested, which are summarized below in Table 1.

Source Data	# Streams	# FC Ports	Performance
1 Media Server – 1 local filesystem	1	1 @ 16 Gb	500 MB/s
2 Media Servers – 8 local filesystems	24	6 @ 16 Gb	4.3 GB/s
4 Media Servers – 16 local filesystems	48	6 @ 16 Gb	7.0 GB/s
6 Media Servers – 24 local filesystems	36	6 @ 16 Gb	9.0 GB/s
8 Media Servers – 32 local filesystems	40	10 @ 16 Gb	10.9 GB/s

Table 1: FalconStor VTL Performance Scaling

From the table shown above, several aspects stand out. The first is that scaling is quite linear moving from a single stream to 24 streams with 2 media servers and then 48 streams on 4 media servers. The performance achieved at this level with 6 FC interfaces was 7.0 GB/s. Scaling linearly beyond this level would have required both 96 CPU cores along with 12 FC connections to achieve 14 GB/s. The test platform was limited both by the CPU cores and the number of FC ports, thus yielding the maximum rate of 10.9 GB/s (10.9 * 3.6 = 39.2 TB/hr.).

Performance Limitations

As with all systems, performance limitations were encountered with the test environment. The performance limitations encountered are listed below, with the first item being the aspect that was the first limitation, followed by other limitations:

1. The read speed of the media servers was a bottleneck. Thus, additional media servers or storage media with higher performance may have enabled higher total performance
2. The FC bandwidth between the client systems and the FalconStor target was also a bottleneck, during testing the available channels were over 90% utilized (with16 Gb FC links)

3. The number of available CPU cores on the FalconStor VTL target system was also a bottleneck. As additional backup jobs were added, additional CPU cores on the FalconStor system were used. At the stated 40 TB/hr rate, more than 90% of the CPU cores were consumed.
4. Write performance of the back-end storage device attached to the FalconStor VTL. At the achieved performance, the backend storage was operating at approximately 2 GB/s with the FC channels utilizing 2 GBs of the 3.2 GBs available bandwidth.

A new generation of systems are available utilizing CPU's with 24 or more cores per socket, providing 2X the computational power of the test configuration. Using, 32 Gb FC cards would likewise provide 2X the I/O throughput and with additional media servers for backup, additional performance may be achievable. Moreover, scaling a FalconStor VTL system to 40 TB/hr and beyond is achievable if configured optimally.

FalconStor VTL Overview

FalconStor has a portfolio of products including a Virtual Tape Library (VTL) for backup and archive modernization and FalconStor Data Mastery Platform for storage orchestration, continuous data protection, and storage analytics.

VTL Features

- **In-line Deduplication** – Provides the shortest time to achieve protection
- **Flexible Deduplication Options** – Inline, post-process, concurrent (aka Turbo) or none
- **Multiple Interfaces & Protocols** – Support for FC and Ethernet connections, utilizing FC-Tape protocol or OST over Fibre Channel, along with SMB, NFS and OST over Ethernet
- **Long Term Retention Options** – Options include physical tape, along with on-premise object storage or cloud-based object storage to eliminate tape without disruption.
- **Dynamic Capacity** – The capacity limits of FalconStor VTL may be increased by adding licenses for additional capacity if required, or by adding additional disk or physical tape capacity
- **Virtual Appliance** – Optional VM based VTL enables flexible deployments for edge or ROBO locations

Evaluation Summary

The subject of data protection can get overlooked by senior IT professionals who are often focused on new topics and technologies. However, across organizations of all sizes improving backup and disaster recovery is typically one of the leading projects year over year. For many IT personnel, data protection consumes a significant portion of their time due to the complexity and the volume of data that must be protected.

As highlighted earlier, Evaluator Group's research into enterprise data protection showed that not only do a large number of firms still utilize physical tapes, many plan to continue doing so for several more years. Moreover, it is logical extension for many companies to utilize a VTL system as a backup target to aid in the utilization of tape for the data protection process, due to the affinity of virtual and physical tapes.

Sustained high throughput is critical to meeting backup windows with enterprises typically using multiple media servers to help transport backup data from the hundreds or thousands of source locations to the desired backup target systems. The performance of the tested FalconStor VTL was the highest performing single node system Evaluator Group is aware of to date at nearly 40 TB/hr. Additionally, with few observed architectural limitations, the FalconStor VTL should scale both performance and capacity by adding additional resources.

FalconStor's approach to data protection is different from some competitors, who offer an appliance. Although deployment is simplified with appliances, upgrading systems can become complicated by configuration restrictions and the differences between a vendor's timeframe for updating products compared to an IT firms desire to upgrade. In contrast, FalconStor offers software that can be combined with industry standard hardware to create backup target, offering flexibility both during initial deployment as well as what components should be upgraded and when.

Taken together, FalconStor's flexibility along with low cost and unmatched performance lead to a compelling value proposition for data protection.

Appendix A - Test Configuration Details

Provided below are the specific components and configuration details of the test environment.

VTL System Node:

- Intel – E5-2690v3 (Haswell) 2 socket system, each at 12 cores. Total = 24 cores and 48 threads
- 128 GB DRAM utilizing 8 @ 16 GB – 2166 MHz DRAM (4 DRAM / CPU)
- FalconStor VTL software version 9.0
- 6 @ Qlogic QLE-2662 – dual port 16 Gb FC

VTL Configuration:

- Total of 8 virtual tape libraries (one per media server), Library type was FalconStor
- 8 tape drives per library, tape drive type was LTO-7
- Total of 96 tapes were configured (12 per library)

Media Server Physical Nodes:

- 2 @ Intel – E5-2690v4 (Broadwell 2 socket system), each at 22 cores. Total = 44 cores / 88 threads
- 256 GB DRAM utilizing 16 @ 16 GB – 2166 MHz DRAM (8 DRAM / CPU)
- VMware ESXi 6.7 hypervisor
- 2 @ Qlogic QLE-2662 – dual port 16 Gb FC
- 4 @ 1.6 TB NVMe – Solid State media (VMFS datastore)

Media Server Virtual Machine (Total of 8 VM's, 2 per host):

- Windows Server 2016
- FC card available to Windows via PCIe passthrough
- 3 TB of file data residing on 2 NVMe devices accessed as VMDK on VMFS datastore
- Enterprise data protection software, media server local to each Windows VM
- File data generated with vdbench consisting of 7:1 data reduction rate

Other Infrastructure:

- Brocade G620 – Gen 6 capable FC switch fabric
- Enterprise data protection software, with scalable "master" and "media – server" architecture

FalconStor Configuration Pricing*:

Item	Description	Price
Server	Dell R730 Server, dual CPU + 6 x dual - 16 Gb FC HBAs	$ 16,785.50
	(2 @ E5-2680v4, 128 GB, 12 @ 16 Gb FC)	
Storage	Dell SCv3020 (20 @ 1.92 TB SSD) = 38 TB RAW	$ 48,498.25
FalconStor	FalconStor VTL Software	$ 21,000.00
Total	FalconStor Configuration Price	$ 86,283.75

***Note**: The stated Dell prices were obtained from Dell's website in November and December 2018. Pricing may have changed and listed systems and prices may no longer be currently available. Configuration is shown for informational purposes as similar to the tested reference configuration. FalconStor software pricing provided by FalconStor Inc.*

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